Never A Dull Moment

Academic Narrative of Hoshangabad Science Teaching Programme

SUSHIL JOSHI

Translated from Hindi by
Rex D'Rozario

With a long foreword by
Vijaya S.Varma

eklavya

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Author: Sushil Joshi
Translated from the Hindi by Rex D'Rozario
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FOREWORD

Introductory remarks

Documentation of the Hoshangabad Science Teaching Programme (HSTP), which ran predominantly in rural government middle schools of Madhya Pradesh, is almost non-existent even though it was one of the most sustained interventions in the government system of education in India – running as it did from 1972 to 2002. Sushil Joshi's *Jashn-e-taleem* was therefore a welcome addition to the meagre body of literature on HSTP when it was published in Hindi in 2008. Sushil Joshi's work was a labour of love, considering that he has dedicated a considerable portion of his working life to HSTP – almost 20 years while it was still functioning and thereafter to Eklavya's publication and science programmes. His account is both comprehensive and encyclopaedic arising as it does from a close association with the programme that not many had the opportunity for. The book is written with considerable sympathy and understanding and touches on almost all aspects of the programme from the early beginnings to its final closure. I should add that many believe that, in a sense, HSTP never closed. It continues to live on in the lives of the thousands of students, the hundreds of schoolteachers and the many resource persons whose good fortune it was to have participated in it. It also lives on in the educational programmes that have engaged

Eklavya's attention both while it was running and even after its formal closure.

It is with great pleasure and a sense of privilege that I take this opportunity to write this foreword to the English translation of Sushil Joshi's book titled *Never a Dull Moment* which is also being published by Eklavya. I know of many who have read *Jashn-e-taleem* and benefitted from it but I also know of many, whose lack of facility with Hindi has not permitted them to engage with it fully. They will now be able to do so and the reach of this work will be considerably increased. I believe that students of education and those who worry about the future of science education in Indian schools equally need to be aware of what HSTP attempted and why, what it managed to achieve and what it did not. They need to be aware of the lessons that they can learn from the experiences of the programme. That is why this translation was sorely needed.

The AISTA experience

I will begin by giving an account of my own personal journey with science education and the way it is entangled with the early phase of HSTP because that is the period in which my involvement with it was closest. It all started with the attempt by the Physics Study Group of the All India Science Teachers Association (AISTA) to develop a series of experimental workbooks in Physics for middle schools in India. BG Pitre was the Director, Professors HS Hans and Yash Pal were consultants and I, a young university lecturer who had just completed his PhD, became a member of its writing panel in 1967. The group comprised mainly teachers from public schools across north India and the philosophy and approach of the group were very strongly influenced by the Nuffield Science

Programme. An interesting thing to note is that the study group was funded jointly by the National Council of Educational Research and Training (NCERT) and the National Science Foundation. A series of meetings and workshops were organised in public schools in Dehra Dun, Ajmer and Nabha and on 26 January 1971 the first part of the workbook *Physics through Experiments* was published. However the whole initiative soon collapsed because the NCERT withdrew its funding at short notice although it had promised support for three years and even though the manuscripts of the workbooks for the subsequent two years were ready, only the workbook for year one could be published. The decision to stop funding probably also marked a change in NCERT policy when it switched from supporting external agencies (external to NCERT) for curriculum development to in-house development and production.

There were a number of reasons as to why the AISTA programme collapsed. The primary cause was of course the withdrawal of financial support by the NCERT after the first year workbook was published. A contributing reason was that the schools from which the participating teachers were drawn were all elite public schools with well-equipped laboratories of their own and most were already using the books and materials from the Nuffield programme on which the AISTA material was based. It is also likely that the management of the participating schools viewed the local effort as inferior, not kosher enough, having been produced by their own teachers, in comparison to the Nuffield material, which certainly had much better production values to say nothing of the excellent quality of the basic material.

The other thing of note is that although BG Pitre and his colleague CK Dixit were certainly instrumental in taking the programme to the Bombay Municipal Schools, the transition was in no small measure facilitated by Yash Pal by virtue of his being a mentor of the AISTA group while being based then at the Tata Institute of Fundamental Research in Bombay.

The Bombay experiment, however, also proved to be short-lived and folded up when the participating schoolteachers realised that their students, although taught the new curriculum with the new methodology, would actually be expected to sit the conventional Board examination at the end of class VII, for which the programme did not prepare them in any way.

The Delhi Group

In August of 1972, Anil Sadgopal came to the Chemistry Department of the University of Delhi to give a talk on the Hoshangabad programme, which had then just begun. There was a sense of *déjà vu* as I listened to him in the audience. When he spoke of the philosophy and the physics material that the Hoshangabad programme was using, it all sounded so familiar and so strongly reminiscent of the AISTA effort I had been part of a year earlier, particularly as the physics part of the workbook *Bal Vaigyanik* was a direct translation of the AISTA workbook *Physics through Experiments*. It was therefore easy for me to become a part of the team of faculty members from the science departments of the university that gathered together in a short span of time to help provide academic support to the nascent programme.

The meeting was followed by visits by faculty from Delhi to see the programme in action in the 16 schools around Rasulia and Bankhedi. I remember my first visit to attend a monthly meeting that was held in Kishore Bharati in September-October 1972. The overnight journey in the third class sleeper by the GT Express to Hoshangabad, the two-rupee trip in Kale Khan's tonga from the railway station to Rasulia, the trip on the Land Rover with Sudarshan Kapur to Kishore Bharati, crossing the dry bed of the river Tawa on the way, the school visits around Bankhedi, the abject conditions of the schools, the interactions with the schoolteachers during the day continuing into demonstrations of zero-cost experiments at night in a dimly lit room with straw spread across the floor, sleeping out at night with the stars so bright it would appear you could reach out and pluck them from the sky, then returning to Delhi and the sharing of experiences in the main lecture theatre of the Department of Physics packed with students and teachers – these and other such experiences fed into the formation of the Delhi group. The group consisted of teachers and students who agreed to come together to take on the academic responsibility for developing the physical sciences part of the Hoshangabad curriculum. The group examined the workbook that had been put together for the first year (the *Bal Vaigyanik* with a red cover, which came to be fondly known as the *Lal Vaigyanik*) and decided to write the material afresh while accepting the basic philosophy and the approach. It undertook the responsibility of getting the first-year material ready and trial it at the teacher-training programme that was to be held the following summer. It also persuaded, first the authorities of the University of Delhi, and then the mandarins of the University Grants Commission (UGC) to allow members of the group to be given Duty Leave, two at a time, to spend up to six months in the field getting familiar with the conditions in the schools, to develop curricula, do regular school follow up and organise monthly meetings of the programme schoolteachers. As many as nine members of the Delhi group made use of this provision, which was written into the statute books by the UGC. This was a historic decision because it thereby legitimised, for the first time in India, the official engagement of university faculty, other than from Departments of Education, with work in school education. Faculty members of Madhya Pradesh colleges and universities later used this provision to enable similar participation in HSTP.

The Participating Schoolteachers

One must remember that as a matter of policy, none of the schoolteachers who participated in HSTP were specially selected and, as it turned out, many had studied science only till the middle school. They were not specially qualified to participate in the programme. Considerable investment of time and effort had therefore to be made in convincing them of the philosophical groundings of the programme, getting them to discard the traditional pedagogy they used in the classroom, getting them familiar with the new way of teaching, the new material they would be using, the new experiments they would be getting their students to perform and the kinds of discussion they would have to engage in with their students in order for the students to arrive at the conclusions that they were expected to.

We became aware of the almost complete intellectual isolation of these schoolteachers, who had almost no access to sources of information or support mechanisms that could help them with problems with their teaching or the difficulties that they would encounter in their classrooms. They had no access to libraries, no experts they could consult to help them answer any of the questions or settle any of the doubts that arose in their minds as they went around their daily duties of teaching children. Trying to remove this isolation was one of the most important challenges the programme faced and we tried to respond to this by organising prolonged contact sessions for them with subject experts during the annual training programmes, during monthly meetings and school follow up visits. We tried to empower our schoolteachers by involving them as much as possible with all aspects of the programme – with curricular development, improvement of curricular material and the framing of question papers, by mentoring them as much as possible and by treating them with respect and listening to their views and opinions.

The role of schoolteachers in HSTP was not envisaged to be what one traditionally comes across in Indian schools – of being the source of all knowledge in the classroom; but neither was there any attempt to make their role redundant. It was in recognition of a teacher's central role in the pedagogy of HSTP that so much effort and resources were expended on the intensive teacher-training sessions that were a mandatory feature of the programme.

However, it was also true that our interactions with them sometimes had little effect on the commitment of individual teachers. Some of them clearly couldn't care less. They felt they were made to work hard, harder than their colleagues who were not part of the programme, without any reward. Yet teachers attended our meetings and training programmes in large numbers and often with a great deal of enthusiasm and interest. It goes without saying that despite our attempts we certainly failed to carry every teacher with us and the number of such teachers increased as the programme grew and it became more difficult to maintain the same level of intensity of the interaction of the resource group with them. There is no gainsaying the fact that in most instances the motivation and commitment of teachers to their profession is a personal one but it is not as if external factors do not matter. We knew of teachers who were casual in their work in their school, but when they happened to get transferred to a school where the parents were vigilant about the quality of the education their children were receiving, the behaviour of the same teachers changed for the better almost overnight. However, such cases were rare.

This brings us to the question of community involvement in the management of education. Its after-day critics sometimes blame the HSTP organisers for not attempting to engage with or involve the local community in the running of the programme, arguing that such engagement would have prevented the government from shutting down HSTP as easily as it did. There are some obvious benefits that could have derived from such engagement but like many things it can be a double-edged weapon. Whether such involvement would be beneficial or not clearly depends on the nature of the involvement – the devil as usual lies in the details. It would most certainly have an impact on teacher accountability and work ethic. But this must be weighed against its possible adverse impact on teacher professionalism. If you extend the involvement of the community to the level of teacher appointments and decisions in matters related to the curriculum, as would become inevitable once the local panchayat bodies began to taste power, the results could be disastrous. How would one ensure that the involvement would remain at the grass roots level of the community and not be hijacked by the community 'leaders' in yet another exercise of power and control? How would minority interests be protected and who would guarantee the presence of secular and plural views when it came to curricular matters? These are not unfounded fears as not so long ago the value of π, the ratio of the circumference to the diameter of a circle, was deemed by fiat to be 3 in some areas of the United States because the local community demanded that it be in conformity with this value which is ostensibly implied in some passage in the Bible.

Experiments in the Curriculum

One of the challenges of science is that although it seeks to search for universal laws, it must begin with the study of local phenomena. Its quest for the general must be rooted in the particular. Unlike mathematics, which can be based solely on logic and reasoning, science uses logic and reasoning and applies them to observations and experiments on the real world and not some artificial world defined by an autonomous set of axioms or postulates. Science must base itself on observations and experiments because it must, in the ultimate analysis, make statements about the real world. It is the closeness of the correspondence of such predictions with the world of phenomenon that provides the touchstone for the acceptability of any scientific theory.

Thus it is imperative that experimentation and observation should be at the heart of any pedagogy of science, particularly at the school level when students are first learning the subject. Although there was no self-conscious effort to actually teach the scientific method in HSTP, it is also true that we believed that we should not lose sight of this central truth that science is not the same as mathematics and that students have to be shown that science is firmly rooted in reality and not merely a construct of the human mind.

The situation in the 1970s, even in the best of our schools, used to be that there was hardly any experimentation in the science classrooms and this unfortunately has not changed much in the intervening forty years. And even the little that did or does exist is not actual experimentation by students but some scattered demonstrations by teachers. The situation even today is that experiments are either totally absent or, even when they are present, most of the experimentation is in the form of verifying already known laws – there is practically no investigative activity involved. Is it any wonder then that most of the students we graduate are good in theoretical studies but so lacking in basic scientific skills, including experimentation and analysis?

There is need therefore to look critically at why the Indian school system, whether government or private, does not encourage experimentation in the classroom. There is the oft-touted explanation that it has to do with inherent Brahminic Indian sensibilities – the disdain for working with one's hands. Such arguments are quite fashionable amongst intellectual circles but I wonder how much truth they carry. A more likely explanation is the disinclination to make investments in infrastructure by those who are in charge of implementation of programmes, which also translates into a disinclination to make the associated investment in teacher training. To me this stems not only from financial considerations and a false sense of economy but also from a lack of appreciation of the role of experimentation in science learning among those who design science curricula and manage education, resulting from their almost total lack of connect with the pedagogy of school science. Such behaviour is rooted in their understanding, or rather their lack of understanding, of the epistemology and philosophy of science and the central role that experimentation and investigation play in the learning and doing of science. They suffer under the delusion that science is a finished story, that at least at the level of school science, all the interesting questions that could have been asked have already been asked and answered, and that the role of school science education is merely to get students to, in essence, memorise the answers to other people's questions. They fail to perceive that science is not a closed story and that even children can and do raise questions that can be original and sometimes extremely difficult to answer.

Whittled down to its basics, the underlying principle of HSTP was simply to teach science for better understanding. In the Indian context where students had no exposure to observation, experimentation or investigation in science classes, it translated into teaching science through experiments to be performed by children themselves. The need to revise the middle school curriculum, prepare new workbooks and organise experiments that were low-cost and could be performed by students in rural schools, the need for teacher training and the necessity of collecting feedback from teachers and students, the need for regular school follow up, the need for a different system of assessment – all followed as consequences of this basic principle.

We realised that the curriculum could not be driven only by the discipline but had also to be responsive to the environment of the child and to the needs of good citizenship. It had to be sensitive to challenges the future would bring. And as, according to an old Danish proverb, it is difficult to make predictions, especially of the future, the best strategy is to teach children so that they can learn to learn for themselves, encourage them to develop enquiring minds and the ability to find answers to such questions through personal and collective investigations. This is the best education we can hope to give to our children.

Kit of Equipment

If you want to run an experiment-based science-teaching programme, you must ensure that the equipment for performing experiments is available in schools. Since the overwhelming majority of our schools continue to have no laboratories, this means that such equipment has to be provided by the organisers. Thus a suitable laboratory kit had to be devised and delivered to each participating school. The Hoshangabad programme was not the first to develop a kit of equipment to go with its curriculum. We were in fact aware of the fate of the UNESCO kits that had been supplied to schools in the mid-1960s. These remained unutilised and we could still see them in some of the older, better known schools in Hoshangabad during our school visits. Ships are safe in harbour but that is not where they are meant to be. The main reason for the non-utilisation of the kits was the fact that teachers were held responsible for all breakages and loss – so the kits remained locked in almirahs and boxes gathering dust – safe but unused.

Since the kit was critical to the programme we made sure that conditions in school were conducive to its utilisation. We made sure that teachers were fully conversant with its use. During the training programmes it was imperative that teachers were trained to perform every experiment that children were required to do in class. Regular replenishment of the material, allowing for breakage, usage and loss was ensured. We also encouraged children to be involved in the storage, management, maintenance and cleaning of the equipment. The assumption was that students would ensure that the equipment was used if they enjoyed doing the experiments and activities, and this assumption turned out to be true.

The presence of the kit not only ensured that experiments could be done in the classrooms but also served to encourage teachers and resource persons to think creatively and take the initiative in trying to replace expensive pieces of equipment with cheaper locally available alternatives.

Critique of HSTP – the Process versus Product debate

One of the most persistent points of criticisms of HSTP has been its insistence that experimentation by children should be at the heart of its pedagogy, sometimes even being elevated to the level of a principle – that no concept that could not be developed through direct experimentation by students should form part of the middle school curriculum. The critics on the other hand argue that there are other time-tested ways of teaching science in which providing information plays an important role and that teaching only through experiments cannot be accepted as a universal pedagogical principle as there are innumerable concepts in science for which students in school cannot perform the relevant experiments. They also argue, evidence from Western countries in the recent past would suggest that activity-based teaching is not as efficacious as it was earlier made out to be. Taken together this would appear to be a serious charge and merits a considered response not only because such arguments have been used to back claims that HSTP was an inferior programme thrust on rural schools but also because alternative approaches to experiment-based science teaching started finding support and resonance even within Eklavya during the years just before the closure of the programme.

The first thing to assert is that science pedagogy based on experimentation alone was never propagated as a universal principle applicable across all classes and in all situations. It was a specific strategy adopted for teaching science in middle schools in the Indian context, a context in which there was no experimentation or investigative activity carried out by children in science classes, a context in which the overwhelming majority of schools did not have any equipment for experimental work let alone anything remotely resembling a laboratory, a context in which there was no difference between the ways in which science and history for example, were taught, a context in which 50 percent of all students enrolled in class 1 would drop out by the end of the middle school and of the remaining only a minority would choose to study science. In such a context we considered it of the highest importance that instead of stuffing the curriculum with information to be transmitted to students through conventional chalk and talk pedagogy, we should convey to our children ways in which they could themselves uncover the wonders of the world of science. It wasn't as if there were not enough wonders that they could uncover even in the materially deprived circumstances of their existence, provided we could open them up to the wonderfully rich natural environment in which their lives were embedded. This is what we set out to do and this is what we believe we succeeded in doing without doubt and in large measure. We considered it important that students be made aware of the nature of science and how it works instead of learning odd facts about science, which would in any case become obsolete by the time they reached adulthood.

Lack of experimentation in the classroom was and is almost uniquely an Indian phenomenon – a fact that is not appreciated by those who use studies abroad to support their criticism of HSTP. Also, in assessing the worth and relevance of studies carried out abroad, the difference in conditions prevailing there as compared with India is not appreciated. Most western countries had a rich tradition of experimentation and investigation by children in the classroom. This was true of science pedagogy in the West even before it became popular to talk of activity-based teaching – a situation way, way different from the one prevailing in Indian schools and in the Indian tradition.

Another point of criticism was that the programme was critically dependent on the schoolteachers and that if teachers were absent from school or did not teach, learning in HSTP classes came to a grinding halt, whereas, so the argument went, in conventional classrooms which are textbook driven and without the HSTP emphasis on experimentation, children could read the textbooks and learn on their own. The question is, what do they learn? Facts? But what good is that except to pass exams? As far as science is concerned, no learning takes place unless it is based on experience.

Attempts were made to assess HSTP by comparing the performance of its graduates with students of the conventional programme in the class 10 examinations and in most cases the difference was found to be not statistically significant. I would like to understand why should teaching for understanding also improve children's performance in conventional examinations. Why is this even expected? The conventional examination, as everyone knows, tests mainly for memory recall and why should training for better understanding in earlier classes at all affect a student's ability to memorise answers to a set of anticipated questions that forms the bedrock of success in conventional fixed-time examinations?

Expand or die

After HSTP was extended to cover the whole of Hoshangabad district, there came a phase when the phrase 'either we expand further or we die' began to be bandied about. Three possibilities for expansion were then considered: the geographical expansion of the programme over the whole state, or expansion into other subjects and developing an integrated curriculum for the whole of the middle school, or developing an integrated science curriculum for middle, secondary and higher secondary schools. After a series of meetings and discussions, Eklavya decided in 1984 that the geographical expansion of the Science Teaching Programme was what it would work for, choosing the intellectually least challenging option. It decided to take the middle school curriculum, that had been tried and tested in Hoshangabad district, and implement it unchanged in other districts with the ultimate vision of spreading the programme across the whole of Madhya Pradesh. Even if the intention was to extend the programme geographically, a different model could have been chosen. The Delhi group had in fact suggested that geographical expansion should not be accomplished by merely replicating the Hoshangabad programme in other districts of the state but by spreading the philosophy of HSTP by seeding local initiatives, which would take on the philosophy and approach of the programme without necessarily replicating the same curriculum. However this did not find favour with the Eklavya group. Mechanical replication won over a more imaginative expansion. The NCERT model proved too seductive and destroyed the possibility of developing a network of networks in which Eklavya would act as one of many nodes sharing a common vision rather than a common programme. Maybe it was a matter only of the victory of what was possible over what was desirable. Maybe it was based on a realistic estimate of the effort that would be required to set up such a network in the light of the difficulties experienced even in enlarging the HSTP academic group to a size required to handle effectively the tasks that kept arising even in its day-to-day functioning.

Kishore Bharati and Friends Rural Centre were rightly lauded for starting HSTP, but I believe they were glad to pull out when they realised the enormity of the task and the time it would take to make any significant and lasting impact on the system. Their spirits were not up to it, and in a sense the birth of Eklavya was precipitated by their reluctance to continue with what they had started. Maybe the decision in favour of geographical expansion was equally pragmatic, based on the realisation of the enormity of the task of seeding Eklavya-like institutions in every district. Where would the funds and more importantly, the people come from?

This decision was, however, a watershed in that it marked the beginning of the distancing of what remained of the Delhi group from the future organisation and running of HSTP. Decentralisation appeared to have become an empty dream. No one seemed to be prepared to work for it when the dominant paradigm seemed to be to wield more and more control over a larger and larger geographical area. The seductiveness of the NCERT model, the dream of changing the system centrally – one large battle rather than many small skirmishes won out; but change, lasting change, appears not to come about this way.

The Government

When the Madhya Pradesh government decided to pull the shutters down on HSTP, there were sustained and widespread protests in academic circles across the country, but it all proved to be of no avail. The government remained unmoved and made it known in no uncertain terms that they were the landlords and organisations like Eklavya were nothing more than mere tenants to be tolerated so long only till the powers that be decided otherwise. Maybe they thought that Eklavya was not deferential enough, claiming too much credit for what was happening, after all, in government schools by government sufferance. Maybe

Eklavya forgot that government policies can change not only when a new political party comes to power or when a minister changes but also when one bureaucrat gets replaced by another. Maybe the decision to shut down HSTP was as much to do with the change in the vision of the government bureaucracy in respect of its managerial role in the public education system as any of the educational reasons it trotted out to justify the closure.

Future

I think the end of HSTP also marked the end of an era in educational experimentation and change in India. Never again, I believe, will any programme of intervention in the education system be allowed the freedom to experiment with curriculum structure, textbook development, teacher training and examination reform that HSTP enjoyed. The times, they have changed, and a new reality confronts educational reform in India. Given the government's and NCERT's reluctance to cede control over curricula, it is unlikely that another programme like HSTP will ever again be sponsored by the Education Department of any State and the future for non-government intervention in the education sector looks bleak. The way forward would appear to be to accept the state curriculum as given and try to make science teaching more experiment driven within the given framework. This is what UNESCO and its programme "Scientific and Technological Literacy for All" did in the mid-1990s.

The greater cause for pessimism is however the experience with erstwhile resource persons from HSTP working with NCERT in its last round of writing science textbooks for classes 6 to 12. Instead of trying a decentralised mode of working with centres spread throughout the country, they all agreed to be flown into

Delhi and work out of there on a single set of textbooks that would be either used directly or act as models throughout the land. They did not protest when only a sprinkling of schoolteachers was involved in the writing, not even when experimentation in the science classes was made incidental to the whole exercise. They pressed for no trialling of the textbooks, no collection of feedback and, worst of all, no training of teachers in the new materials. This compromise on all issues that were dear to the Hoshangabad programme augurs ill for any meaningful reform in school science pedagogy in future.

Was this failure to use the lessons from HSTP in engagement with other programmes of curricular reform by resource persons with a long history of association with HSTP merely a compromise with the reality of the prevailing paradigm? This failure would appear to me to be a much more deadly blow to all that HSTP stood for than its actual closure in 2002.

Acknowledgement

Finally, I must take this opportunity to thank and acknowledge the many colleagues who together constituted the Delhi group of the Hoshangabad programme, for the many weeks stretching into years of the most enjoyable and fruitful engagement that it has been my pleasure to participate in. The honour of being at the top of the list must of course and without doubt go to Pramod Srivastava, fondly known among the cognoscenti as the “Educator General of India”, without whose vision and persistence the group would probably never have come into existence. I would like to thank Man Mohan Kapoor, Natrajan Panchapakesan, Raj Rup, Vishnu Bhatia, Jai Dev Anand, KV Sane, VM Khanna, Dr Uppal, the Jaiswals,

Kamal Mahendroo, Sadhna Saxena, Vinod Raina, Hriday Kant Dewan, and Anita Rampal who rallied to the call over the years. This is not to ignore or belittle the contribution of many, many others but only to recall the names of those I interacted with most closely and put on record my gratitude for the memorable times we had together.

Vijaya S. Varma

Delhi

1

A SINGULAR INITIATIVE

July 3, 2002 was a dark day in the history of education. It was on this day that the Madhya Pradesh government decided to draw the curtains on an innovative educational programme known the world over as the Hoshangabad Science Teaching Programme (HSTP). The state government's ill-conceived move did not come as a surprise to those conversant with the processes of privatisation and globalisation. Several authors have analysed the issues emanating from this malafide decision of the state government.

The HSTP initiative began as a small experiment in 1972. The legend has it that when the two voluntary organisations – Friends Rural Centre (FRC) and Kishore Bharati (KB) – approached the Madhya Pradesh government seeking permission to implement an innovative programme in state-run middle schools, the then Director of Public Instruction, Dr. B. D. Sharma, setting aside any possible objection, had famously observed, "The present state of science education in these schools is so deplorable that these novices cannot possibly make it any worse. So I see no reason to deny them permission." This tongue-in-cheek – but insightful – observation of a competent bureaucrat paved the way for a remarkable transformation in school science education.

The platform provided by these two voluntary organisations quickly drew scientists from the Tata Institute of Fundamental Research (TIFR) in Mumbai, members of the All India Science Teachers' Association (AISTA), and academic staff from Delhi University (DU). They joined hands with the teachers of 16 middle schools in the Hoshangabad district of Madhya Pradesh to embark on a journey to make education, especially science education, a meaningful and joyful experience for school children. The initiative drew countless participants as it evolved, attracting scholars, teachers and scientists from colleges, universities and research institutions across the country.

This was, perhaps, the HSTP's most significant feature. It unleashed creative energy in the field of education across the country and provided a platform for its expression. It was a collective effort to improve science education in schools in which professors and students from colleges and universities, scientists and research scholars from research establishments, school teachers, artisans and craftsmen, farmers, social activists and engineers, and doctors and educationists participated.

Another significant feature of the programme was that every participant was engaged in a simultaneous process of teaching and learning. As a result, there was never a dull moment in its 30-year history. All the participants, including the students, enjoyed it. The environment it created was of shared joy that bound the participants together. This atmosphere of joy inspired people to give their best and the courage to try new and fresh ideas in education. This is why the HSTP was always able to retain a measure of freshness and depth throughout its 30-year history.

One other aspect also needs to be considered. The HSTP may have been fun, but it did not lack in educational rigour. The

HSTP never allowed '*chalta hai*' attitude. The task on hand could be writing a chapter, trying out an experiment, ensuring the authenticity of a diagram, teacher training, or even proofreading *Bal Vaigyanik,* compromises on quality were never part of the equation.

Discovery and the environment

The HSTP was a discovery- and environment-based innovation in which children interacted with their environment, conducted experiments, and formulated verifiable hypotheses. It was, perhaps, for the first time in the country that children in middle schools learnt scientific concepts by conducting experiments in groups, going on field trips, recording their observations and analysing data to derive conclusions and have fun in the process. Their teacher was their guide and companion in the process. And the children enjoyed doing all this, throwing the traditional method of rote learning out of the window.

The HSTP group emphasised the fun aspect of learning, which was later incorporated into the lexicon of mainstream education as 'joy of learning'. When an HSTP resource person N. Panchapakesan was asked to list the lessons from HSTP following its closure, he answered with little hesitation, "We enjoyed ourselves. The teachers enjoyed themselves. The children enjoyed themselves. What more do you want?"

But 'fun and enjoyment', apparently, wasn't considered a component of learning by the bureaucracy. Submitting a report recommending that the HSTP be shut down, a senior bureaucrat of the Madhya Pradesh government dismissed the innovation as being without merit, scarcely disguising his sarcasm as he wrote, "The only argument in its favour is the 'enjoyment of children' which is an intangible and an inadequate index of quality of learning."

Stated briefly, the HSTP sought to structure the curriculum around doing science and conceptual development, rather than base it on the idea of information explosion. Children arrived at scientific laws, definitions and concepts by conducting experiments, tabulating and analysing their observations and data, and engaging in group discussions in the classroom.

The essence of the programme was to make children independent learners. To equip them for the task, it sought to familiarise them with methods and practices that would help them seek answers to new questions and problems they may confront in future.

The HSTP experiment entered its second phase in 1975, when it was scaled up to cover all the middle schools in Hoshangabad district following intensive field testing in its pilot phase in 16 middle schools.

When the state government took the ill-conceived decision to close down the programme, HSTP was operative in over 800 schools spread over 15 districts of the state. The students who had studied science using its methodology over the 30 years of its existence numbered over 250,000. More than 3,000 teachers were involved in its implementation, having undergone a series of unprecedented training programmes whose depth and rigour could only be appreciated through actual experience. Developing a core group of around 200 resource teachers who could train teachers and organise large-scale training was another of its contributions. Many of these teachers have played a leading role in conducting teacher training camps in other states.

The HSTP also covered new grounds in terms of teacher participation in every aspect of the programme. The programme has contributed significantly in understanding the potential and challenges of teacher participation.

Right from the first phase of implementation it had become clear that the teachers were at the lowest rung in the educational hierarchy. Within the classroom, they were the unquestioned fount of all knowledge, but the moment they confronted even the most insignificant authority in the educational bureaucracy, they became servile and submissive. Therefore, it seemed meaningless to talk of improving education without, at the same time, according a respectful place to teachers. Although, within the larger social fabric they appear to stand alongside the feudal class, within the school system teachers were lacking in self-esteem vis-a-vis the bureaucracy. Yet, they are forced to wear the mantle of omniscient in the classroom.

These concerns shaped the HSTP's engagement with teachers. Especially, the lack of academic dialogue amongst teachers, or a dialogue around issues important to their profession, prompted the HSTP group to try and create such formal fora where teachers could look at themselves as members of an academic professional group.

The programme not only uncovered the possibilities of educational change, it also indicated a direction of this change and multiple dimensions of its implementation. Probably, this was the most influential programme in contemporary scenario. Its impact can be seen in all aspects of educational thought and systems.

The HSTP viewed intervention as a multi-pronged process requiring simultaneous action on many fronts. Tinkering here and there was not enough; that was clear from the outset. All academic aspects of the teaching-learning process were addressed, beginning with the teachers actively participating in developing teaching-learning materials. A kit for conducting experiments was put together to go with the new workbooks being prepared.

Teacher training has already been mentioned. A decentralised system of follow-up to schools was also put in place to help the teachers in the classroom and to collect feedback. In addition, a fictitious character named 'Sawaliram' was set up to address rising curiosity of children.

The examination system went through fundamental changes to free it of the tension it usually generated in children's minds. New ways of assessing what the children had learnt were introduced. The emphasis shifted from testing for rote learning and memory recall to assessing the development of conceptual understanding and experimental skills.

The HSTP can also be seen as the first instance of an intervention for educational change in the government school system by an agency outside the state education department. Indeed, the fresh breeze needed for shaking the system out of its inertia could have been provided only by such 'outsiders' free of the 'educational straitjacket'.

Not being tied to the hierarchy of the education department was a definite advantage. This allowed HSTP to establish an equation of equality at all levels among those interested in education and change. In the thirty year history of HSTP, a virtual absence of formally trained educators/educationists is also a remarkable fact.

The HSTP created and consolidated a framework of decentralised structures for its implementation, breathing new life into concepts such as the School Complex and *Sangam Kendra* enunciated in the 1964-66 Education Commission Report (Kothari Commission). It also helped to weaken the stranglehold of administration over the teachers while adding an academic dimension to the administrative apparatus.

The HSTP was a singular experiment in India's educational scenario and a source of inspiration for other initiatives across the country, adding new dimensions to the discourse on education. The purpose of this volume is to present its academic and administrative aspects in an organised and structured manner.

We mainly discuss three components of the programme in the book:

- Development of the material and its structure
- Teacher involvement: groundwork and inputs (and support)
- Examinations and student evaluation

Material includes curriculum, syllabus, workbooks, kit for experiments, etc. The book seeks to trace the process of evolution of curriculum and syllabus and their periodic revision. While clarifying the rationale behind the changes and the factors influencing them, we shall also try to explain how the curriculum was translated into teaching-learning materials.

We have outlined different aspects of a typical chapter to introduce the reader to the *Bal Vaigyanik* workbooks. These aspects are discussed in detail, after which a synopsis of all the chapters from the three *Bal Vaigyanik* editions published to date is presented. To understand the evolution of chapters with the group's growing understanding of issues, biographical sketches of three chapters have been presented in some detail.

Bal Vaigyanik chapters unfold several dimensions of the teaching-learning process. Attempts were made to prepare teacher's guides to make this process accessible to teachers. A chapter described this attempt to prepare these guides and share the experiences of their uilisation.

Development of an experimental kit has been an important part of curricular development. This has been discussed breifly. One of the concerns often expressed about experiment-based learning is that the requirement of a laboratory and equipment makes it an expensive proposition. We examine the validity of this concern and discuss our attempts to make the kit more accessible and inexpensive, a process which saw contributions from scores of teachers and others.

As has been pointed out, one of the hallmarks of HSTP was its intensive engagement with teachers. One chapter narrates our experiences in this area, tracing how teacher involvement and participation grew to become the innovation's most important component.

We next discuss the issue of use of the material in actual school setting. The main source of data for this chapter is the periodic follow-up reports filed by members of the HSTP resource group and the operational group, based on their school visits. Information gathered from interviews and focused group discussions with teachers and reports submitted by some of the teachers have also been incorporated.

The final chapter in the book is devoted to the examination system – one of the most sensitive and dominant elements of our education system. Apart from giving a detailed account of the changes in evaluation and assessment introduced by the HSTP, we present an analysis of our actual field experiences of conducting examinations.

2

IMPORTANT MILESTONES

1972: The government approves proposal for innovation in science education in 16 middle schools submitted by Kishore Bharati (KB), Bankhedi, and Friends Rural Centre (FRC), Rasulia. The programme begins with support from the All India Science Teachers Association (AISTA). First teacher training camp held in May. First edition of *Bal Vaigyanik* published in September.

1973: The Science Education Group of Delhi University (DU) joins the programme. The University Grants Commission (UGC) extends official approval for their participation.

1975: The Science Teachers Group from colleges of Madhya Pradesh joins the programme. After three years of effort, chapters of the *Bal Vaigyanik* workbooks for classes 6, 7 and 8 are published as card sheets. UGC announces fellowships for volunteers participating in the programme.

The government grants permission for making changes in the examination system. The first batch of children sits for the class 8 Board examination, conducted by KB and FRC.

1977: Joint decision by the Education Department, Government of Madhya Pradesh, and the National Council for Educational Research and Training (NCERT) to expand HSTP to all the middle schools in Hoshangabad district. The Regional College of Education (RCE), Bhopal, coordinates preparation of detailed proposal for district-level expansion. The *Bal Vaigyanik* curriculum and workbooks approved by the State Textbook Review Committee.

1978: District-level expansion takes place. The Madhya Pradesh Textbook Corporation (MPTBC) begins publication of *Bal Vaigyanik*. A Steering Committee, with Director, Public Instruction (DPI) as chairman, set up and a Science Cell established in the Divisional Superintendent of Education (DSE) Office, Narmada Division, to administer the programme.

1982: Formation of Eklavya. State Council for Educational Research and Training (SCERT) established. Deputation of government teachers to the HSTP begins.

1984: Seeding of programme under the auspices of SCERT in three districts through School Complex route as model for state-level expansion: Ujjain (Narwar Complex), Dewas (Hat Pipalya Complex) and Dhar (Tirla and Dhar Complex).

1985: Seeding in three more districts: Shajapur (Agar Complex), Mandsaur (Pipliya Mandi Complex) and Ratlam (Namli Complex).

1986: Seeding in six more districts: Narsinghpur (Gotegaon Complex), Chhindwara (Parasia Complex), Khandwa (Harsud Complex), Indore (Sanwer Complex), Jhabua (Meghnagar Complex) and Khargone (Mandleshwar Complex).

1987-89: First revision of *Bal Vaigyanik*, based on feedback from schools.

1990: Eklavya submits proposal for state-level expansion of the HSTP to the Madhya Pradesh government and the Ministry of Human Resources Development (MHRD), Government of India. The NCERT sets up six-member expert committee under the chairmanship of Prof. B. Ganguly to review the programme.

1991: The Ganguly Committee submits its report. Appreciating the programme, it recommends its phased expansion across the state.

Planning for state-level expansion begins but a change in government at the state level derails the process. The new government calls for fresh review of HSTP and sets up expert committee under the chairmanship of Dr. G. N. Mishra, Director, State Institute for Science Education.

1992: The Mishra Committee presents a favourable report but for undisclosed reasons the report is never released nor made public.

1993: Five institutions in Gujarat join hands, get government approval, and launch a Learner Centred (*Adhyeta Kendri*) Science Teaching Programme, based on the HSTP methodology, in three districts of the state.

1994: State-level expansion of the HSTP again on the agenda. The government sets up a new committee under the chairmanship of Director, SCERT, to formulate expansion plan. Committee postpones work on the plan, citing SCERT's preoccupation with the District Primary Education Programme (DPEP).

Work on the second revision of *Bal Vaigyanik* begins but is kept on hold.

1995: Resource teacher training workshops begin.

Kit replacement streamlined by levying a science cess on all middle schools in the state to meet the expenditure.

1996: Decentralised teacher training model adopted to address problems of private schools and facilitate participation of resource teachers.

1998: English edition of *Bal Vaigyanik* published.

Lok Jumbish Parishad seeds the programme in Rajasthan and publishes workbooks titled *Khojbeen*.

1999: *Bal Vaigyanik* revision, on hold since 1994, taken up again. Teachers participate on a mass scale to field-test material with the children.

2000: Revised edition of the class 6 *Bal Vaigyanik* published after approval by the Madhya Pradesh Textbook Standing Committee.

Discussions on state-level expansion renewed.

2001: Revised edition of the class 7 *Bal Vaigyanik* published.

Rewriting/revision of the class 8 *Bal Vaigyanik* begins.

2002: The government decides to shut down the programme. Revised edition of the class 8 *Bal Vaigyanik* remains unpublished.

3

ACADEMIC ANTECEDENTS[1]

The launch of the Sputnik by the Soviet Union in 1950s ushered in a new era in space exploration. It also started a global debate on science education. This remarkable feat was a big blow for the United States of America during the Cold War regime. It was thought that there is something seriously wrong with science education in the US which is not producing good scientists. The introspection inspired several science education projects in its schools but once the US launched its own spacecraft, interest in science education quickly waned, as did government funding for such efforts.

There, the main cause for concern during this phase was that children in schools were increasingly turning away from the sciences. To address this concern, the projects that were taken up largely focused on incorporating intense training and exposure to the methodology of science and to give children

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[1] This chapter was written on the basis of material taken mainly from two sources: the minutes of a workshop conducted by Kishore Bharati in October 1983, and a paper presented by Prof. Yash Pal at "A Meeting of Leaders of Science and Mathematics Improvement Projects" held in October 1972.

the chance to 'work like scientists' in the classroom. However, in their endeavour to expose the child to underlying unifying principles of science, they failed to give adequate space to the child's environment and experiences. Moreover, they did not pay enough attention to what level of abstraction could be introduced at what age.

There was another lacuna from the educational point of view. No serious attempt was made to develop the kind of knowledge and skills in children that would help them live fruitful lives as rational, thinking individuals. The answer to this problem lay in making science education more useful in everyday life of people.[2]

Interestingly, no one thought it important to analyse science education in schools in the Soviet Union during the 1960s to find out what its special characteristics were, if any, and whether these characteristics had any causal relationship with the country's accomplishments in space.

India, too, recognised the urgent need to do something to improve the quality of science education in its schools in the mid-1960s. Several informal as well as organised efforts were taken up during this period but government-sponsored innovations began only after the National Council for Educational Research and Training (NCERT) was set up. The new institution developed some science books – known as NCERT-UNESCO materials – which it distributed to the states. These books were translated into regional languages and given to government schools, along with a laboratory kit for conducting the experiments they contained, but it does not seem

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[2] Naomi Frelindich, "From Sputnik to TIMSS: Reforms in Science Education Make Headway Despite Setbacks." *The Harvard Education Letter,* Volume 14, September-October 1998.

that much use was made of them in the schools. These materials were superior to the traditional materials in one respect only – these were books which were inexpensive, yet error-free. The curriculum was traditional and the books were packed with information.

In 1967-68, the NCERT took up the task of preparing new textbooks. It provided financial assistance for setting up 21 study groups in different science streams to undertake this task. A series of textbooks of varying quality was prepared for middle schools, some of them decidedly better than the existing ones.

One such NCERT-supported group was the Physics Study Group of the All India Science Teachers Association (AISTA). Largely comprising school science teachers, but with a fair sprinkling of college professors and practising scientists in an advisory role, it had prepared a book titled *Physics Through Experiments*.

Two teachers from the prestigious Doon School in Dehra Dun, B. G. Pitre and C. K. Dixit, had played a leading role in preparing the book. They were influenced by the Nuffield Foundation Science Teaching Project that was underway in England at the time, although their book was largely based on their own classroom experiences of teaching physics.

Pitre and Dixit were not happy with the way physics was taught in schools and were keen to change it. Fortunately, they had the advantage of being able to field-test the materials they were developing in their school itself. Moreover, they benefitted from creative critique by other members of the Association.

Physics Through Experiments was fundamentally different from existing science textbooks that brimmed with information. Its curriculum was based on the principle that it is impossible to give children all of 'modern knowledge' because this knowledge is expanding at so rapid a pace that it is impossible for any child to assimilate all of it. Children have limits imposed by their physical and mental age. So it is best to teach them methods of acquiring knowledge and train them to use the tool to do so.

The main difference between AISTA books and the traditional books was not the presence or absence of experiments; the real difference was in their objectives.

The Physics Study Group opted for the 'discovery approach' to science teaching, drawing inspiration and moral strength from similar innovations taking place across the world, the Nuffield programme in particular, as mentioned earlier. However, their experiment attracted flak from many educational experts in the country. Although these experts were not against the 'discovery approach' in principle, they felt that a poor country like India, with schools bereft of resources and staffed by ill-trained teachers, could not afford to introduce such an innovation.

In this context, it is interesting to note the comments made by the NCERT field advisor several years later in 1972, when Kishore Bharati and Friends Rural Centre submitted a proposal to the Madhya Pradesh government for improving science teaching in schools: "The NCERT is of the opinion that teaching this kind of science in schools is not possible in a poor country like India. Such science is suitable for wealthy countries like the USA and other western nations."

The Physics Study Group thus had to rely on testing its methodology and demonstrate it in the schools to justify its rationale.

The first field tests were conducted informally in a few select public schools, since the group members were mostly teachers from such resource-rich schools. The feedback from these initial trials was highly positive and everybody agreed that it works in these schools, but the lingering doubt that was often voiced was whether similar success could be achieved in resource-poor schools in the large cities and villages of the country.

From public schools to municipal schools

The NCERT turned a blind eye to *Physics Through Experiments*, not paying much attention to it. So Pitre and Dixit began a dialogue with scientists from the Tata Institute of Fundamental Research (TIFR) in Bombay (now Mumbai), introducing them to the book. Fortunately, scientists there were also grappling with similar concerns and struggling to find ways to link science to society and had already started a few initiatives.

Two scientists in the group, Yash Pal and V. G. Kulkarni, were joyed by *Physics Through Experiments* and expressed the desire to take up a similar experiment in science teaching in the municipal schools of Bombay, using the book as a starting point. The Bombay Municipal Corporation (BMC) gave them permission to field test the methodology and materials in 10 of its schools.

Middle schools in Maharashtra cover classes 5 to 7, with children in class 7 appearing for a Board examination. So the proposal submitted to the BMC had a three-year time frame from 1970 to 1972, beginning with class 5 and gradually going up to class 7.

Thus, an engagement between the TIFR and the BMC created the first opportunity for field testing the material in ordinary schools. A resource group comprising the TIFR scientists and the director of the Physics Study Group was set up to implement the programme.

The science textbook written for elite public schools like the Doon School was translated into Marathi - and reached Bombay's municipal schools. For the first time, it went into the hands of teachers other than its creators. This meant that the teachers had to be trained in its methodology and necessary arrangements for training had to be made. It was a new experience for Pitre and his associates, who had never before trained teachers.

Another problem was that the book contained chapters relating only to physics. So the TIFR scientists wrote and added some biology and chemistry chapters. They titled their new textbook *Prayogic Padaarth Vigyan* (meaning Experimental Material Science) and used it as a sourcebook for training the municipal school teachers, with people like V. G. Kulkarni and Yash Pal acting as resource persons.

The first teacher orientation camp was held in early 1970. It became clear from the experience of this camp as to what kind of changes would have to be made in the textbook and the kit material. Most of the teachers did not have any formal training in science teaching and had studied only up to high school.

The textbooks went through several revisions based on the feedback collected through regular follow-up by the members of the resource group and teacher's monthly meetings.

Examinations at the end of each academic session were also conducted by the resource group, introducing many innovations in the assessment methods. It was felt necessary to discuss the assessment method with the teachers because they appeared to have a tendency to undervalue the students' answers.

The children, however, enjoyed the new curriculum and their performance improved considerably, with very few failures being registered. The already good attendance improved further. They were constantly offering valuable suggestions to improve the programme. For example, they wanted their science period to be the last one in the daily timetable so that they could stay on in class after school hours to continue the experiments.

The transition from public schools to municipal schools, thus, saw the introduction of many significant changes. For one, chapters in chemistry and biology were developed. Second, new and improved teacher training methods were evolved. Third, a dialogue on examinations was initiated and assessment methods came under increasing scrutiny and analysis. In addition, the workbooks went through several revisions on the basis of the feedback collected.

But the programme could not continue beyond three years. The most important reason for its closure – if not the only one – was the refusal of the BMC to permit any modifications in the Board examination at the end of class 7. The BMC had not objected to modifications in the internal examinations conducted for classes 5 and 6 but when it came to Board examination for class 7, no such flexibility was allowed and children had to sit for the common examination conducted by the state education department.

The teachers and the resource group were aware that the traditional examination, which tests only for memorised information and definitions/formulas, was ill-suited to assess student performance in the new methodology. So they were apprehensive that the students would fare extremely poorly if they were made to sit for this examination.

As it turned out, the students did not fare too badly, as was pointed out by V. G. Kulkarni in a paper he presented at a science education conference held in Madurai in January 1973. "The performance of these students is much better not only in an objective examination but also in a conventional examination as compared with that of a control group. At least so far as physics and chemistry are concerned, they have not lost anything by way of facts,"[3] he wrote.

Anil Sadgopal analysed the reasons for the BMC's refusal to permit any modification in the Board examination in his book *Shiksha Mein Badlaav Ka Savaal*[4] (The Question of Change in Education). He concluded that the series of events leading up to the refusal clearly showed that examinations are a powerful weapon to maintain the status quo in education. Not surprisingly, the issue of changing the Board examination became a major challenge for the Hoshangabad experiment.

Although it was short-lived, the municipal corporation schools experiment had very positive outcomes. Many teachers were so enthused by the programme that they expressed the hope that the authorities would permit them to continue teaching science by this methodology even after the programme had run its course in their schools. Whether they received official permission or not is not known.

The journey from Bombay to Hoshangabad

Now, the question is: How did the BMC programme travel from Bombay to Hoshangabad? The answer makes for an interesting story. At the time the programme was running in Bombay's municipal schools, Anil Sadgopal was a scientist at TIFR. Now

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[3] V. G. Kulkarni, "Need for Innovation in Science Education," Inaugural Address at the COSIP conference, Madurai, January 1973.

[4] Anil Sadgopal, *Shiksha Mein Badlaav Ka Savaal,* Granth Shilpi, New Delhi, 2000, p. 58.

read the story in his own words:

> I was a scientist at the TIFR from 1969 to 1971 and I was looking at the programme merely as an interested observer. I took no active part in it except to sit totally entranced all day long by Pitre's training methods on the first day of the training camp. ...However, I was then in the process of completing my scientific work and preparing to leave the institute. [Anil Sadgopal was busy setting up Kishore Bharati at the time. The organisation was subsequently established in Palia Piparia village of Bankhedi block in Hoshangabad district of Madhya Pradesh.]
>
> ...I came to Hoshangabad around that time. We [Kishore Bharati] did not have the slightest intention of teaching science in schools. We had in mind an education to address the issues of livelihood of poor children and their struggle against oppression in rural society.
>
> My decision to come to Hoshangabad was influenced by Sudarshan Kapur, the then Co-ordinator of Friends Rural Centre, an organisation located in Rasulia, a village near Hoshangabad town. The centre had an abiding interest in education and had even set up a school in Rasulia, which, for various reasons, had been shut down. Sudarshan asked me what Friends Rural Centre should do in future. I narrated the AISTA story to him and suggested he get in touch with Kulkarni, Pitre and the rest of the group. That was enough to ignite a spark in him. He felt his answer lay in bringing the Bombay municipal school experiment to this area and he pursued this objective with single-minded devotion. This was how the programme took roots here.

Sudarshan Kapur adds pertinent details to this narrative:

> The Hoshangabad Science Teaching Programme (HSTP) has its origins in the meeting of many minds and two projects

> – the Friends Rural Center, Rasulia (the Centre)...and Kishore Bharati. In the early 1970s, while in search of a site to start Kishore Bharati, Dr. Anil Sadgopal visited the Center. It was a time when the Center was engaged in the evaluation of all of its programmes, especially school education.
>
> (The Center had a long history of involvement in education, including Gandhiji's concept of Basic Education.) Yet for a number of years, the Center's only contribution to general education was the management of an on-site middle school...Just running a school located within the four walls of the Center, a poor one at that, made no sense at all... After agonising deliberations, by the beginning of the 1970s, the Governing Body of the Center was ready to close down its school. The Board authorised [the] Center staff to identify a programme that might have a wide-ranging impact on school education throughout the district and even the state of Madhya Pradesh.
>
> Meanwhile, Dr. Sadgopal and his colleagues identified a site and secured land near Bankhedi from the Government of Madhya Pradesh to launch Kishore Bharati. Kishore Bharati and the Center agreed to cooperate across the board. Hoshangabad Science Teaching Programme was one of the most important outcomes of this collaboration. It offered us, so we argued, an opportunity to make a contribution to the improvement of science curriculum, ways of learning, and methods of teaching in government schools,... At the same time, it offered possibilities for transforming school education in Madhya Pradesh. It was against this background that the decision to launch the science-teaching programme (and other initiatives) was mooted.[5]

This was in January-February 1972.

[5] Sudarshan Kapur, personal correspondence.

In February 1972, Kishore Bharati and Friends Rural Centre submitted a proposal to the Madhya Pradesh government seeking permission to conduct an experiment in science education in middle schools of Hoshangabad district. The proposal stated:

> In the last few decades revolutionary changes have taken place in the concepts of education. But these ideas have had little impact on educational programmes of our schools and colleges.
>
> The aim of education should be to acquaint the student with basic theories and common concepts rather than stuff his/her mind with information.
>
> The leading scientists and educationists of the country agree that the child can understand theories only through experiments and open discussion. Whatever is taught in most textbooks being used for science teaching in schools and colleges has become dated or perhaps has been wrong in certain cases. Any innovative science teaching programme should aim at presenting science as an exciting subject whose boundaries are constantly expanding.
>
> The role of the teacher should be that of an observer and a guide, rather than that of a supervisor, who helps the child conduct experiments and think analytically instead of just demonstrating the experiments.
>
> Rigid curriculum and textbooks leave no scope for innovation at the school level. All the concerned parties in an evolving science teaching programme – students, teachers, educationists and scientists – will contribute to its growth and transformation through constant feedback and classroom experience.
>
> The physics teaching programme prepared by the physics

> group of the All India Science Teachers Association fulfils the above-mentioned objectives.
>
> It is proposed that the programme of the physics group of the All India Science Teachers Association be implemented in the primary and middle schools of the Hoshangabad district of Madhya Pradesh.
>
> An orientation camp for 30 teachers from 15 schools could be organised in May-June 1972. During the camp the textbooks and the kit will be reorganised to make them suitable for rural schools. The physical environment of the villages will be made the basis for examples and experimental material.
>
> The schools included in the programme should be exempted from the state syllabus and examinations.

The proposal envisaged the experiment being conducted in 15 schools. After the state government gave the go ahead, a total of 16 middle schools were included.

Thus HSTP began in 1972 without a well-defined curriculum and syllabus. The beginning was made with very limited academic resources and just a broad understanding of objectives and methodology of science education.

From 1972 to 1975

A lot of ground was covered from 1972 to 1975. Just as the move from the Doon School to Bombay was an important step, the journey from the municipal schools to the rural schools of Hoshangabad district was a big leap forward. There were many components to this leap.

The first textbook, *Bal Vaigyanik* (which could more appropriately be termed a 'workbook'), was published in October 1972. Its purpose was to ensure that children learned science by working like 'child scientists' in the classroom. The first edition had a red cover, so it was affectionately referred to as the *"Lal Vaigyanik"*, and that's the name we'll use to refer to this edition. All other editions will be referred to as *Bal Vaigyanik*.

There were 12 chapters of physics and 8 of biology in the *Lal Vaigyanik*. All the chapters were based on the experimentation and discovery approach:

वस्तुएँ और समूह (Objects and groups)
दूरी और उसका मापन (Distance and its measurement)
घट-बढ़ और सन्निकटन (Variations and approximation)
सतह और क्षेत्रफल (Surface and area)
स्थान और सापेक्ष स्थिति (Relative position and location)
आयतन और धारिता (Volume and capacity)
निकाय और पारस्परिक क्रिया (System and interaction)
समय और पुनरावर्ती निकाय (Time and periodic systems)
बल और भार (Force and weight)
भार और तुला (Weight and balance)
विद्युत प्रवाह और उसका परिपथ (Electric flow and circuit)
चुम्बक और पारस्परिक क्रिया (Magnets and interaction)
जीव-जगत में विविधता (Variations in the living world)
वृद्धि (Growth)
विकास (Development)
भोजन और पाचन क्रिया (Food and digestion)
श्वसन और शक्ति (Respiration and power)
सूर्य का प्रकाश और भोजन की उत्पत्ति (Sunlight and production of food)
संवेदनशीलता और प्रतिक्रिया (Sensitivity and response)
सजीव और निर्जीव (Living and nonliving)

The first teacher training workshop was organised in May 1972 at Friends Rural Centre, even before the first edition of the textbook was published. Thus, the effort to develop a curriculum and the textbooks begins with this workshop. Many new dimensions were added to the innovation in its transition from Bombay to Hoshangabad but these were not planned or the result of a well thought out strategy or policy statement. Theoretical aspects of the curriculum evolved as the work progressed and as new resource persons joined the programme. The experience and insights gained from schools and teacher training workshops had a bearing on the process.

Before we proceed, one important thing must be mentioned. Although not directly related, it had great impact on every single aspect of the HSTP.

The Friends Rural Centre and Kishore Bharati were both multi-dimensional organisations rooted in a rural context. Friends Rural Centre was situated in Rasulia, a village on the outskirts of Hoshangabad town, which was the divisional headquarters of the district of the same name. Kishore Bharati was located at the eastern end of the district in Palia Piparia village of Bankhedi development block.

The Friends Rural Centre was (and is) a Quaker organisation established towards the end of the 19th century to provide relief to people in times of famine. In 1971, it was working under the guidance of the noted Gandhian scholar Marjorie Sykes. She was of the opinion that the centre should take up work in education that was pioneering in nature and could help change the mainstream educational system. That implied that any programme that the Friends Rural Centre took up should not remain an isolated island of excellence. Obviously, the Bombay municipal schools science teaching experiment fulfilled both these conditions.

Kishore Bharati, on the other hand, had been established to explore the kind of education which must be provided to rural children who are unable to attend regular schools due to poverty, so that they could overcome the problems of unemployment and exploitation. In a way, this quest was inspired by Mahatma Gandhi's Nai Taleem experiment.

Both Friends Rural Centre and Kishore Bharati had definite ideas and approaches regarding rural society, rural development and the role of education in socio-economic development. Their work included agriculture, animal husbandry and health, etc. Quite naturally, we see a definite rural slant to the HSTP. Also, the attempt to weave science education around the environment, in particular the rural environment, was a direct consequence of the special circumstances of these two organisations. Their socio-political concerns coloured every aspect of the innovation and the educational materials.

It may also be mentioned that the natural environment of these two organisations also attracted people, drawing a steady stream of volunteers to the programme. Activities connected to agriculture and the land went on all year round and there was a steady stream of villagers coming and going. Thus, there was a spontaneous contact with farming and local people and it was natural that it influenced the educational activities being undertaken.

In other words, while *Physics Through Experiments* and *Prayogic Padaarth Vigyan* explored and amplified the internal processes and methods of science in science education, HSTP added the crucial input of linking science teaching-learning around the world and environment of the child and the socio-economic issues.

Professionals and experts join the programme

A crucial development in the early history of the HSTP was a visit to the Friends Rural Centre by Rashid Shaikh, a volunteer from the Indian Institute of Technology, Kanpur. He became the innovation's first full-time worker.

Shaikh felt that a programme like the HSTP required a strong resource group and the country had enough people worried about contradictions in science education. He mentioned meeting Dr. Krishna Sane from Delhi University's chemistry department at an NCERT Science Talent Search summer workshop. He was greatly impressed by his teaching methods. So he took Anil Sadgopal along to meet Dr. Sane at Delhi University in August-September 1972.

Dr. Sane got together a group of teachers from the university's physics and chemistry departments who were concerned about science education. Thus, like TIFR, here also there were people ready to take the plunge. They had seen that students seeking admission to the university had a poor grounding in science and they felt the root cause lay with science teaching in schools.

When this group of 15-20 teachers met in the chemistry department of the university, every teacher present expressed a desire to join the HSTP experiment. Among them was Dr. Vijaya Varma, who had helped the Physics Study Group write *Physics Through Experiments*. He was delighted to learn that the work started in 1966-67 had reached Hoshangabad.

The Delhi University group visited Hoshangabad in December 1972 and again in January 1973 to attend the monthly meetings of the school science teachers. Their presence led to a sea change in the tenor of the meetings. Their deep understanding of science and the new ideas, methods and experiments they introduced breathed new life into these meetings. The teachers were enthused, the HSTP organisers were encouraged and the Delhi University group found a platform for itself.

The growing involvement of the group led to the formulation of two proposals that were submitted to the University Grants Commission and Delhi University. The proposals basically asked the university to permit its teachers to participate in a school science teaching project. It was a novel suggestion. It was perhaps for the first time anywhere in the country that university teachers were seeking to work on science education in schools. After much haggling and persuasion, the university granted permission and the University Grants Commission also extended its support. Thus began a long involvement of teachers, and later students, from Delhi University, which had a decisive influence on HSTP. This was probably the first time that the university teachers were participating directly in school education.

Most of the Delhi University teachers were from the physics and chemistry departments and although there were a few from biology, their involvement proved to be short-lived. However, sometime in 1975 a group of college teachers from Madhya Pradesh joined the programme and most of them happened to be from the life sciences.

In this way, a strong group of subject specialists, volunteers and teachers came into being. They worked together to develop chapters, new assessment methods, teacher training practices, kit materials and support systems for teachers etc. For the first time teachers from universities, colleges and schools were working together to address problems in school education, especially science education.

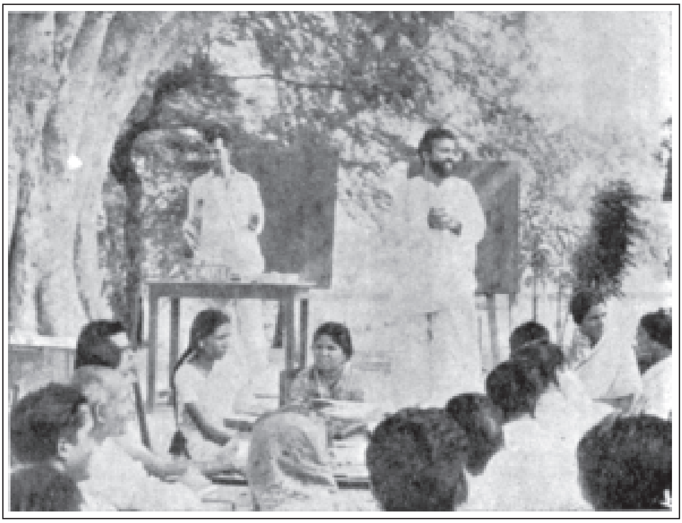
There was another remarkable aspect of the HSTP, viz., absence of 'education experts' during its entire history. Be they scientists from the TIFR, people from the IITs or universities or colleges, researchers from various research organisations, or even school teachers, they were all either practising scientists or science teachers. None of them were 'educationists'.

Only occasionally did some faculty members from the Regional Colleges of Education (now Regional Institutes of Education) and some colleges of education in Madhya Pradesh participate. This noticeable absence of experts formally qualified in education must have left its stamp on the programme and the way it evolved.

The first training camp

HSTP conducted its first 21-day orientation workshop in May 1972. Forty school science teachers sat with the newly constituted resource group in a meeting room at Friends Rural Centre. Physics chapters were already there based on *Physics Through Experiments*. However, chemistry and biology chapters had to be prepared.

Some research scholars from the molecular biology unit of the TIFR had put together several biology experiments, writing them down in an orderly manner for presentation at the workshop. However, within days of participating in the workshop, they had gained a fair measure of exposure to the conditions in government schools, the academic level of the students, prevailing social beliefs and practices, etc. When the time came to try out their experiments they realised that what



An open-air training session

they had written was not related to the local context. They admitted that it was a mistaken notion that science experiments can be developed without understanding the milieu.

The chemistry experts from Delhi University also went through a similar process of self-realisation and it is reported that they made a ceremonial bonfire of the textbook they had prepared. The message emanating from their dramatic move was strong and clear – science concepts and pedagogy should be structured around the environment and the local context of the learners.

The workshop illustrated one more truth. The kit material used was fairly simple. The list included pipettes, burettes, round bottom flasks and test tube stands, etc. These materials appeared to create a sense of alienation among the teachers. Nothing could be done about replacing them or reworking the experiments in that workshop. But the nature of kit materials remained an overriding concern that eventually led to a special workshop being convened in 1975 solely to discuss the issue.

The *Lal Vaigyanik*

The *Lal Vaigyanik* was printed in September 1972. This textbook was prepared using *Prayogic Padaarth Vigyan* and *Physics Through Experiments* as a model. *Physics Through Experiments* dealt solely with physics, while *Prayogic Padaarth Vigyan* included some biology and chemistry chapters that the TIFR group had developed during the course of the BMC school experiment.

In Hoshangabad, a decision was taken to prepare these chapters anew. The *Lal Vaigyanik* was essentially a translation of *Physics Through Experiments* and the few biology chapters prepared by the TIFR group. Interestingly, it contained no chemistry chapters.

The striking feature of the *Lal Vaigyanik* was its friendly approach and style. It invited children to learn science, conduct investigations and have fun doing all this. This approach is clearly illustrated in the foreword to the book, "Come, let's do experiments":

> These books give methods to do the experiments yourself and gain a good understanding of the subject.
>
> If you enjoy 'doing' new experiments to learn new things instead of 'memorising' or 'reading about' them, you will find it easy to learn science.
>
> We hope that using the methods suggested in this book, you will get as much pleasure and satisfaction as the scientists get.

Thus three things were evident. First, the HSTP textbooks would not dish out information. Second, children should enjoy learning science using this methodology. These two aspects directly contradict the traditional belief that education basically means memorising information, with no space for enjoyment.

The third point was that children should themselves experience the processes of scientific investigation.

The *Lal Vaigyanik* physics chapters focused on three scientific concepts. The first was making groups, second measurement, and third interactions. They were considered to be important concepts in developing scientific understanding. In the case of biology chapters, these were possibly the only chapters that could be written at the time within the framework of the discovery method. Even within these constraints the chapters took up and discussed some fundamental life science concepts: understanding the properties of living things (nutrition, respiration, growth and development, sensitivity), and distinguishing between living and non-living things on the basis of these properties. The concept of diversity in the living world, another important concept in modern biology, was also emphasised.

But these chapters were still not linked to children's environment. The physics chapters, especially, were largely 'laboratory-based'. Even the biology chapters did not use the environment as a starting point.

The *Lal Vaigyanik* chapters also assumed many things. To take an example, they assumed that mathematical skills were fairly well developed in children of that age group. Similarly, in the chapter on growth it was assumed that children could construct graphs. There are many such examples. These assumptions faced serious challenges as the programme evolved.

Chapters as cards

The first training workshop and the experience with *Lal Vaigyanik* had shown that all the chapters, whether written or planned, would go through several revisions and reformulations on the basis of field-level experiences and the feedback collected. The experimental nature of the programme demanded it. So an important decision was taken at this point. No textbook would be printed, because a printed book draws a line, creating the illusion of a 'final product'.

So each chapter, develop on the basis of *Lal Vaigyanik* experience, was printed separately on thick card sheets. These chapter cards were given to the teachers and students one at a time as they were printed. The teachers were made to understand that these were draft chapters that would be revised as new insights emerged from teaching-learning experiences in the classroom.

The cards facilitated continuous process of revision. Frequent changes could be made and the revised chapters could be quickly reprinted to make them available to the teachers and students. There was another advantage with card sheets. A chapter could easily be transferred from one grade to another if it was found to be too easy or too difficult for the grade it was initially visualised for.

Several chapters were tested in schools in this way between 1972 and 1975 and a final set of HSTP chapters slowly emerged. During the same period, structure of chapters and various dimensions of the curriculum also got defined. So, it would be useful to examine some of the processes of this period more closely.

The HSTP had no preconceived idea or plan about which chapters and topics should be included or excluded. There was considerable freedom to choose the topics one wished to explore and write on. So a wide range of chapters on diverse topics was prepared, many eventually becoming part of *Bal Vaigyanik* while many others were left out along the way.

The process was simple. A resource person would be given the responsibility of preparing a chapter on a specified topic. The resource team would first discuss the topics, focusing on its scientific content, the kind of experiments to be included, its step by step build-up of logic and so on. The potential author thus got a framework for writing the draft chapter.

Once the first draft was prepared, it was tried out with the teachers at the orientation workshops. Each group of teachers was given a chapter for the day. They first performed its experiments, carrying out the instructions to the letter. Once this process was over, they gave their feedback, commenting on every single aspect of the chapter, its language, the wording of the instructions, the problems they faced in understanding the instructions and performing the experiment, gaps in conceptual clarity, and so on.

The teachers and resource persons would then sit together to analyse the feedback, discussing each point in depth. Points that evaded a consensus or failed to be resolved were placed before a 'commission', which would conduct an exhaustive inquiry on the chapter and present a report of its investigation. Enough time was reserved for in-depth discussions on the conceptual issues, so that the structure of chapters and related matters could be taken up. The author would then rework the chapter on the basis of the collective feedback during the workshop itself and present the reworked chapter for a second round of trial.

The next step was to prepare the required diagrams, edit the language, design the layout and print the chapter. Once printed, the chapter would again be presented to the teachers, this time for classroom teaching, for trialling and further study. It wasn't as if all the chapters were written at the beginning of the year and given to the teachers. Chapter writing was a continual process all year round.

Resource group members would be present in the classroom when the chapters were taught. Detailed feedback would be collected on every chapter, every experiment and every question asked. This feedback was crucial to the evolution and development of HSTP and its educational materials. Unfortunately, it seems that a large chunk of this feedback was oral, as written record is very scanty.

During this time, several surveys and studies were also conducted with children. One was a survey of children's understanding of the decimal system. The results were so disheartening that an additional chapter, "Games with an Abacus", was specially developed to reinforce understanding of place value and decimals.

Thus slowly evolved the chapters one by one. Teachers were informed about the chapters from *Lal Vaigyanik* and cards to be used in the classroom. When the programme covered all the three classes (6, 7 and 8), all the chapters of *Lal Vaigyanik* were not done in a single class. These were distributed across classes. In other words, in each of the three grades, some chapters were used from *Lal Vaigyanik* and the rest from the cards. These discussions were taken up each year as the group was learning through trial and error as to which concepts are suitable for a particular grade and what pre-requisites can be taken for granted. It had to be ensured that if there are certain pre-requisites in terms of concepts or skills, they should either be there already or a remedial chapter should be developed.

While doing all these experiments, clarity on curricular issues and syllabus was emerging and some general principles were crystalising and understanding was becoming more sophisticated. In the next chapter, we discuss some of these issues.

Bal Vaigyanik

The Development of Chapters

The development of *Bal Vaigyanik* chapters broadly followed the process outlined below:

Selection of the topics on the basis of their context and relevance to rural children and requirements of the discipline.

↓

Framework of the chapter formulated by subject experts.

↓

Revision of the framework on the basis of the review by the resource group.

↓

Revised draft presented to the teachers.

↓

Testing the practicality of the experiments by the teachers.

↓

Revision of the chapter on the basis of feedback from the teachers on language, content, experiments, etc.

↓

Rewritten chapter trialled with students.

↓

Fresh revision on the basis of feedback from classroom.

↓

Printing of the chapter.

↓

Continuous improvement of the chapter on the basis of continuous follow up and the feedback collected.

4

CURRICULUM AND SYLLABUS

In this chapter we shall examine the theoretical foundations of the HSTP curriculum and syllabus. However, it would be wrong to assume that these were known from day one. Rather, as the work progressed understanding grew and this understanding took the form of some principles. As this understanding and theory is linked to work and practice, it is evident that these are continuously changing and evolving. So it is fruitless to try and understand the HSTP by pigeonholing it in any 'ism'.

One thing the HSTP group was deeply aware of right from the outset was that 'information explosion' cannot be the basis of curriculum. The group believed that if we pack the programme in the name of 'information explosion', a time will come when it will be impossible to include more. Moreover, even if a curriculum managed to cover all the existing information at a given point in time, the children would find the information dated and probably even irrelevant 10 years later. That's why the emphasis was on learning by themselves. It was clear to the group that this would be a slow process because children would be participants in the journey.

Most of the principles of the HSTP curriculum and syllabus emerged during the years from 1972 to 1977, which was the most intensive phase of the programme. This theoretical understanding was presented during a meeting that Kishore Bharati organised from October 3 to 8, 1983.

The important issues related to curriculum and its development are presented here. This outline is mainly based on the meeting mentioned above and some other sources.

1. The curriculum should be activity-based, with children performing experiments themselves. The central idea was that science teaching in middle schools should be based on experiments. And it wasn't enough that the teacher demonstrated the experiments to children. Expectation was that children will perform experiments in groups, discuss the results, and scientific principles would emerge from this discussion. Experiments should be so sequenced that children gradually move towards scientific laws, principles, theories. Each activity must be designed keeping children's understanding in mind. Observations must be repeated several times to ensure development of a concept. It should not be expected that doing experiment once will lead to a concept. A variety of experiments needs to be performed a number of times so that children proceed step by step.

One important aspect of the experiments was that their results and conclusions should not be given in the textbook so that children enjoy a sense of discovery.

There was an attempt to let children acquire the ability to design experiments themselves.

Learning about the idea of controls in experiments was another aspect of experimental method; if there are more that one factors that may affect the outcome of an experiment, they should be able to perform controlled experiments to find out the factor(s) actually responsible.

The main concern of the HSTP and its predecessors was that science learning should be structured around experiments and activity, with children participating in the process of 'discovering' scientific concepts and laws. This became the guiding principle. It came to mean that concepts that could not be 'discovered' through experiments would have to be excluded. This was the reason why a decision was taken to not include atomic structure and chemical symbols in the curriculum.

However, this did not imply that the HSTP held the position that science could only be taught through experiments. The understanding was that the focus at middle school level should be more on inculcating a scientific attitude and developing scientific skills in children and for this to happen, it was necessary that they perform experiments. However, in the higher classes – or even in their daily life – children will need to accept and understand lot of such information emanating from the work of scientists. What the HSTP basically sought to develop in children were those qualities that would help them to be critical while acquiring and using such information and distinguish between what is true and what is false.

2. The curriculum should be related to the environment of the learner. This was not difficult in the case of life sciences where the approach was to take up topics based on observations of plant and animal life. This was attempted to some extent in physics and chemistry as well, the approach being to initiate discussion of a concept by taking up an example from the daily life of children, which could be some common experience or apparatus or machinery. The idea was to make them feel they were learning something about what was around them.

To make environment the basis of curriculum and to apply what is learnt to understand the environment were both important considerations. For example, when developing a chapter on the concept of volume, we found that children – and most people – had several preconceptions and understood volume in a variety of ways. In the Hoshangabad region, people measured the volume of grain with a vessel known as *pai*. They knew that a *pai* of one type of grain had a different weight from a *pai* of another type of grain. This is related to payment of wages in kind etc. This example was included in the chapter on volume. Wherever there were contradictions between a scientific concept and what people and children understood, it was brought up for discussion in the chapter.

Second aspect of environment based curriculum is to apply whatever has been learned, to the environment. "Lifecycle of animals" is a good example. Children have a lot of misconceptions about how living things come into being. For example, they believe that larvae grow spontaneously in cow dung. So an experiment was designed to address this misconception, helping children understand that larvae and flies can develop only in cow dung that contains eggs and no larvae or flies can be seen emerging from cow dung in which there are no eggs. Once children have seen his, questions are asked leading to a discussion on commonly held beliefs and superstitions.

Field trips were included in the curriculum to link it to the environment. The idea was to take children out of the four walls of the classroom, collect things, gather information about various things including plants and animals. It was important that they should not think that the textbook and the teacher were the sole repositories of knowledge. So wherever possible, they were expected to collect information from other sources, the emphasis being on talking to people – farmers, Agriculture Expansion Officers, veterinary personnel, local artisans and so on. In many instances, surveys were also included as a means of gathering data.

3. One important consideration was that children should not see the curriculum as a burden. They should enjoy experiments and take interest in doing them, not just in the classroom but outside as well. They should also discuss them with each other and with the teacher to move towards scienctific laws, and principles and theories.

4. The most important aspect was the objective of each chapter or topic included in the syllabus. Take the example of the chapter on flowers. Usually, children are taught the names of the parts of a flower, interrelationship, modifications, etc. In *Bal Vaigyanik*, the aim was not just to get to know the names of different parts of a whole lot of flowers and modifications, although the children actually did study number of flowers. However, the objective was that the children should study various flowers collected and be able to explain their structure to others; they should grasp the process of investigation, and understand the structure and composition of each flower they collected. They had to learn the process of studying flowers. This way, they would be able to continue their explorations on any topic they studied in school outside the classroom as well.

5. *Bal Vaigyanik* also expected children to understand and internalise the method of science and get familiar with its elements including performing experiments, discussing and analysing the results, developing hypothesis from their observations and then designing new experiments to test their hypothesis.

6. An important aspect of the curriculum was to encourage and develop children's ability to express their experiences and observations in their own words. They were encouraged to write answers in their own words. There was no attempt that after the experiment and discussion, the teacher would stand up and declare, 'OK, students, we learnt such and such today.' It was clear that children's writing would not be very clear or sophisticated, but it was felt that it is still better that they write the answers in thier own inadequate language rather than taking dictation. Using diagrams to explain their thoughts was seen as another step in developing their understanding.

7. One more aspect that came in for attention was developing the manual skills of children. They were taught how to handle the apparatus for experiments, and even to design apparatus and other equipment themselves.

8. Measurement was also an important part of the curriculum. The curriculum sought to give children a feel of data and how data is to be collected, organised and tabulated for presentation. They were taught how to analyse data by constructing bar diagrams and graphs etc. and what kind of conclusions can be drawn from data.

During measurement it was also emphasized that in any process of measurement there is bound to be variations in the results. The variation can be reduced by improving the technique but it cannot be reduced to zero. Thus, in science you can never claim that such and such result is absolutely accurate.

9. Emphasis was placed on the process of making groups and its use. The concept is woven throughout *Bal Vaigyanik*, given its importance in learning science, developing rules, recognising patterns, framing questions for further study and arriving at a hypothesis.

10. It was also clearly understood that the kit and apparatus are an important part of an experiment and activity-based curriculum. Thus a system must be set up to supply apparatus and materials not available locally.

Viewing the curriculum from another perspective

We get another statement of the curriculum in a different context. From the point of view of examinations, the HSTP emphasized certain processes and concepts which it identified as fundamental concepts. The syllabus and the choice of topics were structured and developed to ensure that children got a sound grounding in these skills and concepts. It can be said that these basic things were the HSTP curriculum because these were the areas in which children were evaluated during the end-of-term examinations.

These basic concepts included the following:

Scientific skills

- Make minute and correct observations.
- Conduct surveys and collect data.
- Organise, tabulate and present data – tables, bar diagrams, graphs and diagrams.
- Analyse data.
- Identify linkages between different experiments.
- Draw conclusions by logical reasoning.
- Ask clear, sharp and new questions at every step of logical reasoning.
- Generalisation and abstraction.
- Experimental skills.
- Measurement and understanding of variations in measurement.
- Draw maps.

- Make apparatus from local materials.

Scientific attitude

- Curiosity.
- Awareness of the environment and ability to continuously learn from it.
- Urge to discover things.
- Understand importance of controls in experiments.
- Demand authencity of facts/information before accepting them.
- Willingness to accept that a question may have more than one possible answer.
- Open mind to differences, challenges, criticisms.

Concepts

- Groups and sub-groups.
- Classification.
- Coordinates.
- Area, volume, weight.
- Separation.
- Acids, bases, salts and neutralisation.
- Identify various substances through chemical analysis.
- Understand the importance of diversity in the living world as the basis for all biological theories.
- Chance and probability.

Selection of content

The guiding principle in defining the syllabus was that only those scientific concepts would be included that can be taught through experiments or activities, or that are within the ambit of a child's direct experience or observation. If there are no appropriate activities or experiments to explore a concept, it was not to be taken up for study. Appropriate meant those activities and experiments that could be taken up in a rural middle school.

Another guiding principle was that the syllabus should be linked to the environment of the children.

Similarly, general scientific processes such as grouping were emphasised and given precedence.

To some extent, the prescribed state curriculum was also kept in mind, especially in the life sciences. This is evident from a note written in December 1990 by Arvind Gupte[1], a resource person with Eklavya, in which he stated that the basis for formulating the biology syllabus at the time of the 1978 district level expansion was that it should more or less be in line with the prescribed science curriculum for middle schools. So, chapters relating to the structure and functions of animals and plants were included automatically. Even then, some topics in the state syllabus were consciously excluded. These included cell structure, cell division and the standard classification of plants and animals. Cells are such microscopic entities that middle school children cannot possibly visualise or understand them. Cell division is even more abstract and any descriptive chapter on the subject would only confuse the children further.

Some topics were included in *Bal Vaigyanik* which were not in the prescribed state syllabus. One example was diversity in the living world, which is a fundamental concept in modern biology. However, many topics in the state curriculum were excluded on the basis of the criterion of direct observation or experimental investigation. These included atomic structure, chemical symbols and formulae, equations, standard biological classification and so on.

[1] Arvind Gupte, "A Note on Biology Chapters," December 1990.

Another reason for excluding atomic structure and chemical symbols was the belief that children of that age group (10 to 13 years) are not at the cognitive level where they can understand an abstract concept like atomic structure. A related concern was that if atomic structure had to be taught, it would require the kind of experiments that would help children understand that bulk objects are composed of minute atoms. There are experiments that can illustrate that atoms do have a solid foundation, but it requires a certain level of mental maturity to understand these experiments. Moreover, the equipment required to carry out these experiments is prohibitively expensive. It was unacceptable that the teacher will somehow explain that the models provide proof of atomic nature and structure.

Similarly, biological classification has a conceptual basis, but it is a highly abstract concept. Classification is based on evolution. So to talk about classification without going into its evolutionary basis is nothing more than just memorising information. It is useless to burden the child with such inessential information in the early stages.

In Madhya Pradesh it is unlikely that many children get to see ferns. Even if they have seen them, it is difficult to explain to them how they are different from flowering plants that look more or less similar. It is even more difficult to explain that echinodermata are thorny skinned animals whose skeletons are composed of calcareous plates or ossicles.

Another problem is that animal and plant taxonomy uses a nomenclature based on Greek and Latin. It would be patently unjust to expect children, who find it difficult to cope with even the English alphabet, to remember or memorise such difficult terminology.

Some Salient Curricular Objectives that emerged from a meeting held on May 12, 1976 to discuss curricular issues:

I. Joy of exploring our surroundings and learning:
1. Desire to find out about things oneself.
2. Urge to ask questions.
3. Enjoy using all ones senses and doing things.
4. Appreciation of the diversity of living creatures.

II. Observation, explanation and organisation:
1. Ability to group things one collects on the basis of their properties.
2. Ability to group things into living and non-living on the basis of their observable properties.
3. Ability to classify things according to a variety of criteria.
4. Ability to observe regularity in events and movements.
5. Ability to distinguish between relevant and irrelevant observations.

III. Asking questions and designing experiments to investigate their answers; logical thinking:
1. Ability to find answers to simple questions by investigations.
2. Appreciation of the importance of measurement.
3. Comparative analysis on the basis of a property or variable.
4. Identifying the variable that determines a specific property.

IV. Concepts, knowledge and skills:
1. Topics and concepts for chapters, such as acidity, response, repulsion, etc.
2. Ability to measure length, volume and weight using arbitrary as well as standard units.
3. Mathematical skills (including using units and decimals).
4. Skill in handling and using experimental apparatus
5. Ability to search for information in books and other sources.

V. Comprehension and communication:
   1. Ability to understand and explain in simple words and with the help of diagrams.
   2. Ability to record events systematically.
   3. Ability to tabulate data and use tables, bar diagrams and graphs.

VI. Recognising patterns and correlations:
   1. Understand that the apparent form, shape and context of anything depends on the position of the observer.
   2. Appreciation of diversity in living things – seasonal and other changes.
   3. Understand cause-effect relationships.
   4. Understand the relationship between parts and the whole.
   5. Inter-dependence among living things.

Comments:

1. It is commonly assumed that 11-year-old children have a sense of meaning or comprehension. We have included comprehension because we feel the children in our schools lack this ability.

   Several other abilities should be added to this list.

   Goals and competencies that have been achieved, or considered trivial, should be removed from this list. Similarly, those that cannot be attained should also be omitted.
2. In the Class 8 question paper 60% of the questions are based on V.1, III.1 and IV.1. We have to decide whether this is justified.
3. Authors of chapters should ensure that IV.1 figures prominently and is dealt with in depth in all chapters they develop. For example, that air expands when heated, or that repulsion is the identifying property of magnets.
4. In order to develop their comprehension abilities, children should be taken on field trips in the first six months in class 6, and asked to write descriptive material individually.

Recognising the importance of classification in science the HSTP took a different approach to the concept and introduced it in *Bal Vaigyanik* with a different objective. In the chapter titled "Laws of Classification", children begin by making groups of the contents of their school bags and slowly work their way up to an understanding of the laws of classification. Classification of living things begins by making groups of living creatures in the surroundings, on the basis of their characteristics.

Sequential development of the content

The topics in the syllabus are presented in a very orderly and structured manner in *Bal Vaigyanik*, keeping in mind the gradual development of concepts, their interlinkages, complexity and level of abstraction, etc.

The textbook first introduces qualitative concepts before gradually and progressively moving to quantitative concepts. Thus, in class 6 qualitative concepts predominate, with the proportion of quantitative concepts increasing as the children progress through classes 7 and 8. There are many examples of this gradual progression. For example, grouping (qualitative) features in class 6 while area and volume measurements are taken up in class 7. More difficult quantitative concepts, such as probability, are reserved for class 8.

Similarly, in chemistry separation is taken up in class 6, while acids, bases and salts, in which counting and measurement are involved, are dealt with in class 8. It isn't as if quantitative concepts are totally excluded in class 6, but the focus is on the qualitative. Some quantitative concepts such as measuring distances are included in class 6. Initially, area and volume were also included in the class 6 syllabus. But we soon realised that children were facing difficulties in dealing with these concepts because they needed to learn many more things before they could handle such concepts. That's why we later shifted these chapters to class 7.

Many concepts require a higher level of abstraction, conceptual understanding and mathematical skills. For instance, children are stumped by decimal division. Or some concepts require the development of experimental skills. For example, to get more appropriate results in experiments with hard and soft water, it is essential to ensure that the apparatus is cleaned well and special care is taken while conducting the experiment.

There is another thing. Educationists call it moving from the known to the unknown. We followed this principle by linking concepts to the environment of children and beginning with familiar examples.

Another guiding principle in evolving the syllabus was that abstract thinking should be developed in children. This is introduced step by step. Thus, in classes 6 and 7 they are expected to draw a conclusion or reach a principle/law of whatever situation they are studying in a single step. Two-, three- or more step logic is not expected in class 6. Some of it is expected in class 7 and multi-step reasoning increases in class 8.

The first attempt to move beyond one-step reasoning in class 7 was in starch production in leaves. After children have learnt in this chapter ("Sunlight and Starch in Leaves") that leaves cannot produce starch without sunlight, they are asked the question: What is the importance of sunlight and green leaves in life? They are then expected to combine concepts they had learnt in several different chapters while searching for the answer, such as the importance of starch in our food in the chapter "Food and Digestion". Another question posed to them in the chapter was: Would we get milk if the earth was in permanent darkness?

But this process reached its limit in the chapter "Exploring the Sky". This particular chapter, which is essentially a study of the solar system and its motions, was divided in two sections that were taken up separately in class 7 and class 8. It involves combining the results of six or seven experiments/observations to draw some conclusions. These experiments/observations generate data that can be interpreted in two ways. One is simpler and, hence, considered better, in keeping with the law of parsimony or Occam's Razor which says that the simpler answer is the better answer. But we found it difficult to explain the idea even to the teachers. This chapter used the technique of building a model to understand the phenomenon.

A similar situation was faced in the chapter "Chance and Probability": no conclusions seem to emerge from individual experiments. It requires collating and interpreting a large mass of data. Yet, even that does not give a straightforward or obvious conclusion: one needs to recognise a pattern in the data to draw any conclusion. This is an even higher level of abstraction.

The inclusion of such abstract concepts gave rise to another concern: would it be proper to evaluate students' understanding of these concepts in depth in the examination? In this context, the consensus in the HSTP group was that when you take children through an intensive process of abstraction, they should not be expected to internalise it completely. It is enough if they gain a broad understanding and sense of the overall concept. For example, in "Chance and Probability", it is sufficient if they can recognise a pattern in the throw of a dice and decipher which patterns are either impossible or have very little chance of occurring. Such an approach is important if one wants to keep an element of flexibility in the curriculum.

The general understanding in the HSTP was that information should not be given in the chapters. But there appears to be a misunderstanding on this score that requires to be cleared. The children often require information to help them proceed with some experiments or aid them in analysing the results. If they have no way of acquiring this information while doing the experiment, then the required information is given in callibrated doses to help them proceed. But this understanding has seen a lot of change over time.

The *Bal Vaigyanik* syllabus has internal links. A lot of work has gone into establishing these linkages which have two facets. First is the step by step progression of the content and topics. Other is linkages at the conceptual level. The step by step progress is clearly evident in the chapter "Learning about Graphs". The process begins in class 6, where children learn to make bar diagrams. Then there is a chapter in class 7, where they learn about Cartesian coordinates and how to scale a figure up or down. The chapter on making graphs then follows. Likewise, in class 8 there is a chapter on interpreting the graphs that they make. Such step by step organisation and progression is seen at many places.

Another example of such progression can be seen in the chapter "Air". Several properties of air are studied in this chapter. It is then followed by the chapter "Gases" in which the properties of oxygen and carbon dioxide are studied. Next comes a chapter, "Respiration", which can be taken up only after children have done the chapters on air and gases and understood the properties of gases. Concept of living and non-living has also been developed step by step. After studying characteristics of living beings with respect to many plants and animals, children classify living and non-living on the basis of these properties in class 8 and investigate their inter-relationship.

Considerable effort went into finding new and exciting, yet simple ways of communicating the content. For example, the children found it difficult to understand why an electric motor rotated. Some volunteers came up with a totally new way of explaining the phenomenon – a toy electric acrobat. Using another model they were able to demonstrate the right hand rule.

In the chapter “Internal Organs”, it was felt that a wrong concept was being conveyed to the children – that all body organs were on the same plane, when in reality they are on different planes. A special activity was designed for the purpose in which the children cut out pictures of the various organs and assembled them in a given order on a large outline of the body. In doing so, the organs are automatically positioned in different planes and levels in the body.

Many such examples can be cited from other chapters.

Many experiments and exercises were included to stimulate the creative abilities of children, both the scientific creativity and the ability to make different artefacts. For example, class 7 has a chapter on making objects of different shapes using matchsticks and valve tubes. In addition, different chapters carry instructions to make microscopes, lactometers, hand pumps, periscopes, kaleidoscopes and weighing balances. These have been consciously introduced into the syllabus.

Environment-based curriculum: some issues

Nowadays, most elementary education programmes talk about structuring learning around the immediate environment of the child.

In a surprising judgement, the Supreme Court decreed that environmental education should be made compulsory in all classes. The understanding behind this judgement seems to be that environment should be taught like one more subject.

The HSTP's understanding of environment-based education is slightly different. It believes that the environment (the milieu of the child) should play a major role in the process of learning different scientific concepts. This means taking all examples from the local environment to further the learning process. In turn, any concept or scientific principle emerging in the classroom should be applied to the environment and analysed. All local sources of information and knowledge – village elders, *patwaris*, ordinary farmers, health workers, etc. – should be tapped. The local language should also be given its due place. And most important of all, when studying a topic, it is necessary to take into consideration prevalent local beliefs and understanding on the subject. Underlining this aspect of the HSTP, Yash Pal wrote the following about the programme's very first teacher training workshop: "Contrary to the usual opinion that investigatory approach to science learning would be unsuitable for Indian conditions, we have come to believe that this is the very approach we need to follow if we want science education to take roots in a soil seeded with beliefs, myths and experience which in the traditional way of learning are never engaged with, much less made use of."[2]

In fact, the HSTP's understanding seems to be that all information is contained in the environment and the objective of school education is to teach children the methods by which they can acquire this information and analyse it. So it is more

[2] Yash Pal, "Today's Education for the Needs of Tomorrow," Physics Study Group, December 1972.

appropriate to say that the *Bal Vaigyanik* curriculum is linked to the environment than saying that it is environment-based. Education should be linked to the child's surroundings. This includes not just the natural and physical environment but the community, family, customs, traditions, etc. Culling out information from all these sources is integral to HSTP. That's why the children go on field trips, conduct surveys and talk to village elders, craftsmen etc., to get more information. Many household objects are also used as teaching aids to link learning with the child's environs.

Using the environment as a base for learning emerges in many ways in *Bal Vaigyanik*.

The easiest and most obvious examples are in the life sciences. Many biology chapters study things present in the children's environment. The 1978 edition of the textbooks had 22 biology chapters of which six required the children to go on field trips.

In some chapters, children study specimens collected from the environment. Apart from these, chapters like "Food and Digestion" begin with a discussion on food, feeding habits and organs involved in feeding in animals around. Children's prior knowledge is collated and new information is gathered by direct observations. Even the study of human food does not begin with some abstract categories. Rather, children examine the food material actually consumed and then classify them into groups. This chapter also touches on the link between malnutrition and poverty, with the children conducting a survey to find out why malnourished children get less food.

In case of flowers, seeds, etc. priority is given to things brought by children themselves.

One of the challenges in environment-based learning is taxonomy. We have discussed this issue briefly earlier. Nowhere does HSTP insist that children memorise the standard classification categories. Instead, in the chapter "Classification of Living Beings" several common sense categories – habitat, skin cover, etc. – have been included in addition to standard categories such as vertebrae, wings, presence of mammary glands, number of legs, etc.

The environment base is not as strong in the chemistry and physics chapters. Nevertheless, wherever the opportunity presented itself, attempts were made to use materials and examples found in the immediate vicinity of children to develop an understanding of physical and chemical principles and concepts. This can be seen in chapters like "Soil", "Acids, Bases and Salts", "Chance and Probability", "Separation of Substances" etc., where the experiments have been designed using locally available materials and the discussions are guided by local examples.

Learning measurement is remarkable in this context. Measurements of distance, area and volume begin with examining the understanding of these quantities in the local milieu. For example, discussion on "area" begins with the question of measuring the area of agricultural fields, while "volume" begins by examining people's preconceptions about volume and then tries to build on these.

Another aspect of linking learning to the environment is language. Processes of education involve three kinds of languages. First is the language people use in their daily lives to communicate with one another. Second is the language the teacher speaks to the students. Third is the language the teacher expects the students to write. While preparing the first edition (1978) of *Bal Vaigyanik*, the HSTP group paid special attention to using the language the children normally speak to the extent possible.

The biggest problem in this connection was dealing with standard scientific terminology. Most of these technical words are difficult and create obstacles in learning. The only option the children have is to memorise them. So the HSTP group tried to avoid using terminology as far as possible, taking recourse to it only as a compromise. Take the example of the chapter on "Bones". Most textbooks have a diagram of the skeleton labelled with difficult sanskritised names. *Bal Vaigyanik* used common words in their place to simplify the text, although it compromised by giving the technical terms in parenthesis, for example, *ankh ka gaddha* (eye socket) was used instead of *netr kotar*. The idea was to help children to identify bones, not memorise difficult words. This problem of technical terminology is not a trivial issue.

However, when something was referred to by different names in different dialects in the district, a decision was taken to use '*khadi boli*' words owing to objection by teachers.

All this shows that an environment-based curriculum or teaching method has many facets. Designing such a curriculum to understand scientific concepts means structuring it around examples taken from the children's immediate context; taking cognizance of their knowledge base and understanding in the teaching method and textbook; making full use of knowledge embedded in the local context and engaging with it; and making the maximum use of children's language in the textbook.

When the time came to prepare the *Bal Vaigyanik* textbooks following the initial experiment with chapters on cards, a special 'ruralisation' workshop was organised, as the name suggests, to make the chapters more appropriate for and to the rural environment. This was in 1975. Apart from the HSTP resource group around 40 teachers who were active in the programme also participated. The discussions were focused on grouping and classification, measurement, biology chapters and experimental kit.

The workshop spent three days trying to understand how concepts such as grouping, classification and measurement could be of use in a rural setting and how exactly these concepts were seen and understood at the local level. In biology, the point of interest was choosing topics that would be relevant in the rural context. Many small projects were tried out but nothing substantial in terms of concrete textual material seems to have emerged from these exercises. However, the workshop did sensitise the teachers to a new understanding of curriculum and material development. It also highlighted and gave a sense of seriousness to the idea of environment-based curriculum. The workshop came out with a strong and unequivocal message that environment-based learning is an important component of curriculum development.

Interestingly, common understanding of environment education is limited to reading nice descriptions of the environment while a real interaction with the environment, soiling ones hands is abhorred. This point came across several times in the school level feedback about the field trips. The teachers mostly talked about the problems such excursions pose: it is difficult to control the children; they tend to wander away; they can be bitten by snakes; they ruin the crops; and so on.

The root cause of these complaints seemed to be a cultural dislike of 'muddying one's hands' in a 'dirty' activity, so every attempt is made to keep classroom teaching away from such pursuits. This antipathy was fairly deep-rooted in the public consciousness, as seen in a letter written in 2002 by the then Member of Legislative Assembly (MLA) from Itarsi to the Hoshangabad district Planning Committee: “The children are put to unnecessary hardships because they have to collect specimens of different kinds of leaves for their experiments.”

Apart from the reluctance and difficulties of teachers and parents, environment-based curriculum, pedagogy and textbooks faced two new challenges as early as 1978, when the HSTP was expanded to cover the entire Hoshangabad district.

The first challenge was the geographical vastness of Hoshangabad district (which has since been divided into two – Hoshangabad and Harda districts). Different regions in the district have different languages and cultures, and agricultural practices are also quite varied. For example, rice is grown in one region while cotton is grown in another equally large region. This diversity put a new kind of pressure on *Bal Vaigyanik*, of which the choice of words formed only a small part.

Such a diversity is bound to affect the kind of examples chosen for study and the concepts on whose basis learning was expected to proceed. And the problem was not limited to biology alone. The most striking example can be seen in the study of chance and probability, about which Krishna Kumar once commented that basing the study of such a difficult concept on the arrival and departure timings of local trains was a unique innovation in science teaching. The study of chance and probability begins with the timetable of a local passenger train at Bankhedi station and the history of its actual daily arrival and departure. This chapter was retained in its original form right through the course of HSTP although it was unclear whether children from other regions of Madhya Pradesh were able to relate to the example used. There are other similar examples, including in the chapter on volume, which used local concepts as a basis for its development.

This should be an important aspect of any environment-based curriculum – curriculum should be linked to the local milieu and the learning process should be structured around the existing knowledge base of children. At the same time, the objective should be to generalise and decontextualise children's understanding to the extent possible.

In this context one other thing needs consideration. If we are talking about a rural environment, different places could have different crops, or different insects and animals, or flowers and leaves, but the method by which concepts are arrived at would be more or less similar. The children would use similar methods to study different kinds of farming. That's why every chapter in *Bal Vaigyanik* can easily be used across regions. They do not describe any specific environment but expect and encourage children to study various components and processes occurring in their own environment to arrive at a description. Therefore, *Bal Vaigyanik* chapters can be used across regions.

This approach can be described in another way: the chapters are environment-based but independent of any specific regional environment. Such an approach more or less works for rural areas (although even here there is the question of non-agricultural areas) but urban areas pose an altogether different set of challenges.

The district-level expansion brought this problem to the fore because it meant the programme was no longer limited to the rural areas. *Bal Vaigyanik*, in which the crop-related chapters were exclusively based on local knowledge and direct observations of events in the field, began to be taught in schools in towns and cities where a large section of students had no direct experience of farming. If we accept that agriculture should be a part of a science curriculum, the question one needs to answer is: how can children from urban areas be included in the learning process?

The question has a corollary. If a curriculum is to be environment-based, shouldn't chapters linked to the environment of urban students also be developed? This was a fresh challenge that inspired many discussions, with one school of thought suggesting that it may be better to present two alternative sets of chapters, one urban-based and the other rural-based. But nothing came of this suggestion. However, in the third edition of *Bal Vaigyanik*, the format of agriculture-related chapters was modified. Instead of depending on direct field observations, the development of concepts in the chapters was linked to the analysis of data provided in the textbook itself. Similarly, in the chapter on plant growth and reproduction, some important experiments were excluded. Even the students in rural schools had been finding it difficult to carry out these experiments. But the basic reason for their exclusion was, nevertheless, the HSTP's inability to offer a creative alternative.

This question can be looked at from a different perspective. If expansion of the programme involves replacing interaction with the environment by written data in textbooks, then aren't we depriving children of an important source of learning? This is a point that the advocates and proponents of a single textbook for the entire state or country need to seriously ponder on. And if we are to look beyond the physical or natural environment towards the total milieu, then even more serious questions arise about the processes of centralisation.

The obsession with not giving information

While writing the *Bal Vaigyanik* textbooks, it was decided that children should discover things for themselves. So the emphasis was on discovering information, laws, theories, and so on. It also meant that information should not be directly fed to the children. Fear was that providing information in textbooks would lead to questions in examinations being based solely on this information content. This would encourage the tendency to memorise, which would, in turn, weaken the process and understanding. Another fear was that once the doors are open, it would lead to a flood of information, given the fact that the mainstream wants textbooks to be packed with as much information as possible. But the most serious misgiving concerned the negative impact it might have on the process of discovery.

The decision to exclude information (definitions, laws, etc.) was influenced by another consideration too. The HSTP was generally seen as 'learning by doing' science. This seemed to imply that all that was needed was for the children to do a whole lot of experiments. The aspect of the HSTP pedagogy which was never properly understood was the one dealing with discovery. Its objective is not merely to do experiments but to deliberate on one's observations, express opinions, appreciate and understand the opinions of others, reason, arrive at conclusions, test and confirm one's conclusions and so on. This entire process can be replaced and made redundant if a concise statement of what is to be discovered is provided in the book. That would appear simpler as reasoning and working your way in an unknown territory to an unknown destination may be at times frustrating and disheartening. Thus, you opt for a rugged road instead of a smooth path when you decide to exclude information and adopt a discovery approach. In the 1970s, mainstream textbooks were obsessed with the phenomena of 'information explosion', an obsession that is still evident today, although more muted. The credit for this change in thinking, both explicit and implicit, should go to the HSTP group, which refused to structure its curriculum around the 'information explosion' and kept the discourse on the subject alive in the public consciousness.

But, with the benefit of hindsight today, this rigid stand does appear to have become a dogma. By totally excluding information, *Bal Vaigyanik* tended to make the discovery process appear a bit artificial and sometimes forced. One effect of this rigid adherence to learning by doing can be seen on language; *Bal Vaigyanik* has mainly two genre of langauge use: instruction and questions.

Quite often, some information is essential to keep the discussions or chain of experiments moving forward. However, the *Bal Vaigyanik* textbooks insisted on performing another experiment to acquire even this information, which sometimes tended to break the natural flow. Later experiences in the HSTP clearly show that it is not necessary that information will always become an obstacle in the process of discovery or would impede thinking on the part of the students.

For example, there was a chapter "Starch in Leaves and Sunlight" in the first edition (1979) of the class 7 *Bal Vaigyanik*. The children perform a classical experiment to 'discover' that starch production in leaves occurs only in the presence of sunlight. They cover a portion of a leaf with black paper and examine the leaf a few days later to see in which portions starch is produced and in which portions it is not.

To interpret the results, children need to know that the portion of the leaf covered by black paper does not receive sunlight. But instead of giving them this information directly, *Bal Vaigyanik* asks them to cover their eyes with black paper, look at the sun and then figure out why black paper is used in the experiment. Ironically, this example is one of those rare exceptions where *Bal Vaigyanik* actually gives the results of the experiment: "You found out from this experiment that leaves require sunlight to produce starch."

Generally speaking, whenever a choice was required to be made between giving information or doing an experiment, *Bal Vaigyanik* opted for the latter.

Take another example from the chapter "Air" in the class 7, 1979 edition:

> Experiment 1: Blow on your hand. Explain what you experience. (1)
>
> Hold a leaf or a piece of paper at one end and blow on the other end. What happens to the leaf when you do this? (2)
>
> Now hold the other end of the leaf and blow on it.
>
> Can you tell why the leaf fluttered when you blew on it and what went from your mouth to the leaf? (3)

The entire sequence appears a bit forced and childish – even trivial. It may have been better to simply write a good paragraph instead.

The same chapter provides another example. In one section the children have to measure the volume of air. To do this, some air is collected in a water-filled plastic bottle by displacement of water. While measuring the volume of air, the children have to make sure that the air pressure inside the bottle equals the atmospheric pressure. The way this is done is to hold the bottle in water at a depth where the level of water inside and outside the bottle is the same. Instead of explaining this procedure in the chapter, a question is posed to the children:

> "Should the bottle be held in any particular position when examining the level of water inside it? Discuss with your teacher."

This is one of the major problems with *Bal Vaigyanik* – an uncertainty about the role of the teacher. In many instances it appears as if the question a teacher would normally ask or should ask in a given situation is made part of the chapter itself. For instance, Experiment 1 from "Air" in the example cited above actually replaces an introduction. The teacher could initiate the discussion in many different ways. A process of discovery can hardly be pre-empted. Indeed, this struggle to retain the flexibility in the process while fitting it in a framework of a syllabus is evident in many chapters.

Perhaps it would be better to completely do away with the textbook in a discovery-based learning methodology. The teacher would then have only the outline of a chapter and would have the flexibility to structure the classroom activity accordingly. The framework would, however, have to be fairly detailed and based on an in-depth understanding of the topic. It would also contain experiments and activities. It should describe a process to be undertaken with children and the teacher should have the freedom to decide what exactly to do in a particular classroom.

An even better approach would be to let the children's questions determine and inspire the learning process. The role of the teacher would then be to place these questions in their proper perspective and suggest appropriate experiments and activities for exploration. One such experiment was carried out in the Science Education and Communication Centre of Delhi University under the supervision of resource persons associated with the HSTP, with many from the HSTP group participating in different ways. However, this is not the appropriate place to discuss this experiment, which was called "Science and Technology Literacy for All".

In the present educational scenario, a textbook is considered essential for school education. Although, *Bal Vaigyanik* was there, the parents always complained that it had nothing that the children could memorise. They also complained that they didn't have a clue about how to prepare their children for the examinations. *Bal Vaigyanik* just didn't fit into their idea of a textbook. So one can well imagine the trauma of the parents if there were no textbook.

There is another equally important aspect of excluding information in the textbook. The writers of *Bal Vaigyanik* knew that children would need information at different stages in the learning process. At places, such information would guide them to put their conclusions in a perspective. Or it would help them understand which new experiment to do or how to reach a conclusion. The authors of *Bal Vaigyanik* came up with a way to get around this problem. Wherever information was needed, they instructed the children to discuss the matter with their teacher. Similarly, there are questions which ask the children to discuss among themselves to find an answer. These are two indicators of the situations where the teacher is expected to play a different role. These questions can't be answered solely on the basis of the experiments but require additional information, reasoning and experience. The teacher is expected to provide these additional inputs.

One advantage of this arrangement is that there is no need to give the information in the textbook. The teacher can decide how much information to give and in what manner to give it, based on the situation in the classroom. This saves *Bal Vaigyanik* from the information load. But the disadvantage is that everything now depends on how well the teacher understands the subject and how skilled and prepared she is to deal with the situation. This is one area that requires further innovation.

The teacher's guides, supplementary reading materials and annotated editions of *Bal Vaigyanik* were seen as part of this arrangement, although these have not proved fully satisfactory. The later editions seem to have adopted a more liberal approach. Many changes were introduced in the third edition, including incorporating some supplementary materials within the textbook.

These changes in the later editions were a result of the emergence of a school of thought within the HSTP group that *Bal Vaigyanik* had become too terse and dry, with a rigid and monotonous question-experiment-question-experiment format. Doubts were raised as to what effect does it have on the observations and conclusions if an experiment is conducted without any prior expectations. A study conducted in a few schools by Anita Rampal, a resource person of the HSTP, showed that if there is no clear expectation or hypothesis, children fail to make even fairly obvious observations. For example, if you place a magnet below a cardboard sheet on which iron filings are spread and if you gently tap the board, you can clearly see the magnetic lines of force as the filings rearrange themselves. But for the children involved in this study, it still remained a jumble of iron filings. Another problem with *Bal Vaigyanik* chapters was that most experiments started with no pointers as to why they were being performed. This tended to dampen their enthusiasm and deprive them of an important aspect of science, viz., presence of some hypothesis before undertaking an experiment.

It was becoming clear that some elements of learning were being overlooked in the single-minded pursuit of 'learning by doing'. For example, reading about experiments conducted by other scientists, making use of historical development of the subject under study, reading interesting narratives and being able to view one's own activities in a larger perspective.

The issue was intensely debated in the HSTP group but many resource persons continued to strongly believe that introducing such additional elements would weaken the experiment-based discovery approach. They felt that stories and histories would predominate and overwhelm the experiments, weakening the process of learning by doing.

In the meanwhile, it was also being understood that 'information' does not necessarily mean supplying conclusions of the experiments and/or providing definitions and laws. In a wider sense, information means appropriate descriptions and narratives which would excite children to think, present a broader perspective and relate whatever they learn to a variety of situations/contexts.

Rigorous pursuit of learning by doing raised another problem as well: several topics, such as nutrition in plants, force, crops, growth and development, were being left somewhere half-way. These were pursued only to the extent experiments were available or could be designed at the middle school level. On the other hand, there were topics for which excellent experiments were available but the level of thinking and reasoning necessary to make sense from the results of these experiments (especially with the available teachers) was beyond the middle school students. Nevertheless, these topics were included in *Bal Vaigyanik*. The limited capabilities of the teachers to guide them also did not help in the matter. Nevertheless, a few such chapters were included in *Bal Vaigyanik*, the most striking examples being "Looking at the Sky" and "Chance and Probability" (first edition, 1978-1980).

Another practical difficulty with *Bal Vaigyanik* was the problems the parents faced at home when they tried to help their children in their studies. They did not know what to do with the textbook or how to use it. This was because *Bal Vaigyanik* was never visualised as a stand-alone textbook. Of course it addressed the children directly, but its purpose was to prescribe a process that would be taken forward by the combined efforts of the children and their teacher. The children were not expected to sit alone, do the experiments, and answer the questions to reach the required conclusion. Rather, they were supposed to work together to look for answers, taking the guidance of their teacher wherever necessary. The teachers were trained to guide this process but the parents were nowhere in the picture.

Supplementary material: a mirage

As pointed out earlier, the HSTP resource group never underestimated the importance of information. It was just that its understanding was evolving. For example, in 1983 it stated:

> "We avoid giving information from our side. But we have given whatever minimum information is needed, after carefully assessing the situation, to help children take the experiments forward or analyse their observations."

It is clear that at no stage was information looked at as a means of learning. It was used only when all other alternatives were exhausted. Even then it was used stingily and with caution. The fear was that if information was included, children would begin memorising. Thus, this understanding about information takes the form of patchwork. Information was never seen as an integral part of the process but only as a compromise.

However, the problem was recognised quite early in the biology chapters. A note on these chapters, written in 1990, brings this out:

> "Given the nature of biology, it is impossible to adopt the same approach as in physics and chemistry. You cannot completely cut out information and terminology in biology."

Awareness of the importance of information and descriptions in learning grew slowly and began to be expressed in different ways. One more idea was that the teachers should be equipped with 'additional information' on various topics. But simultaneously, there was a fear that the teachers would burden the children with this information. Another demand was for teacher's guides. It was thought that these guides could contain the information that teachers need to be able to carry discussions forward in the classroom.

The information issue came up for discussion in a workshop organised in October 1985 to discuss the revision of the *Bal Vaigyanik* textbooks. Almost all the chapters were reviewed in depth during the workshop and many suggestions for improving them were made. Among them was the need to include more information in some chapters. There were also suggestions to provide the information in the teacher's guides or as supplementary material. However, it was never clear as to what form this supplementary material would take and where and how this would reach the children. Thus, this suggestion never took a concrete shape. Around this time, Eklavya had launched a children's science magazine – *Chakmak* – and many felt this magazine could serve as a vehicle for bringing supplementary material to the children.

Another suggestion was to add some portions containing information to *Bal Vaigyanik* with the stipulation that questions on this content would not figure in the examinations. This suggestion made it clear that the central issue was not whether to provide information or not but the fear that there would be pressure on the children to memorise such content.

Decision was taken not to include information in the second edition of *Bal Vaigyanik*. At least, no one took the position that information should be included as a learning tool.

The report of the Ganguli Committee set up by the central government proved to be a watershed in this debate. The committee fully agreed with and supported the HSTP's curricular objectives and methodology but also expressed concern about the imbalance between the 'method' and 'product' aspects of science in *Bal Vaigyanik*, pointing out that the product aspect had been almost totally overlooked. The 'product' was a reference to scientific definitions, laws, theories, etc. The question the committee raised concerned the HSTP's view on transferring 'accumulated scientific knowledge' to students.

The report of the committee was an important reference point in the *Bal Vaigyanik* revision process which began in 1994. However, the group felt constrained in this regard. The group had no model to present information in a manner which would encourage the process of critical thinking in students. Available models were of information-based curricula that focused on children memorising whatever information was given. The challenge was to devise a new approach. The apprehension was that information would replace any experiments or activities, or dampen the excitement of discovery, or render the experiments redundant. These were unacceptable to the HSTP group. However, once these limits were breached creatively, the group willingly accepted chapters based on information. The third edition of *Bal Vaigyanik* included several chapters in which information or descriptive content was blended into the learning process. Some examples are "Questions and Answers about Crops", "Nutrition in Plants", "Force, Force Everywhere", etc.

Flexibility of the curriculum

The HSTP's understanding of curriculum was not limited to the textbook. Although, individual chapters were based on different topics, a common purpose of all chapters was to highlight the method of science. The course a chapter would take in the classroom depended on the teacher and the children. Influencing factors included the interest and ability of the teacher, the atmosphere in the classroom and so on. That's why one could not foretell the time required to complete any particular chapter. Nor could one predict what all children would learn when it was completed. That would depend on how each layer of the chapter unfolded. As Vijaya Varma commented,

> "We have emphasised that children should learn through their own efforts. It isn't necessary that the teacher alone is the guide; what's important is that the children should be participants in the process."

This flexibility did make life more difficult for the teachers, who were used to transacting a predetermined curriculum where their only job was to complete the lessons in the textbook. Here they often found themselves in situations where the discussion after an experiment became so involved that it took up the entire day. Or an experiment was not done properly and it became difficult to proceed. Or a child or a group would come up with a different observation about an experiment and time would be spent in resolving the issue. But one has to factor in for these hazards of discovery approach. During the teacher training sessions at least, there were times when an experiment raised questions that needed new experiments to be done, leaving the chapter and the session planning in a limbo.

The traditional practice in the education department is for each teacher to make a 'syllabus'. Quite often, the department makes the syllabus and hands it over to the teachers. Thus, the syllabus, also called a unit plan, is a plan for the whole year based on pre-determined time alotted to each chapter, if not to every part of a chapter. It was impossible to construct such a syllabus for *Bal Vaigyanik*. The demand for such a syllabus in the HSTP was a constant refrain of the teachers and the education department. The HSTP group resisted but eventually capitulated and made a 'syllabus' that was distributed. The anguish the exercise caused in the group can be seen in the following covering letter sent along with the syllabus:

> This unit-wise science curriculum is a compromise we have reached after four long years of dialogue with you and the education department. We believe that there is a contradiction between an experiment-cum-activity-based pedagogy and a programmed unit-wise syllabus. That is why we request you to view this unit plan as an outline and not a constraint. The

> challenge to your enthusiasm, imagination and initiative is to break the boundaries of the syllabus and inspire your students to think independently. We are optimistic that if you transcend its limits it will give a new direction to the science teaching programme (January 9, 1977).

Actually, this is applicable to any process of curriculum development. Especially, it should be a basic requirement when a single curriculum is being planned for the entire country. However, at the time of the district-level expansion of the HSTP in May 1978, it was imperative that there be a textbook whose syllabus could be completed in a school year. This is how the HSTP 'syllabus' came to be fossilized, putting a question mark on the flexibility of the curriculum. Was this a positive or a negative development? One doesn't know.

From what has been said until now it is clear that the HSTP curriculum went far beyond *Bal Vaigyanik* and its content. What its chapters did was define a process to give concrete form to the different elements of the curriculum. Later, we shall discuss these elements in more detail. We will also trace the evolution of these elements from the first edition (1978) to the third edition (2000).

But before we proceed it may be useful to have a look at the framework of a typical *Bal Vaigyanik* chapter. In the next chapter, we look at the structure of a *Bal Vaigyanik* chapter and try and highlight a few more elements of the curriculum.

5

THE STRUCTURE OF A CHAPTER

The following discussion is based on the first edition of *Bal Vaigyanik* (1978-80), although reference is made to the later editions wherever necessary.

As was said earlier, the *Bal Vaigyanik* chapters are strictly based on discovery approach. We shall discuss chapters later, but first let us take a look at a typical chapter.

The content is presented according to a well thought-out plan. The starting point is usually some aspect of the local environment. A series of questions is asked to bring out and systematise whatever information and understanding children already have. The next step is to develop this understanding with the help of some experiments, which they have to perform. Instructions are given for performing each experiment, followed by a series of questions about the experiment, given in a logical sequence. These are the kind of questions that experience tells us are likely to arise or should arise. The children are expected to make sense of the data they collect from the experiment, and arrive at some logical conclusions. This is the general procedure.

Different *Bal Vaigyanik* chapters initiate this process in different ways. In some, questions are asked to first bring out the understanding of the children. For example, the chapter "Volume" in class 7 asks:

> How many cups can you fill from a pot of tea?
>
> How do you measure the milk you get from your cow?
>
> Is the weight of one *pai* of paddy equal to the weight of one *pai* of wheat?
>
> If their weights are not equal, then what is equal between the two?

(*Pai* is a vessel used to measure grain and other things.)

Some chapters begin with an experiment or activity which raises some questions related to content of the chapter. For example, the chapter "Why Do Things Float" in class 8 states:

> You may have seen that some things float on water while some things sink. Have you ever put things that float in water in kerosene to see what happens?
>
> Take a boiling tube and fill half of it with water. Pour about 15-20 ml of kerosene in it. Now drop 2-3 coloured buttons, 1-2 pins, some bits of matchsticks, small balls of paper, small pebbles, some sand, pieces of wax, etc., one by one into the boiling tube and observe what happens.
>
> Cover the mouth of the boiling tube with your palm, shake it well and then place it on the stand. After a while, observe what has happened in the boiling tube.
>
> ...Why do different things behave in different ways? Which things float in which liquid and which things sink? How can you make iron float in water? You will get answers to these questions in this chapter.

The next step in every chapter is to instruct children how to do a set of experiments or activities. A series of questions is asked after each experiment which helps them record their observations, analyse these observations and derive some conclusions. This is the broad framework.

A person merely reading these chapters is unlikely to get a true picture of the nuances and depth of the *Bal Vaigyanik* content because simply reading *Bal Vaigyanik* chapters does not give much indication of the kind of wonders they can produce in the classroom. One needs to go into other things to get a better understanding.

In a way, *Bal Vaigyanik* can be seen as an incomplete book. It contains only instructions to do experiments followed by a host of questions. It is completed only after the questions are answered. *Sawaliram*[1] explains this in the following manner:

> Your textbook asks questions after every experiment and field trip. Every question is numbered. You must note the number of the question in your exercise book before writing the answer...Your textbook has the questions and your exercise book contains the answers. The two together make a complete book.

But *Bal Vaigyanik* is not just about questions and answers. There is a whole process between the questions and the answers that the children have to navigate. This is a process of performing experiments, making observations, discussing the observations in the classroom, tabulating and analysing data, and then drawing conclusions that can be developed into theories and laws. *Sawaliram* explains this process in the 1989 edition of the class

[1] *Sawaliram* is an imaginary character created by HSTP to carry on a continuing dialogue with children. Experiences with this character are discussed later.

8 *Bal Vaigyanik*:

> You have to find answers to the questions asked in *Bal Vaigyanik* yourself by doing the experiments. You must then discuss among yourselves to decide what is right or wrong. If you just get the answers from somewhere without doing the experiments, do you think you would ever learn the way to look for and discover answers?...Would a person giving you readymade answers be doing you a favour or a disservice?

This was written at a time when some teachers had started dictating answers in the classroom, thus undermining the discovery approach. Some publishers had even prepared *Bal Vaigyanik* 'guides' and were pressurising booksellers to stock and sell them, the condition being that children could buy *Bal Vaigyanik* only if they also bought the guides. It's another matter that these guides never became popular.

The different elements of the HSTP curriculum are woven in almost every *Bal Vaigyanik* chapter. Which element is developed best in which chapter in a particular class depends on the interest, skills, confidence, knowledge base and understanding of the teacher, the enthusiasm of the children and the atmosphere within the classroom.

Viewed from this angle, there are two parts to each chapter, both equally important. First is the subject matter, which could be magnetism or food and digestion. Second is the teaching methodology, which is more or less similar in most chapters and involves performing experiments, making and recording observations, organising and tabulating data, recognising patterns in the data, arriving at conclusions through critical analysis and reasoning, confirming the results on the basis of previous knowledge and experience, and explaining your findings in your own words. These aspects are integrated into the syllabus; hence the need to give a separate note on 'scientific method' or 'science in our lives' was never felt.

There was, however, one limitation that needs to be pointed out. From the beginning it was felt that topics in biology cannot always fit into this typical framework. While it is easy to use experiments as a base to study concepts in physics and chemistry, it is difficult to rigorously follow this approach in biology. Sometimes it is necessary to give some technical terminology or information/definitions. Thus biology chapters in *Bal Vaigyanik* can be divided into three broad types:

1. A large number of chapters are based on field trips and seek to familiarise children to the environment in which plants and animals thrive. Chapters related to leaves, roots, crops, agricultural pests, life cycle of animals, insects belong to this category.
2. Those based on hands-on experiments. Chapters like "Seeds and Germination", "Food and Digestion", "Sensitivity", "Growth", "Development", "Respiration", "Internal Organs of the Body", and "Living World through a Microscope" fall in this category.
3. Those developed around discussions based on childrem's prior knowledge. Some examples include "Living and Non-living", "Classification" and "Animal Reproduction".

Although various elements are woven together, it would be useful to discuss them separately. This will help us look at each element in detail and also clarify how the curricular understanding was given a concrete shape.

A look at the first edition of *Bal Vaigyanik* (1978-80) shows that many chapters tend to begin abruptly. No background is given. This became a major point of criticism later on. Actually, it's not only in the beginning of each chapter but in several other places as well that one sees such abruptness.

To illustrate the point, look at the beginning of a few chapters from the class 6 *Bal Vaigyanik*:

Chapter 2 ("Learning to Make Groups"): "Write the names of all the children in the classroom in serial order (1)."

Chapter 6 ("Force and Weight"): "What is force? When we lift a weight, be it a bucket filled with water or a sack of grain, we feel a tightening in the body. Do you experience the same feeling while drawing water from a well or ploughing a field? (1)"

Chapter 8 ("Seeds and Their Germination"): "Village life is linked to agriculture. Farming normally begins with the seed. Make a list of those crops that do not grow from seeds. (1)"

Chapter 9 ("Electricity – 1"): "*Preparation* – Get a cell from your torch or radio at home to do this experiment. After performing the experiment replace the cell in your torch or radio."

Chapter 11 ("Measuring Distance"): "How do you measure the distance between the *gilli* and the base when you play *gilli danda*? (1)"

These are examples of chapters which begin with a question or set of instructions. Other chapters begin with a brief background. This is the pattern found throughout *Bal Vaigyanik*.

Experiments and activities

Detailed instructions are given on how to perform experiments or carry out activities. These directions are given both in the text and through diagrams and illustrations. The idea was to make them as clear as possible so that the children face no problem in understanding them and performing the experiments themselves.

Unlike mainstream textbooks, nowhere in *Bal Vaigyanik* are the instructions followed by a list of observations and conclusions that children are expected to draw from the experiments. On the contrary, every effort is made to ensure that they get not even the slightest indication of the kind of observations to expect. Sometimes, in this zeal, the array of questions appears just a bit too much and too complicated. But to keep up the interest of the children in actually doing the experiment, it was felt necessary to withhold observations and conclusions and to make sure that they don't get readymade answers from some other source.

The HSTP curriculum is not just about performing experiments but about striving to analyse and interpret observations. Mainstream textbooks like those prepared by the NCERT short circuit the 'learning by doing' process by disclosing both the observations and the results. It is in this respect that one can say that *Bal Vaigyanik* contains no information.

The decision to exclude all 'information' about experimental observations and conclusions was a conscious one. The understanding behind this was that giving any such 'information' beforehand would render the experiments redundant and would kill the enthusiasm of the children. This is what happens in the mainstream textbooks where all one needs to do is read the 'experiments'. This is what makes *Bal Vaigyanik* uniquely different.

However, *Lal Vaigyanik* did not take as strong a stand on this issue. The first HSTP textbook often draws conclusions by explaining to the children what they had learned after performing many of the experiments they had just done.

Incorrect observations

The possibility of children making incorrect observations when doing an experiment is very real. It could be because they are not doing the experiment properly or because they fail to make the expected observations even when they do the experiment correctly. The teachers came across both such situations in the classroom.

Sarla Naphde, a teacher in the government middle school at Jumerati, Hoshangabad, gave her view on this dilemma: "When an experiment fails, we just don't understand what the children should write in their exercise books. I feel, they should write only what is actually observed." (Follow-up report, Panchapakesan, July 3, 1976).

In such situations, the HSTP methodology expects the experiment to be repeated and made 'successful'. Take a look at the following example from a follow-up report of the government middle school at Malakhedi in Hoshangabad district about an experiment to measure the time taken for various quantities of water to fall from a burette and then making a graph from the data (follow-up report, Vijaya Verma, November 1 to 6, 1973):

November 1, 1973

Burette experiment in the chapter on time. They had all assumed that equal amount of water flows out in equal time intervals. They refused to believe in the experiment which shows that this does not happen. When they let the water flow by removing the finger from burette's mouth for 5 seconds several times, and found that the results are reproducible, children showed some doubts but there is strong feeling that the experiment has failed.

November 6, 1973

Most probably they have not repeated the burette experiment. We set the experiment again, making arrangement for water to fall drop by drop. The flow of water reduces with falling level of water but the students insist that this anomaly is due to some impurity in the water. We repeated the experiment and found that results were different – children felt that they were right and were happy. We filtered well water and using the finger as a stopper, measured the height of water (in the burette) every five seconds. When they saw that the drop in height reduces with passage of time, they again said that it is because of impurity in water. But this time the results were reproducible, and everybody took turns to open the burette and measuring the time. Ultimately they were convinced that equal amount of water does not flow out in equal intervals of time, and stopped saying that the experiment has failed.

But what happens if the children do the experiment incorrectly or if they make 'wrong' observations? This is a valid question to ask but it should be seen as a challenge rather than a problem.

The challenge is to make the experiment so simple and foolproof that there is little scope for procedural mistakes or incorrect observations. In other words, it means increasing the 'tolerance limits' of experiments. But more important, even if wrong observations are made, the teacher should see them as an opportunity to further the educational goals.

Anyway, it should be admitted that if no experiments are done in the classroom, teaching-learning process would break down because the children cannot make do by only reading their textbook at home. When seen in this light, *Bal Vaigyanik* makes greater demands for teacher's active role in the learning process.

There is another important aspect of the *Bal Vaigyanik* experiments that needs to be noted. They are not 'verification' experiments. Which means that they are not expected to prove an already known law or hypothesis. Verification experiments are the norm in high schools and colleges. Without going into an analysis of how useful these experiments are in a learning process, it suffices to state that the *Bal Vaigyanik* experiments are primarily used as a base to learn how to construct a hypothesis or law.

A third aspect of the experiments in the HSTP textbooks is that, barring a few exceptions, all are meant to be performed by the children, not demonstrated by the teacher.

Idea of experimental control

> The basic issues of discovery approach soon began surfacing. For example, discussing plant life in a biology session, a teacher-farmer raised the question, "How do fertilisers 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 turning brown after cutting."
>
> Although the question appeared trivial to us, it could not be ignored. Such questions form the backbone of discovery approach, providing links to further experimentation. A heated debate followed. It was decided to modify the experiment by including a second twig placed in plain water. The concept of using 'controls' was born. ("The Hoshangabad Vigyan," *Science Today*, December 1977.)

"The snake dances to the tune of the snake charmer's flute." On the face of it there seems little ground to doubt the truth of this saying because every year when *Nag Panchami* comes, the snake charmer plays his flute and the snake dances. There are many such observations from which conclusions can 'easily' be drawn. But this 'ease' is deceptive and can be misleading. Whether it is the influence of planets on human life, the efficacy of medications or faith healing, every instance it appears that a certain action is followed by a certain effect. It is concluded that the said action is the cause of the effect. However, the reality could be something different. There could be many possible explanations for the perceived effects. For example, it could be sheer coincidence that the activity and the result occur together. Or there could be a third reason why they always occur together. Or there could be a cause-effect link between them.

In modern science, experiments are an important means of collecting information, establishing cause-effect relationships and providing proof of any occurrences. But one needs to exercise caution in using experiments for these purposes, especially establishing causal relationships. Many times there could be more than a single factor at work, which would make it difficult to draw conclusions from experimental observations. It is to avoid such confusing situations that the concept of 'control' has been developed.

In experiments with controls, all the factors apparently causing observed changes in the experiment are first identified. Then each of these factors is changed one by one – which is to say that each factor is changed while keeping the rest of the factors unchanged – and the results are observed. The problem is that it isn't always possible to do this. So the method used is to perform the same experiment simultaneously in two ways. All factors remain the same in both experiments except for one which is different. Such experiments are called controlled experiments.

Bal Vaigyanik gives a lot of importance to such experiments. At least eight such experiments have been consciously included in the syllabus for classes 6-8 and the questions asked after performing them are such that children clearly understand the importance of controls. Any good science curriculum must have such experiments because we tend to draw conclusions on the basis of observations we make in our daily life ignoring the fact that there was no provision of controls. The snake and the charmer's flute is a good example of this.

Some examples of such experiments from *Bal Vaigyanik* (1978) are given here:

Class	Chapter	Experiment
6	Food and Digestion	Effect of saliva on starch. Transport of water-soluble minerals in plants.
6	Sensitivity	Sensitivity of plants to light. Sensitivity of plants to gravity.
7	Water - Hard and Soft	Effect of different salts on hardness of water.
7	Growth	The role of cotyledons in growth.
7	Starch in leaves and Sunlight	The role of sunlight in production of starch
7	Respiration	Properties of inhaled and exhaled air.
8	Life Cycle of Animals	Examining the concept of spontaneous generation.
8	Reproduction in Plants	The role of the male in reproduction.

Interestingly, most of these experiments are in the biology chapters. This is, perhaps, because investigating things in biology is more complicated due to the greater intermeshing of causative factors.

Bal Vaigyanik repeatedly cautions children that any experiment may be influenced by more than one factor and they should be careful to take all these factors into account while drawing conclusions. When investigating a hypothesis, they are encouraged to control all counfounding factors. This can be seen in the following example of an experiment to investigate the role of our ears in tracing the source of sound ("Sensitivity – Perceiving Our Surroundings", class 6, third edition, 2000):

> Ask a child to sit on a chair placed in the centre of the classroom. Blindfold her.
>
> Four children should now stand at a little distance around her – one directly in front of her, another behind and the other two on either side. The next step is for the children to clap one by one, but in random order. The blindfolded child should point in the direction from which she thinks the sound is coming.

When this experiment was performed in the government middle school in Rani Pipariya (Sohagpur tehsil), the other children in the class observing the experiment saw that the blindfolded girl could easily identify the direction of the sound coming from her left and right but was confused about the direction of the sound coming from the front and the back – or above her head. After the experiment, they were asked why she had been blindfolded in an experiment that dealt with hearing sounds with her ears. They very enthusiastically said that if she were not blindfolded she could easily see from which direction the sound was coming.

There are many such experiments in *Bal Vaigyanik* that give children an opportunity to develop their reasoning powers. They are even urged to design such experiments.

One such example is seen in a chapter from the class 7 workbook (third edition, 2001). Children do not perform an experiment but are asked to analyse the observations from a set of experiments done elsewhere:

A scientist performs some experiments to test the sensitivity of snakes. He makes the following observations:

A. He blindfolds the snake and plays a snake charmer's flute. He sees that the snake is not affected by the sound of the flute.

B. He then drags a chair on the floor and observes that the snake reacts to the sound.

C. He now removes the blindfold, stands in front of the snake and makes the motion of playing the flute, but without any sound coming from the flute. The snake sways to the motion of the flute.

D. Instead of the flute, he now holds a rod in his hands and repeats the motion. Again the snake sways to the motion.

Answer the following questions on the basis of this experiment:

Does the snake sway in response to the sound of the flute?

How did the snake sense and respond to the sound of the chair being dragged on the floor?

Other sources of information

Bal Vaigyanik consciously tries not to limit the learning process to the textbook. Many chapters, especially in biology, emphasize field trips and surveys. The field trips have diverse objectives. In some cases, children are asked to collect samples and specimens of different things while in others they are asked to observe and study plants and animals in their natural habitat. Sometimes they are even expected to perform experiments *in situ*.

Children can also collect information through surveys. Some examples include surveys of malnutrition among children, or crops and factors damaging them. In some chapters children are expected to contact and invite specialists and professionals – like the local veterinarian or Agriculture Extension Officer – to discuss various topics with them in the classroom.

Field trips

An important component of an environment-based curriculum is going outside the classroom to study the surroundings; in particular the soil, water, plants and flowers, crops, insects, birds and animals, etc. should be studied in the open air.

The HSTP placed a lot of emphasis on field trips. Wherever possible, children are asked to go out of the classroom to study their surroundings and are given clear instructions about what to observe, what to do and what samples to collect. Nowhere have the field trips been short-circuited by statements such as 'if you look around...' .

Some chapters, like "Soil, Stones and Rocks", "Flowers and Fruits", "Grouping of Leaves", "Reproduction in Plants", "The World of Insects", "Our Crops and Their Grouping", etc., are almost exclusively based on field trips and field observations. Others like "Water – Hard and Soft", "Food and Digestion", etc., are based on conducting experiments with materials collected directly from the surroundings.

The success of this element of the curriculum crucially depends on how much the teacher knows about the environment. It is natural for children to observe and ask innumerable questions about insects, plants, animals, crop diseases, weeds and everything else they encounter. They are curious about these things. If the teacher is unable to answer their questions the field trips would become sterile exercises of collecting specimens and samples. That's why it was once even suggested that *Bal*

Vaigyanik should have a companion field guide to the environment that could be taken along on field trips. But this project never took off.

However, it must be admitted that, unfortunately, field trips was the first element of the HSTP which became defunct. They just didn't happen in most schools. Even where field trips were undertaken, they were limited to collecting specimens and samples. Of course, one could argue that there must have been constraints of time and management, but this cannot disguise the fact that most teachers were not convinced or enthused about the educational value of these exercises. That would be too much to expect from a teaching community habituated to textbook learning. And in any case, examinations determine the school education scenario and it was true that the field trips did not impact the exam results.

It appears that the HSTP group accepted this situation as a *fait accompli* because we see the framework of field trips changing in the second and third editions of *Bal Vaigyanik*.

First, it was felt that if the purpose of field trips was solely to collect samples it would be easier to tell the children to collect them on way to school from their homes. Where field trips were retained, it was mandatory that children must undertake some activity or make some observation in the field situation. For example, in field trips to study plant life, they were asked to observe the arrangement of leaves on plants and make sketches of them in their exercise books. This was one way to make these excursions more meaningful.

The restructuring of several chapters also saw the exclusion of experiments conducted during field trips, although some other chapters did see the introduction of new experiments.

The barrage of questions

Questions are asked after every experiment in *Bal Vaigyanik*. These are of two kinds. First are those that focus on the observations children are expected to make and help them note these down in an organised manner in their exercise books, sometimes even tabulating their data.

There was a problem with such questions, which was addressed in the third edition of *Bal Vaigyanik*. The problem was that the questions always followed the experiment. During the experiment, children had no clue about what observations they were supposed to make. Obviously, many things happen during an experiment. They were absolutely clueless about the objective of the experiment and did not know where to focus their attention. In the first edition of *Bal Vaigyanik*, many experiments didn't have any background references. Their connection to the previous experiment too was often unclear. So children didn't have any expectations and did not know what they needed to focus on.

One probable reason for asking questions in this manner was that the resource group felt that the experiment would become meaningless if even the slightest inkling of what is to be observed is given. There is another more likely reason. The teacher was supposed to establish the background and framework of the experiment through discussions in the classroom. The expectation then was that the teacher and the children would carefully read the entire related portion before doing the experiment.

Whatever the reason, one of the criticisms *Bal Vaigyanik* faced was that it was very terse. This criticism was addressed in the third edition, which made the experiments more meaningful. Unfortunately, this process was short-circuited by the closure of the HSTP and feedback on these changes is not available. In this edition of *Bal Vaigyanik*, the children are often asked to guess the kind of observations they expect to make before doing the experiments, which encourages a hypothesis building attitude.

Another criticism about *Bal Vaigyanik* was that there are far too many questions. Of course, questions need to be asked in a logical sequence to help children build up a theory step by step. This may be why so many questions are asked. However, no distinction is made between questions which help mere recording of observations, those requiring a discussion leading to answers, and those whose answers would lead to the overall conclusions children are expected to draw from the experiment. All these different types of questions are undifferentiated and given equal weight.

It is hoped that the teacher will ensure that all children make the 'correct' observations by seeing all the observations. If that does not happen, the 'incorrect' observations will be discussed to try and figure out whether something may have gone wrong in performing the experiment. It is natural for children to make mistakes while doing experiments themselves. In a class of 10 groups, the likelihood of several groups doing the experiment correctly is high, so the teacher can use this variation to suggest the need for repeating the experiment. But this is a delicate task because the implicit suggestion then is that there *is* a 'correct' observation to be made which the teacher knows. It requires cleverness and skill to handle the situation and organise such a discussion.

Once the observations are recorded, another set of questions is asked. These questions are different from the earlier set, although the textbook gives no indication of the difference. They help children to explain their observations. For explanation, children will make use of their prior knowledge in addition to the observations of the experiment. Ideally, every child gets an opportunity to present her/his explanation as well as challenge others and try to understand them. In this dialogue and discussion, teacher's involvement is crucial. (S)he is not expected to provide the 'correct explanation'. Instead, (s)he is expected to facilitate a classroom discussion about the explanations coming forth, pose questions to help children clarify and refine their answers, connect and examine them in the context of other experiences and if necessary suggest further experiments to decide between competing hypotheses and help them perform such experiments. This process is as important as reaching the correct conclusion.

A look at children's exercise books reveals another thing. Usually the children would note down these answers along with the questions given in *Bal Vaigyanik*. More often, the answers were dictated by the teacher. However, they give no indication of the process through which they arrived at their answers. So it is difficult to tell how much the children may benefit if they read these answers a few days later.

Building and developing models

One important activity to improve understanding in science is model building, both physical and mental. Historically, scientific understanding has depended a lot on building models of real phenomena, whether of the solar system or of the atomic structure.

Bal Vaigyanik familiarises children with model building. The first edition has many examples, although their number is fewer in subsequent editions.

Some examples from chapters in the first edition (1978-80) are given below:

Chapter	Model
Soil, Stones and Rocks (class 6)	Brick kiln to understand how rocks are formed.
Living World through a Microscope (class 8)	Various models to understand the three-dimensional structure of cells.
Electricity – 3 (class 8)	Toy (electric) acrobat to understand the right hand rule.
Looking at the Sky – 2 (class 8)	Various models to understand the apparent motion of sun/moon; phases of moon; solar/lunar eclipses; and heliocentric solar system.
Internal Organs of the Body – 2 (class 8)	Various models to get a feel of the arrangement of organs in the body.

If you see an illustration of a dissected body in a textbook, you cannot figure out how organs are arranged in the body, not in the least that they are found in various planes. The HSTP tried to address this problem. The kit provided to each school contained two preserved specimens of dissected rats. The children could get a fair idea of the internal structure of the body. This was perhaps the first time that such specimens were made available in middle schools. For many teachers, it was the first time that they had seen the internal organs of an animal.

After observing these specimens, children were asked to build a paper model of the human body.

Children loved the activity. The kit supplied with the textbook contained a diagram of the outline of the human body printed on a sheet of paper, with diagrams of each organ given separately alongside. The children had to cut out the organs and fit them in the positions shown in the body outline in a given order. When this was done in the proper sequence, organs got arranged in their correct place and layer on different planes, just as they are arranged in our bodies. This activity was later developed as an independent teaching aid.

Many models were included to create mental images in the minds of children. These models were thought-provoking but most teachers found them quite difficult. One example is the model of the living cell. Children need to understand that cells are not flat and two-dimensional, as they appear to be when seen through a microscope. The HSTP tried to do this by familiarising children with the concept of longitudinal and transverse sections. They were asked to imagine how various things would look if sectioned longitudinally or transversely and then draw a picture of the original.

Models were also used in the chapter "Looking at the Sky". But these were much more abstract. In this chapter children conduct experiments to chart the path of the sun and the moon in the sky, after which they chart the paths of stars too. Through a process of reasoning they reach an understanding that these paths would remain the same regardless of whether the earth rotates on its axis or whether the other heavenly bodies revolve around the earth. They are then asked to figure out which would be the more acceptable explanation for their observations.

Models were also constructed to understand eclipses and the phases of moon.

Children generally found models linked to astronomical and microscopic observations fairly difficult to understand. This could possibly be because they could not visualise or comprehend things on a micro or mega scale.

The use of models as learning aids was severely restricted in the second edition of *Bal Vaigyanik*. The model of the internal organs of the human body remained, as did the model of the phases of moon, but as a component model buiding became negligible. This did not happen intentionally. Rather, they became the first casualty when difficult portions of the textbook were earmarked for removal. This was especially true of models that demanded a high level of abstraction. What was, in fact, needed was to take learning through model building as a challenge and include a few simple and novel activities in the content.

Manual skills

Bal Vaigyanik often demands that children make different kinds of artefacts, especially equipment or apparatus required for doing the experiments. Some chapters exclusively focus on children building things for themselves, such as "Fun and Games" (class 6), "An Interesting Game" (class 7), "Machines" (class 8), etc. Others require them to make some apparatus, such as "Principle of Balance ", where they are asked to make a balance and perform experiments with it. Similarly, they make a measuring scale in "Measuring Distance", a measuring jar in "Volume", black boxes to observe sensitivity of plants to sunlight in "Sensitivity", envelopes to collect leaf samples during field trips, and so on. In some other chapters they make gadgets to illustrate the principles they have learned, like a pin-hole camera, periscope, kaleidoscope, telescope, microscope, etc., in "Light", hand-pump in "Air", electric motor in "Electricity – 3", lactometer in "Why Do Things Float", and so on. *Bal Vaigyanik* gave detailed instructions for making these gadgets and the required materials were provided in the kit to ensure that the children actually made them.

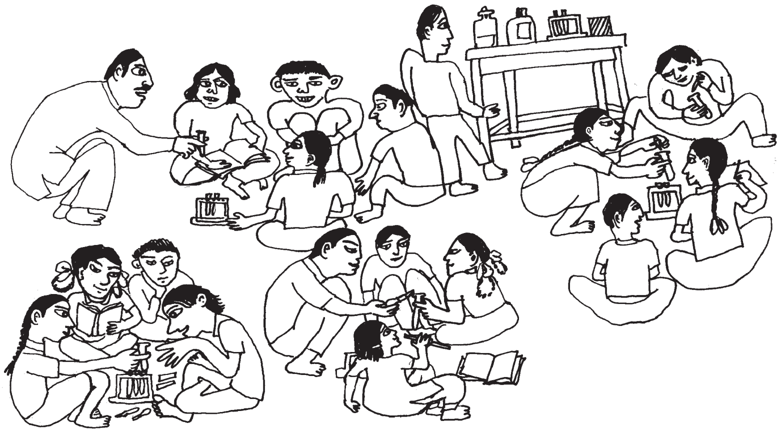
We shall now discuss two important components of the HSTP curriculum that seldom figure in any of the curricular statements but were nevertheless an integral feature of all classroom activities. These are working in groups and creating an environment for open discussion in the classroom to ensure that all decisions and conclusions are reached collectively.

Learning in Groups

A look at the HSTP chapters shows that learning is not seen as an individual activity but as a collective process. Ordinarily, textbooks are written with a view that a child will read them alone and learn everything. A lot of emphasis is put on the child sitting alone in a quiet and peaceful atmosphere where (s)he can focus all her/his attention on the textbook. *Bal Vaigyanik* creates a totally different, almost opposite learning environment.

The feature that most distinguishes this environment is the 'group', refered to as *Toli* in *Bal Vaigyanik*. *Sawaliram*, the fictitious character who holds a continuing dialogue with children, introduces the idea of group learning in a letter addressed to them:

> "You will perform experiments in groups of four. So choose your companions."



The teacher is expected to organise the class into groups of four children each at the beginning of the school year. The experiment kit is designed on the assumption that all the activities in the class will be performed in groups. So the number of sets of kit for each class is calculated on the basis of the number of groups in the class.

Working in groups to perform experiments brings down the cost of kit materials required for each class. It also has critical impacts on the learning process. Firstly, it changes the basic architecture of the classroom and the way it functions. In a conventioanl classroom, children sit in rows facing the teacher. In an HSTP classroom they sit in groups of four, discussing whatever they do or observe, the kit and other learning materials placed in their midst. The teacher often finds it difficult to draw the attention of children in such an ambience, so engrossed they become in whatever they are doing. There is a lot of commotion and noise in the classroom as children discuss excitedly among themselves and move around the classroom to see what other groups are doing, or to collect more kit materials to pursue their own experiments. In fact, one of the criticisms levelled against the HSTP was that it bred indiscipline in the classroom. High school teachers on follow up visits to the HSTP schools or even the fellow teachers in other classes usually complained that the HSTP classrooms were too noisy.

Interestingly, when the programme was shut down, one thing former HSTP students recollected most fondly was working in groups. Even the teachers liked the arrangement. Most teachers and students saw group learning as a unique experiment, with the students repeatedly pointing out that they learned a lot from one another in the group. They also pointed out that the whole class participated in discussions to draw conclusions from the experiments they conducted. They felt that working in a group made their friendships more meaningful. The teachers found that they were able to develop strong professional links with their peers during their training sessions, where they also worked in groups. One teacher Sunila Masih even presented a paper on group learning at a National Seminar on Science Teaching (2002). She observed:

> "Working in groups led to discussions among children, countless conflicts in argument, the opportunity to analyse, review and sharpen understanding of the topic under discussion, and collective thinking in reaching conclusions."

She also found that:

> "It put an end to the tendency among teachers to lecture endlessly while at the same time it enabled the students to learn from one another's experiences."

In a good classroom where group activity flourished, it was often difficult to spot the teacher. (S)he was seldom to be found in her traditional spot in the classroom (in front of the blackboard) but kept moving from group to group, helping and guiding the students. On their part, students were free to call the teacher to their group, and they often did, to show the result of an experiment or to ask for help.

By making the students more autonomous, group functioning reconfigures the 'latent' power equation in the classroom. The shift may have been partial but it was not trivial.

Working in groups has an element of collectivity in learning. It pervades *Bal Vaigyanik*. Children are constantly exhorted to discuss, compare observations and exchange information among themselves. They are not expected to sit alone and answer the questions asked at the end of each experiment. True, the children in each group note down the experimental observations of their group. But when it comes to explaining the observations, ideally the teacher is expected to ask each child to present her individual explanation, giving reasons, and then allow other children to offer their comments. The teacher may ask questions to take the discussion forward. In other words, the process of reaching conclusions from experimental observations is a collective activity and the conclusions represent a shared understanding.

Although this is a common process implicit in *Bal Vaigyanik's* content, at places it is specifically mentioned that the conclusion should emerge after collective deliberation.

In some chapters or topics it is absolutely necessary to analyse the observations of the entire class in order to reach a conclusion. Without such collation one cannot proceed to the next topic or chapter. Two such examples are "Variations in Measurement" and "Chance and Probability". In these chapters, the activities can progress only if the results from the experiments conducted by all the groups are entered into a common table.

To understand the concept of approximation and variations in measurement, all the children are asked to measure the blackboard in the classroom. A collective process then follows, in which they identify and weed out totally wrong measurements, make a histogram from the remaining 'correct' measurements, find the average measurement and so on. This is a collective activity.

In "Chance and Probability" (class 8), the first activity following the introductory questions is a game – the 'Heads and Tails Race'. In the game, lines are drawn in chalk on the ground. The players stand on the middle line and each of them tosses a coin. If the coin lands heads up, the player moves a step forward to the line in front. If it lands tails up, the player moves a step backwards to the line behind. The players keep tossing the coin and moving forwards or backwards after each toss. Each player keeps a record of all her forward/backward steps to show her location after each move throughout the course of the game. The teacher then prepares a collective chart showing how many players are standing on each line at the end of each move. The children analyse the two charts – individual and collective – together. They try to see if a pattern emerges after comparing the charts. The most important questions requiring to be answered are the following:

> It is possible that a student may toss only heads or another may toss only tails or a third may toss heads and tails in a fixed, repetitive order.
>
> In such a situation, on what basis would you draw a conclusion about the order of heads or tails falling at each throw ? Would you decide on the basis of the 'exceptional' results of one or two students or the results of the majority of students ? Explain, giving reasons.

> Make a bar diagram of the number of students on each line after each throw on the basis of the collective table.

The bar diagrams are then analysed. The most delightful scene in this activity is when children generate data on heads and tails by tossing dice to draw their bar diagrams and then pin these diagrams on the wall of the classroom – not just to display them but to conduct a collective analysis. Each group makes a consolidated bar diagram of all the bar diagrams generated in the class, which tells them how many heads and tails there are of the entire class after each move. The comparison of the individual and collective bar diagrams illustrates the concept of large numbers.

One has to see to believe the kind of activity generated during the teaching of this chapter.

These were examples where syllabus specifically demands that collective data is analysed and the individual data is then looked at from the perspective of the collective data. There are other places where questions that follow the experiments repeatedly urge students to discuss among themselves before giving answers. The following question in "Learn to Make Groups" (class 6, first edition, 1978) is a good example:

> Babulal placed cubic blocks, round- and rectangular-bottomed boxes, droppers, abacus beads, a microscope, saucers and chemical bottles in one group.
>
> Discuss among yourselves and try to identify the property on the basis of which he formed this group.

Or take the example in "Measuring Distance" (class 6, 1978) where the history of the measuring scale is narrated and the following question is asked:

> Why did they make scales of metal or wood? Why not of cloth or rubber? Discuss among yourselves and explain.

In "Water -- Hard and Soft" (class 7, 1979) the following question is asked after completing the experiment on permanent and temporary hardness:

> If a railway engine uses only temporary hard water in its boiler, how will it affect the working of the engine? Discuss among yourselves and answer.

These are open-ended questions that can have more than one correct answer. At least, children may come up with more than one answer. They may zero in on what they think is the correct answer after discussing among themselves. The teacher is expected to encourage students to voice their opinions and help them reach a conclusion through analysis and reasoning.

In "Making Graphs" (class 7, 1979) children attach different weights to a spring and note its changing length. They then plot a graph of the weight against length of the spring. The problem is that the points don't usually fall in a straight line in practice. One reason is small differences in measurements. The crucial aspect in such a graph is to try and figure out if it is broadly a straight line. So children are asked:

> Keeping it [differences in measurement] in mind can you draw a straight line that does not touch all the points? Is this permitted? Discuss among yourselves and give your answer.
>
> Modify your graph according to what you conclude in your discussions and paste it in your exercise book.

In sum, *Bal Vaigyanik* tries to convert the process of assimilating knowledge into a collective endeavour instead of an activity the individual pursues in solitude. This attempt to introduce group learning and change the ambience in the classroom to one of cooperative effort is a small step in counteracting the spirit of individual competitiveness that pervades school education these days. However, the HSTP examinations continued to remain an individual affair.

What do you think?

One more important aspect of *Bal Vaigyanik* demands attention. Children are often urged to decide things for themselves. In many contexts, there could be more than one possible answer. In such situations, the children are asked: What do you think? Of course, there are many questions in *Bal Vaigyanik* that ask the children for their opinion. But here we are talking about asking them to make a decision in a situation that is not trivial.

The first example of this type of questions comes in the very first chapter – "Fun and Games" – of class 6 (1978). When children make lenses with drops of different liquids, they are asked: "Which drop of liquid makes the best lens?"

No criterion is given to help them make such a decision; they have to figure out for themselves what makes a good lens. There are several criteria they need to consider which could influence their decision. Which lens gives the biggest image? Which liquid is the easiest to fashion into a lens? And so on. The question could easily have been more pointed instead of being open-ended, if it had been framed differently. For example, which lens gives the most magnified image?

This example may seem trivial but it must be seen in the context of textbooks that hesitate to leave even trivial decisions to children. But there are other examples that cannot be considered so trivial.

In "Measuring Distance" (class 6, 1978) the length of a curved line is measured with the help of a divider. Children are first told to open the points of a divider to cover a distance of 8 mm and then asked:

> If you change the distance between the points of the divider to 5 mm and measure the same line again, will there be any difference in its length? Measure it and see for yourselves.
>
> Which of your two measurements do you think is the more correct answer? Explain with reasons.

Now see another example of variations in measurement and approximation in the same chapter. Some students measure the length of a rubber tube. Most of their measurements are in the vicinity of 27 cm. However, one student comes up with a measurement of 37.7 cm. The textbook poses the problem as follows and asks the children to decide:

> The 37.7 cm measurement could either be totally wrong or the student could have been careless in noting down the measurement as 37.7 cm instead of 27.7 cm. Such errors of oversight are common. If you think the answer is wrong you should exclude it. If you think it was the result of carelessness, you should rectify the answer and include it.
>
> What is your decision?

When this particular problem was discussed in the teacher training sessions, it gave rise to intense debate. Some teachers felt that science was about accepting only what is right and there is no question of accepting something after correcting what you think may have been a careless mistake. On the other hand, there were teachers who were willing to accept human errors in measurement.

A similar context comes up again in the same chapter.

> A group of children were asked to guess the length of a matchstick if they could use a scale with least count of 0.1 cm. They came up with the following answers:
>
> Dhaniram – 4.2 cm;
> Tikaram – 4.3 cm;
> Karelal – 4.0 cm;
> Kaliram – 4.25 cm.

The question is:

> Which estimate would you accept?
>
> It is OK for Kaliram to make such a precise measurement?
>
> Is it correct to make a guess of a length that falls between two consecutive markings on a scale? Discuss among yourselves and decide.

This may again appear to be a trivial example. But the issue of whether it is correct "to make a guess of a length that falls between two consecutive markings on a scale" led to intense debate within the HSTP resource group as well.

Another example is from "Enemies of Our Crops" (class 7, 1979):

> A farmer went to the block office and told the Agriculture Extension Officer (AEO) that the leaves of the guava trees in his orchard had suddenly begun to shrivel. Without asking any questions, the AEO gave the farmer a can of chemicals and asked him to spray his trees with it.
>
> Was the AEO wrong in giving this advice? If so, what was the mistake?

The next example, taken from "Classification of Animals" (class 8, first edition, 1980), is especially pertinent for any environment-based science education programme that adopts the discovery approach to learning. Before classifying animals, children are told to collect information about them. They are given the following instructions:

> Make a list of all the animals you have actually seen. Now add the names of those animals that you may not have seen but know about.
>
> How would you decide whether the information about an animal given by you or some other student is true or false?

The following example from "Diversity in the Living World" (class 6, 1978) is also worth noting. Children are asked to spot differences in things around them, such as plants, leaves and even their own fingers. They are then asked to spot differences in the fruits of a single tree, with the following questions posed to them:

> What properties would you choose to identify differences in the fruits and why?
>
> Do you think you can make comparisons by choosing only one property (for example, length)?
>
> How many properties should you choose to make comparisons and why?

Similar questions are posed in "Living and Non-Living" (class 8, Part 1 first edition, 1980):

> You may have heard about sadhus entering *samadhi*. They don't eat or drink anything and don't even move during the time they are in *samadhi*.
>
> Would you say a sadhu in this state is alive? Give reasons for your answer.

One of the objectives of the HSTP is to encourage children to think. More often than not, this is a guided process. They are guided towards scientific laws and theories through observations of experiments and the questions posed after them. But questions like the above are open-ended with no pre-determined 'correct' answers. Children and teachers have to arrive at the 'correct' answers after discussing the matter in class.

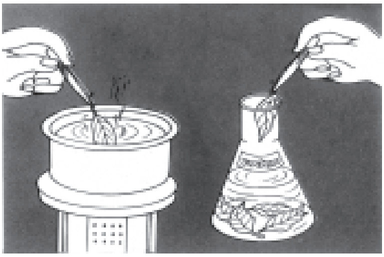
Illustrations and layout

Like other aspects of *Bal Vaigyanik*, its illustrations and layout also evolved over the years. Usually, textbooks do not pay much attention to layout and illustrations, considering them to be of secondary importance. Their main focus is on the written text. Diagrams at best serve as further explanations or embellishments. It must be understood that illustrations can play a much more important role in a textbook as illustrated by the *Bal Vaigyanik* experience.

A lot of attention was paid from the very beginning to ensure that all illustrations in *Bal Vaigyanik* were clear, accurate and unambiguous. Every new edition brought out new dimensions to the art and craft of illustrating textbooks.

The *Lal Vaigyanik* of 1972 reproduced the illustrations from its sourcebook *Physics Through Experiments*, which were made by a professional artist. It has a tranquil feeling. Use of high quality paper and the printing, done at the Thomson Press in Faridabad, ensured that the book had a polished and professional look. It was printed in two colours and the colour registration was perfect. Screens were used to good effect while the illustrations merged seamlessly into the text and were never domineering. The line drawings and photographs assisted balanced presentation of information and instructions.

However, the line drawings showing children performing



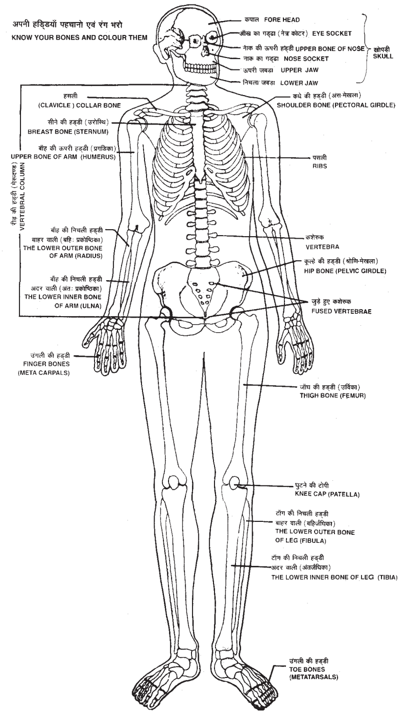
experiments were 'scientific' illustrations: they showed truncated, impersonal hands performing experiments.

The situation remained the same in the 1978-80 *Bal Vaigyanik* editions prepared and published at the time of the district-level expansion, which also contained similar 'scientific' illustrations. However, no professional artist was available to do the layout and illustrations, so the authors did the job themselves.

The early editions have one common feature – their use of space. Their creators did not believe in cramming the books with text and illustrations, so these editions sport wide margins, widely spaced paragraphs and a lot of blank spaces. The reason for doing this is not apparent.

They don't quite look like standard textbooks, at least not from the outside. For example, the front covers of the classes 6, 7 and 8 (part 1) editions carry *Sawaliram's* letter to the students. The back covers have a child's drawing of students going on a field trip with the teacher. A competition had been organised for drawing the cover illustration and the one selected for printing was the winning entry.

The cover illustration for the class 8 (part 2, 1980 edition) was a scene of children participating in the 'heads and tails race' in the "Chance and Probability" chapter. It was made by the late Vishnu Chinchalkar, a well-known artist and illustrator. It is said that Chinchalkar had to make the illustration several times over because the demand from the resource group was to infuse the illustration with the excitement of the activity.



The diagrams in the first edition were mostly used to illustrate or clarify the instructions for conducting experiments. Since they were made by amateur artists, they were a bit crude. However, they never compromised on accuracy. The illustration of the skeletal system in the chapter "Identify Your Bones" is a good example.

The authors of the chapter got together with a group of teachers and doctors to discuss the kind of diagram needed.

Despite their combined efforts, they could not find a good illustration of the skeletal system in any reference book, so one of the teachers (an amateur artist) was despatched to the Gandhi Medical College at Indore to observe an actual human skeleton and make a diagram of it. It was okayed for inclusion in *Bal Vaigyanik* only after close scrutiny. Here's an account of the incident in the words of Umesh Chauhan, the teacher selected to draw the diagram:

> Dr. Anil Sadgopal sent me to Indore to make a life-size diagram of the human skeleton. I used to do a bit of sketching in those days but I lacked in self-confidence. When I visited the Indore Medical College and saw human skeletons hanging in the college museum, I was quite terrified. One night I even

> saw a skeleton in my dreams. But Dr. Prakash Chhajlani and Dr. Ghodapkar, the head of the department, kept encouraging me, so I went to the library to research different illustrations of human bones to understand how they were joined together in the skeleton. It took me seven days to prepare the final illustration, which was included in the class 7 edition of *Bal Vaigyanik*.

While drawing illustrations for experiments, the actual material provided to the schools was kept in mind.The practice continued even after professional artists were employed to do the job. One group of artists even insisted on visiting the schools to see the experiments being performed in an actual classroom before preparing the sketches.

It was in 1985 that the idea of getting professionals in book design was first mooted. The responsibility was given to Kirti Trivedi of the Industrial Design Centre (IDC), Indian Institute of Technology, Mumbai. Trivedi first reviewed the first edition of the class 6 *Bal Vaigyanik* from the perspective of how successful it

> One problem was the kit copy. Children required graph paper, square-lined paper, black paper, diagrams of the skeletal system, etc., to carry out many of the activities. A kit copy was prepared to supply these materials, which was provided free with the textbook. This caused an unanticipated problem. Many children bought second-hand textbooks and many got the textbooks through book banks. Where would these children obtain kit copies from? So kit copies were printed in larger numbers and made available for sale. The IDC team suggested that the textbook, kit copy and answer notebook should all be bound together in a single volume.

was in communicating its content to the students. He drew attention to several details and made many suggestions all of which, unfortunately, were not acted upon. Some of these suggestions are listed below:

1. *Bal Vaigyanik* is a science textbook. Its presentation and layout, which should be orderly and uniform, should clearly reflect this fact.

2. The information and instructions given in the diagrams should be unambiguous and correct. 74 of the 94 diagrams in the class 6 *Bal Vaigyanik* were instructional while 20 were informational. More than half of these illustrations contained errors or were misleading.

3. The use of illustrations and symbols should also evolve gradually like concepts themselves, in a logical, incremental and step-by-step manner. This means first using photographs or three-dimensional illustrations to depict an activity and only then gradually proceeding to line drawings and symbolic representations. Given the standard and quality of printing available, photographs should be used sparingly.

4. There should be clear differentiation in illustrations required for different aspects of the written content, such as instructions for activities, cautions, quotations, statements, thoughts, expressions, etc.

5. Wastage of space should be avoided in the layout. For example, space can be saved by giving diagrams in the wide margins kept for headings in the earlier editions. Similarly, line spacing and the space between paragraphs can also be rationalised.

6. Given the technical problems in printing, it is advisable to go in for single colour printing because it is not possible to ensure quality control in two-colour printing. Registration problems

in two-colour printing lead to lack of clarity and blurring.

The suggestions covered all aspects of the textbook, including layout, diagrams, cover page, binding, etc.

The IDC team took up the design and production of the second edition of the classes 6 and 7 *Bal Vaigyanik*, incorporating all the changes it had suggested. The results were fairly evident. The layout was based on a grid format, so it was orderly and systematic. There was gradual progression from three-dimensional illustrations to two-dimensional line drawings to symbolic representations and flow diagrams. The cover design showed the class for which the textbook was meant, with different representations of the numbers 6 and 7 for those classes. A colour bar code system was used in the class 6 workbook to visually specify details such as chapter number and whether the chapter included a field trip or not.

The introduction of an element like colour coding, however, went against the team's own suggestions. In the absence of 'quality control over printing', colour registration problems resulted in the code being rendered useless. The experience led to colour coding being dropped in the class 7 textbook, although two-colour printing continued to be used, with the expected painful results.

The IDC team had drawn attention to one more problem but didn't do anything to address or rectify it. This problem, referred to earlier as well, was of illustrations showing the apparatus for the experiments or truncated hands holding the apparatus to perform an activity. The book writing team also felt that such truncated hands appeared alien and did not convey to the children that it is they who have to perform the experiments. The problem is that if you want to focus on a particular process in a diagram, showing the complete experimental set up along

The earlier editions of *Bal Vaigyanik* were printed in two colours. The questions were printed in a different colour, as were parts of diagrams. The instructions to do the experiments and other textual material were printed in black. This raised the cost of the textbook. But the HSTP group was able to convince the government that two-colour printing was necessary and desirable, so it should bear the additional cost. It also insisted that the textbook should be made available to the children at the same cost as other science textbooks. However, two-colour printing was eventually abandoned because of technical difficulties such as colour registration and lack of quality control on the part of the printer.

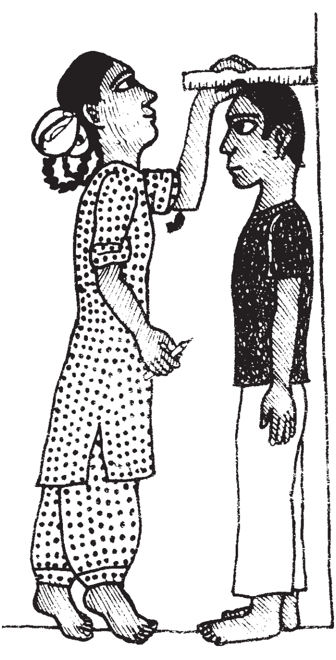
with the children performing the experiment, it gets cluttered. The illustration becomes too complex and distracts attention from the essentials. This is a problem that still requires looking into, especially in a textbook written for young children.

The illustrations prepared by the IDC team did try to focus attention on the activity being performed but they mostly appeared deliberate. It seemed as if the person performing the activity was demonstrating the experiment to an audience. It isn't clear what impact such illustrations had on the children, but they generated a feeling of watching a demonstration rather than doing it yourself.

There was one more noteworthy aspect about the IDC illustrations. Barring a few exceptions, the illustrations in the classes 6 and 7 editions were 'elegant', depicting 'ideal' children with dainty hands performing experiments with great care. They appeared artificial, although they did remain accurate in their information content.

Another approach to textbook illustrations can be seen in the class 8 (1989 edition), which was illustrated by Karen Haydock, a member of the HSTP resource group. Karen has strong viewpoints on children, education, science, textbooks and development. Her illustrations reflect her concerns.

This particular edition teems with human forms: dozens of children performing experiments or just sitting around enjoying the experience. The margins of the workbook also come alive. Where the IDC team had basically used two kinds of illustrations – instructional and informational – Karen introduced a third and a fourth type: one purely for fun and the other to depict or comment upon a situation. They neither illustrated ways of performing an experiment nor contained related information. But they were provoking, raising pertinent questions.



Where the IDC team looked at *Bal Vaigyanik* primarily as a science textbook, Karen added her interpretation. For her, it was more than just a textbook of science, it had to be a book that encouraged children to do some activities and have fun doing them. Karen showed the way to illustrate a different pedagogy. For example, her illustrations portrayed the role of the teacher in the classroom in a totally different way. When depicting human forms, she tended to prefer the female form even in gender-neutral contexts. She also integrated some sharp and pointed comments in her drawings to try and arrest the tendency among the children to accept the activities given and the conclusions drawn with closed eyes and minds.

When the textbook with Karen's drawings came into the hands of children the reactions were mixed but strong, both for and against. The children in her drawings are neither 'ideal' nor 'elegant'. They have some rawness about them. In fact, they can be described as deliberately 'rustic', 'tribal', or 'black', etc. This became a focal point of criticism. But her drawings added a new dimension to the art of illustrating textbooks, although there may be scope for refinement.

The third edition of *Bal Vaigyanik*, published in 2000-02, saw significant changes in the way the HSTP group looked at illustrations. Karen's drawings for the second edition had opened people's minds. Many new ideas surfaced and the task of designing the layout was given to Tarundeep Girdhar of the National Institute of Design (NID), Ahmedabad. Ranjit Balmuchu, an Ahmedabad-based artist, was to make the illustrations.

This design team visited schools in the field area to try and understand how children interpreted illustrations and what kinds of symbols and signage could be used. Its members also wanted to actually see things such as flowers and leaves before drawing them for the books, so that they would look as authentic as possible.

The first step this team took was to junk two-colour printing. They also came up with a way to get around the problem of trucated hands performing experiments. They first drew a picture of the total context of the experiment, showing groups of children performing the experiment, and then focused on

the key activity in the next diagram, which also mostly depicted the complete human form. Like the IDC team, Girdhar also tried to develop different styles of illustrations in a step-wise logical manner, often depicting a single context in two different styles.

This team created two fictitious characters – Changu and Mangu – as vehicles to convey messages to children, such as reinforcing some idea, cautioning them to be careful in performing experiments and so on.

Karen once again took up the responsibility for the layout, design and illustration of the class 8 book of this edition too.

Looking back at the evolution of design and illustrations in the three editions of *Bal Vaigyanik*, two key ideas emerge. First, illustrations can truly serve to enrich the role of a textbook in a learning process, going beyond clarifying instructions or presenting information to help highlight its expectations. Second, as for developing and enriching the curriculum, syllabus, language, etc., learning by doing in a gradual trial and error process also applies in equal measure to improving and evolving illustrations and design. As artists joined the effort, new ideas emerged and were incorporated.

6

A SUMMARY OF THE CHAPTERS

Presenting a summary of the *Bal Vaigyanik* chapters is no easy matter. Even though almost every chapter is woven around a specific concept or topic, the content is not limited by its sub-titles. The chapters concretise and bring to life different elements of the scientific method that are embedded in the content. The summary given below tries to present as complete a picture as possible. The main summary pertains to 1978-80 edition. For purposes of comparison, references have also been made to chapters from *Lal Vaigyanik* as well as the 1987-89 and 2000-02 editions.

Class 6

1. Fun and games (कुछ खेल खिलवाड़)

The first chapter in the class 6 workbook has children observing different things with the help of a lens and a microscope. The lens is made from a fused bulb filled with water, with a wire stand to hold it steady. The children also learn to make and use a matchbox microscope. They are then introduced to the microscope provided in the kit and they use it to make further observations.

Subsequent editions of the workbook contained an improved design of the matchbox microscope. This particular apparatus has inspired many people to apply their minds to improving its performance and their creativity has seen the evolution of several models.

The chapter contains many interesting activities, including observing various things with the apparatus that children themselves design and construct. The 2000 edition included a particularly enjoyable activity in which children generate smaller images with a lens.

The chapter essentially retains the fun and games spirit in all the editions.

2. Learn to make groups (समूह बनाना सीखो)

The activities in this chapter are linked to concepts such as identifying properties of various things, grouping things on the basis of these properties, recognising the properties of a given group, understanding that things can fall into two or more groups (overlapping group), etc.

Lal Vaigyanik had a similar chapter titled "Things and Groups", which also explored differences between things and contained an activity where two things are compared using a measuring scale. In addition, it had an 'odd man out' activity as well as questions for homework.

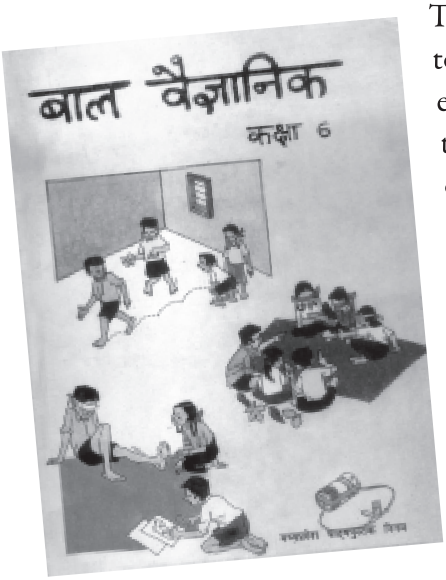
In the 1987 edition the chapter began by identifying differences between things, followed by recognising similarities, then forming groups on the basis of similarities, and concluded with a discussion on meaningful groups. The 'odd man out' activity, which was also included, held out the possibility of there being more than one correct answer.

The 2000 edition had the same concepts but it contained more exercises, with grouping also being done using pictures.

3. Grouping of leaves (पत्तियों का समूहीकरण)

This is a field trip-based chapter. The leaves collected during the field trip are studied and grouped in the classroom. Children first tabulate their properties and then group them according to these properties in a second table. They also build a herbarium with the collected samples. The chapter also includes making paper envelopes to collect leaves.

The 1987 edition did not have the envelope-making activity. The rest of the content was more or less the same.



The chapter was titled “Getting to Know Leaves” in the 2000 edition. During the field trip, the children made additional observations about leaf arrangement (phyllotaxy) while collecting leaf samples. Grouping was done in a single table; special emphasis was given to groupings based on venation. Two games to familiarise children with leaf properties were included, apart from some interesting additional information on the subject.

4. Magnets (चुम्बक)

The chapter has the following content: magnetic/non-magnetic materials (experiment 1), magnetic poles (experiment 2), effect of the medium on the action of magnets (experiments 3 and 4), magnetic field (experiment 5), finding direction with magnets (experiment 6), attraction/repulsion in magnets (experiment 7), recognizing that repulsion and not attraction is the way to identify a magnet, and making magnets (experiment 8, 9 and 10).

There were no changes in the 1987 edition except for the addition of an anecdotal story about the discovery of magnetism.

Two games based on the magnetic concepts were added to the 2000 edition.

The *Lal Vaigyanik* chapter "Magnets and Magnetic Action" was more or less similar.

5. Our crops and their grouping (हमारी फसलें और समूहीकरण)

This chapter includes field trips during the kharif and rabi seasons. Children collect samples of leaves, fruits and seeds from crops, conduct surveys in 2–3 villages to collect crop data, and discuss agricultural issues with the Agriculture Extension Officer, *gram sewak* and farmers. They learn the importance of various properties of crops in agriculture and group crops on the basis of various criteria, the final activity being preparing a crops exhibition. Particular emphasis is placed on conducting surveys and holding discussions with farmers and agricultural officers for data collection.

The 1987 edition divided the chapter into two chapters: "Our Crops – 1" and "Our Crops – 2" (हमारी फसलें - 1, - 2), covering the kharif and rabi seasons respectively. Apart from the field trips, these chapters had an additional exercise of drawing a flow chart to illustrate the crop cycle.

In the 2000 edition, the chapters were shifted to classes 7 and 8: 'Question and Answers About Crops -1 and -2' (फसलों के सवाल-जवाब - 1, 2). These explore the questions related to crops, such as the growing season, various factors affecting the yield etc. and the method used is classroom discussion based on information provided in the textbook.

6. Force and Weight (बल और भार)

The chapter has experiments to illustrate the different ways in which we experience force, beginning with a discussion of examples from daily life and including attraction/repulsion in magnets (experiment 1), air pressure in a cycle pump (experiment 2), adhesive force of a film of water between two glass strips (experiment 3), forces at a distance (magnet-iron filings), pressure of air and flowing water, quantitative experience of force seen in dipping of a meter scale on which weights are placed (experiment 4), etc. Basically, the concept emerges that force is what we feel as a push or pull and that weight is also a force.

The *Lal Vaigyanik* had a different set of experiments to illustrate force, such as compressing and stretching a spring, placing a brick on a spring and observing what happens, seeing the attractive force of a magnet on an iron bar suspended from a spring (force at a distance), filling two beakers with liquids of different viscosity and assessing the difference in force required to stir them, twisting and bending a thick rubber tube to change its shape, air pressure in a cycle pump, etc. The chapter also discussed units for force and paid a lot of attention to the concept of weight.

The experiments in the 1987 edition were similar to the 1978 edition. But there was an arm wrestling activity to show the direction of force as well as a discussion on gravitational force. The quantitative aspect of force was brought out by the stretching of a rubber band from which different weights were suspended.

In the 2000 edition, the chapter was shifted from class 6 to class 8 under a new title – “Force, Force, Everywhere” (कहां-कहां नहीं है बल). The new chapter is based on analysis of forces in various situations. Friction has been accorded an important place and Galileo’s famous thought experiment is discussed in detail. Force has been associated with acceleration with a caveat that one should be careful in analysing forces when the object is stationary or moving with a constant velocity. Gravitation followed by weight and direction of force have been discussed. There is almost no experiment.

7. Food and Digestion (भोजन और पाचन क्रिया)

The chapter is divided into five parts. It begins with a discussion on how hunger strike or fasting affects the body.

Part 1 uses observations from the animal world to bring out the diversity in foods and ways of feeding. Children prepare a table of different animals and the food they eat, grouping the animals into carnivores, herbivores, omnivores and parasites. The first experiment involves collecting specimens of animals to observe how they ingest food and the organs they use for this. A comparison is made of their behaviour in wild and captive states.

Part 2 deals with testing different foods for starch (experiment 2). Children are also told about other food constituents such as proteins, fat, minerals, etc.

Part 3 discusses the relationship between poverty and nutrition. Children learn about the symptoms of malnutrition and investigate the diet of malnourished children. They are then expected to trace and form an opinion about the links between poverty, food and health on the basis of these observations.

Part 4 has an experiment (experiment 3) to separate starch from wheat flour to show that food contains other constituents in addition to starch. Experiment 4 is a control experiment in which children observe the reaction of saliva on starch and link it to chewing one's food while eating.

They then observe a dissected rat and draw a labelled diagram of its digestive system. The part concludes with a discussion with their teacher, after which they are expected to write 5-10 sentences on the possible link between the food we eat and the blood that flows in our body.

Part 5 is about nutrition in plants. In experiment 5, which is a control experiment, children keep one plant in normal water and another in red-dyed water to observe the red coloured water rising in the plant and establish the role of roots in food uptake. They then cut a transverse section of the stem to trace the path taken by water. Several questions relating to crops and agriculture are then posed.

Children study the *amarbel* (cuscuta) as an example of a parasitic plant and also observe fungi in experiment 7.

The *Lal Vaigyanik* chapter began with food constituents and different foods were tested for starch. It had an experiment to test for the presence of other nutrients and another to observe the effect of saliva on starch.

The 1987 edition had a chapter "Nutrition – 1" that was more or less similar to the 1978 edition but with the following changes.

The section on plant nutrition was omitted (but included in "Nutrition – 2", titled "Nutrition in Plants"), protein and fat tests were included and information about balanced diets was added.

In the 2000 edition, the chapter was titled "Our Food" and did not include animal foods and groupings (carnivore/herbivore etc). The rest of the chapter was the same as in 1987, except for the addition of a story, "A Stomach with a window", which presents an important episode in the history of research on our digestive system.

8. Seeds and Their Grouping (बीज और उनका समूहीकरण)

The chapter begins with a discussion on importance of seeds in farming. In activity 1, children collect seeds of cultivated and wild plants and group them. They then study the external and internal structure of seeds: experiment 2 is about bean seeds, experiment 3 about castor seeds and experiment 4 about maize seeds. Some other seeds are given for homework. Axis, embryo, etc. are defined. They compare the internal structure of various seeds.

Lal Vaigyanik had no such chapter.

In the 1987 edition the chapter was titled "Seeds and Their Germination" (बीज और उनका अंकुरण). Study of castor seed was omitted but there were experiments to study the conditions essential for seed germination; they also study hypogeal and epigeal germination experimentally.

In the 2000 edition the chapter gave more space to investigating nutritive elements in seeds. It also discussed starch, proteins and fat as well as the importance of the seed coat in germination.

9. Electricity – 1 (विद्युत - 1)

The basic aim of the chapter is to familiarise children with the idea of a circuit. They first observe the structure of a torch bulb and then make circuits to understand the concept of an electric circuit (experiment 1). Next follows an investigation of how light is generated in a bulb and the link between cell power and brightness of light. They then study open and closed circuits, analyse variety of circuits (motor vehicles, torch, etc.), identify conductors and non-conductors (experiment 2) and make a switch to understand its role in a circuit.

Lal Vaigyanik had the same chapter.

The 1987 edition included an experiment to make series and parallel circuits using bulbs.

In the 2000 edition, the chapter was titled "Lighting a Bulb" (बल्ब जलाओ जगमग-जगमग). The torch was studied in more detail and more light was thrown on how light is generated in a bulb. Also included was a story about the invention of the electric bulb. But the series and parallel circuits were shifted from class 6 to class 7.

10. Games with an abacus (गणक के खेल)

The chapter seeks to strengthen children's understanding of place value and decimals. The teacher narrates the story of Ghanshyam (which was not part of the chapter itself) to familiarise children with the decimal system. After this they do exercises on place value and decimals using beads on a six-rod abacus.

In the 1987 and 2000 editions Ghanshyam's story was included in the text itself.

11. Measuring Distance (दूरी नापना)

The chapter discusses methods used to measure distances in daily life, including the use of (arbitrary) scales. Children compare things placed close together before using a scale to compare two things. There is the story of how the standard scale evolved. Children make their own scales, learn about least count, units and the correct way of using a scale. This is followed by exercises in measurement, which include estimation, problems in estimating and methods to measure curved lines (with a thread and a divider). The final activity is to make a divider using *babool* (acacia) thorns. A lot of emphasis is placed on measuring with a scale. Children first estimate distances and then check with a scale to see how correct their estimates are.

The chapter in *Lal Vaigyanik* began with problems in estimating distances and went on to exercises in using a standard scale.

The chapter in the 1987 edition was basically similar to the 1978 edition, but curved lines were measured using just a thread, making the *babool* thorn divider redundant.

The chapter in the 2000 edition more or less retained the 1987 format.

12. Separation (पृथक्करण)

After discussing mixed and pure substances encountered in daily life, children are given simple mixtures from which they have to separate different substances (experiment 1). (The separated substances don't necessarily have to be pure: they could themselves be mixtures.) They are encouraged to use their own methods to separate the substances, the only condition being that they must be able to explain the basis of their methods.

In experiment 2, children separate substances on the basis of differences in their solubility, while in experiment 3 they learn about the effect of heat on solubility and how this factor can be used in separation. They then discuss their observations and findings. Experiments 4, 5 and 6 help them to understand process and technique of distillation.

They learn about the effects of heat on solid substances in experiment 7 and study sublimation in experiment 8, discussing examples from daily life.

Experiments 9 and 10 are exercises in chromatography using chalk and filter paper.

This chapter's focus, to a large extent, was on developing children's experimental skills. Activities include preparing solutions, stirring them, holding test tubes, heating them, inserting a glass tube in a rubber cork, and so on. They are told about the precautions they need to take at every stage.

Lal Vaigyanik did not have such a chapter but it existed in the form of cards, and was similar to the 1978 chapter.

The 1987 edition divided the chapter into two parts. "Separation – 1" was retained in class 6 and "Separation – 2" was included in class 7. The class 6 chapter had experiments on solubility and chromatography.

The 2000 edition had just one chapter in class 6, on solubility and chromatography. It had additional information on some important modern-day uses of chromatography. However, it included a new chapter titled "Making Crystals". Another chapter attempting a more quantitative understanding of solubility and containing experiments to measure the solubility of different substances was also developed.

13. Diversity in the Living World (जीवजगत में विविधता)

The chapter deals with diversity among living things. Its activities are structured to observe diversity within an organism as well as diversity between two living things belonging to the same species. Children get a sense of the incredible diversity in organisms by studying differences among human beings, two animals of the same species (such as dogs or calves), trees of a single species, two leaves of the same tree, the fingers of an individual and the thumb impressions of people.

The 1987 edition used fewer examples to put across the same ideas about diversity.

The 2000 edition took the understanding of the concept a step further by viewing diversity in the perspective of evolution of life. The story of DDT and mosquitoes was included to show how the process is impacted by human interventions. Attention was directed to diversity in crops and processes of domestication.

The *Lal Vaigyanik* chapter was similar to the 1978 edition.

14. Variation in Measurement and Approximation (घट-बढ़ और सन्निकटन)

Variation in measurement is a fundamental concept. The chapter begins with everyday observations of variation (like in a game of *gilli-danda*), after which a distinction is made between variation and errors in measurements. In activity 1, a student measures the length of the classroom 10 times while in activity 2 all the children in the class measure the height of the classroom door. After excluding erroneous measurements, they discuss the reasons for variation, using data given in the workbook rather than their own door measurements. This brings up the question about the extent of accuracy needed in a situation, and whether it is correct to report a measurement that is less than the least count of the scale. The concept of approximation is brought in as a possible solution to the problem.

Given the variations that occur, how does one decide which is the correct measurement? Mean value and average are proposed as methods to get an acceptable answer. Children make bar diagrams, find the mode and mean using their door measurement data.

Once the trade-off between accuracy in measurement and the purpose of measurement is established, many exercises in measurement and variation are done.

The chapter in the 1987 edition had two changes. Mode was omitted and only averages were used to address the problem of variation. The second change was in the chapter's approach. It indicated why variations occur and paid more attention to the problem of accuracy in measurement. There were also more exercises in approximation.

The 2000 edition was more or less similar.

The *Lal Vaigyanik* chapter was closer to the 1978 edition. However, it also included errors in measurement.

15. Soil, Stones and Rocks (मिट्टी, पत्थर और चट्टान)

This field trip-based chapter begins with a discussion on the uses of soil and rocks. During the field trip children study the structure of soil, stones and rocks to try and understand how they are formed. In particular, they observe the soil strata and collect soil and rock samples for later study.

The soil samples are examined in detail in the classroom. Apart from particle size, they check whether the soil contains living creatures and decaying substances. To check particle size, they mix the soil with water, wait for the particles to settle and then examine the settled soil (experiment 3). They then drain the water and let the soil dry which is expected to give clues about the process of rock formation.

The stone and rock samples are studied in experiment 4. Children select the properties they wish to investigate. They break the samples to study their inner strata, if visible. The chapter describes the three types of rock (igneous, sedimentary and metamorphic) with the aid of photographs. The collected samples are then grouped accordingly.

The teacher narrates the history of the earth's creation to help children understand how rocks are formed. Various models are used to illustrate the process. For example, the origin and formation of igneous rocks is explained using the brick kiln as a simuli. For sedimentary rocks, children study the dried soil after the water is drained in experiment 3. Metamorphic rock formation is explained in terms of heat and pressure.

In the case of soil formation, children are first introduced to the concept of erosion. To get an idea of various erosive processes, they scrape stones against each other and see what happens, study the marks left on a car's windscreen by the wiper, sandpaper a stone, observe the reaction of acid poured on marble, study stones rutted by falling raindrops and the stone perimeter of a well rutted by the rope for drawing water. They also examine the size and shape of stones. They then try to germinate seeds in powdered stone, a mixture of powdered stone and soil, and a mixture of powdered stone and cow dung.

Finally, some questions are given for further investigation and children are asked to write a paragraph about formation of soil from rocks.

This chapter was omitted from the 1987 and 2000 editions.

16. Groups Within Groups – Making Sub-groups (समूह में समूह – उपसमूह)

The chapter takes the concept of groups a step forward by giving exercises in forming sub-groups. To understand that the process is sequential, children first make groups of the students in the class and then divide them into sub-groups. In doing so, they learn that all members of a sub-group have the properties of the sub-group as well as the original group. The chapter concludes with a 'Guess What It Is' game in which one group of players selects an item from a number of things placed in the centre and the other group has to guess what the thing is by asking questions according to rules laid down.

Some exercises were modified in the 1987 and 2000 editions of this chapter, which was otherwise the same.

Lal Vaigyanik had no such chapter.

17. Sensitivity (संवेदनशीलता)

Children observe through many examples that living beings react to stimuli. This quality is defined as sensitivity. The importance of sensitivity for living creatures is brought out through the example of hunger and thirst. In experiment 1, children learn about the perception of touch by drawing a sensitivity map of the palm. Perception of heat is explained using the example of bed bugs, with an experiment to show deceptive perception of heat. This is followed by an activity to map taste buds on the tongue and an experiment on perception of smell.

There are two experiments to observe sensitivity in plants – sensitivity of plants to sunlight and sensitivity of roots to gravity.

Both experiments help in enhancing the manual skills of children and both of them involve use of controls.

The chapter concludes with a series of sensitivity-related questions, some linked to examples from daily life.

The *Lal Vaigyanik* chapter was similar but included many homework exercises.

The structure of the chapter was the same in the 1987 edition though there were some modifications in the experiments. For example, the touch sensitivity experiment was done on the soles of feet rather than the palm. Some cautions were given in the taste bud experiment while a new experiment on visual perception was added.

The 2000 edition had many changes. First, the chapter was divided into two parts. The first part "Sensitivity – Exploring the Surroundings" (संवेदनशीलता यानी आसपास की खोज-खबर) remained in class 6 while the second part "Sensitivity in Living Beings" (सजीवों में संवेदनशीलता) was included in class 7.

The class 6 chapter dealt with human sensitivity. The attention of children was first drawn to things to which we are sensitive. This was followed by a discussion of organs linked to sensitivity, and several related experiments were done, such as our skin's perception of touch and heat. Children also got to know how visually impaired people use the perception of touch to read.

The experiment to map taste buds on the tongue was omitted though there was an experiment on mixed perceptions of smell and taste.

There were three experiments on sight and one on hearing.

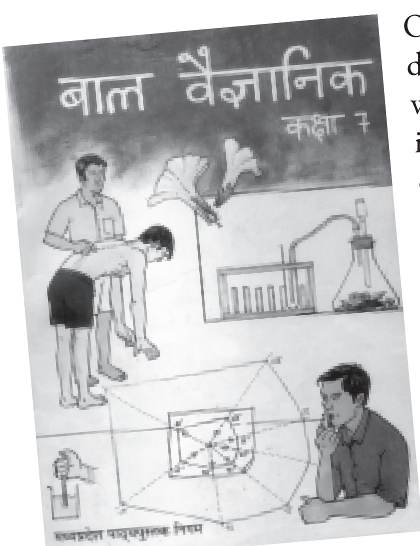
Class 7

1. An interesting game (एक मज़ेदार खेल)

In this chapter, children join matchsticks with pieces of cycle valve tubes to make different shapes and try to identify the properties of these shapes, many of which are three-dimensional. The activity helps them develop their manual skills and encourages them to experiment in building new shapes and models.

2. Water – Hard and Soft (जल – मृदु और कठोर)

The chapter is about testing hardness of water by lathering of soap. Distilled water is used as a control to test the hardness of water from different sources. Next, some selected salts are dissolved, one at a time, in distilled water and the hardness each causes is investigated. The salts are then classified into two groups. In all these experiments, idea of a 'blank' as a control has been introduced.



Once hard and soft water are defined, a question is posed: Is soft water pure? This leads to an interesting discussion on the concept of purity. Another experiment is then done to distinguish between temporary and permanent hardness. More experiments follow on chemical methods to make water soft. The chapter ends with questions that draw attention to the problems caused by hard water in daily life and in industrial usage.

Children learn to handle different chemicals in the experiments and get a lot of practice in taking proper precautions. They are also asked to collect rain water to use in their experiments in place of distilled water.

The chapter in the post-*Lal Vaigyanik* cards was much simpler than the one in the 1978 edition. The first experiment tested hardness in water from different sources, while the second experiment investigated the link between hardness and the presence of different salts (simultaneously looking at temporary and permanent hardness). The third experiment was about methods to remove hardness.

The 1987 edition saw some changes. Firstly, recognising the increased use of detergents in household chores, hardness of water is also tested with detergents. Secondly, after adding the soap solution, children are asked to look at the precipitate in addition to the lather formed. One experiment also tried to establish the relationship between the precipitate and lather formation. The experiment related to temporary hardness was omitted.

There was no major change in the 2000 edition.

3. Roots and Leaves (जड़ और पत्ती)

The grouping exercises in this field trip-based chapter are used to good effect to discover scientific laws. Children first collect leaf and root samples of different plants. Wherever possible, they also collect the seeds of the same plants, or at least try to find out if the seeds have one or more cotyledons.

The plants are then grouped in different ways. First, children study the roots to distinguish between tap roots and fibrous roots and group the plants accordingly. Another basis for grouping is leaf venation, followed by grouping on the basis of simple and compound leaves. Finally, grouping is done on the basis of the number of cotyledons.

These different groupings are then tabulated in a single table, which the children analyse to discover the correlation between various characteristics. The analysis helps them understand the patterns seen in plant structure. This enables them to make predictions about the properties of many other plants.

Children then organise an exhibition of the plant samples collected by them.

The 1987 edition retained the chapter in the same form, but it was shifted to class 6.

The 2000 edition also retained the chapter in class 6 but under the title "Roots, Leaves and Seeds" (जड़, पत्ती और बीज) and omitted references to simple and compound leaves.

4. World of Insects (कीड़ों की दुनिया)

In this chapter, the term 'insect' covers invertebrate animals belonging to *phylum arthropoda*. Children first make a list of insects they know and then group them according to the season in which they appear.

They then go on a field trip to collect various kinds of insects, noting down the place where the insect lives and the food it eats. On returning to school, they list their insect samples according to where they live and then group the insects on this basis.

They study the external structure of the insects, focusing on the joints in their legs. A second grouping is done on the basis of the number of legs, number of body segments and presence/absence of wings. They try to identify the correlation between these various properties to arrive at some general laws about insect structure, which they test by applying to other insects.

The chapter discusses mimicry in insects and ends with children learning how to mount an insect exhibition.

5. Enemies of Our Crops (फसलों के दुश्मन)

Children go on field trips and conduct surveys during the kharif and rabi seasons to collect information on crop diseases, pests, weeds and plant pathogens. They discuss methods to protect plants and combat diseases. They are expected to consult the *gram sewak* (Agriculture Extension Officer) and talk to farmers during these field trips to get useful information to add to their field observations.

This chapter was included in class 8 in the 1987 edition under the title "Protecting Our Crops" (फसलों की सुरक्षा).

It was retained in class 8 in the 2000 edition under the title "Questions and Answers About Our Crops – 2" (फसलों के सवाल-जवाब - 2) with some modification in the topics discussed.

6. Identify Your Bones (अपनी हड्डियां पहचानो)

The chapter begins with a discussion on broken bones to familiarise children with bones and joints. They explore their own bones, feeling them, observing how the joints function and then identify each bone by referring to the diagrams/charts provided in the kit copy as well as x-rays of bones/joints. Various models are also used to show how joints function. Once a bone is identified, children colour it in the diagram of the skeletal system given in the kit copy.

They also learn how to check whether an animal has a vertebral column or not and are told about its importance in classification (vertebrates and invertebrates).

The 1987 edition had a chapter titled “Internal Organs of the Body – 1” (शरीर के आंतरिक अंग - 1) in which muscles, tendons and cartilage were also investigated in addition to bones. It had information about bone/muscle diseases and gave first aid instructions for broken bones.

The chapter in the 2000 edition remained unchanged.

Lal Vaigyanik had no such chapter.

7. Making Maps (नक्शा बनाना सीखो)

The chapter begins with commonly used methods to specify location. It then familiarises children with Cartesian coordinates and has exercises using coordinates. The analogy of children sitting in rows in a classroom is used to explain how Cartesian coordinates can locate points in a regular grid. The discussion covers axis and the use of square-lined paper in map-making.

Next comes the problem of locating randomly scattered things. Children learn about polar coordinates, point of origin, reference line and the need to specify direction. Exercises with polar coordinates follow and the comparative advantages of Cartesian and polar coordinates are highlighted.

The map-making exercise begins after this. Map of a demarcated area is made by choosing a scale, identifying and marking the points etc. A *dev yantra* (a large divider made of bamboo, named after its inventor Devtadeen Mishra of Kishore Bharati) is used to measure distances between points and these distances are scaled down on the map. A method to verify the accuracy of the completed map is also suggested.

Exercises are then done to find out distances between points in a map using the scale.

The chapter in the 1987 edition did not discuss polar coordinates. After taking up Cartesian coordinates, exercises were done to scale up or scale down various shapes and figures. The first exercise was scaling down the picture of a cat using a square grid. Then followed exercises to scale up or scale down pictures without using the square grid. For this, straight lines were drawn from the point of origin to different points of the picture and extended. New points were then marked proportionately on these extended straight lines to scale up/down the picture. Next came drawing a map of an agricultural field, after which its area was calculated. Interestingly, the chapter on area came before the chapter "Making Maps" in the 1987 and 2000 editions. The rest of the chapter remained the same as in 1978.

The chapter in the 2000 edition was similar to the 1987 edition.

In *Lal Vaigyanik*, the chapter was titled "Place and Relative Location" (स्थान और सापेक्ष स्थिति). It discussed and had exercises on Cartesian and polar coordinates. The polar coordinates exercise was in the form of a game to locate a treasure. There was no map-making exercise.

8. Area (क्षेत्रफल)

The chapter is part of the measurement series. The discussion begins with a picture of agricultural fields in which it is difficult to guess their relative sizes. The fields are compared using standard size squares. There is also a discussion of local methods of measuring fields. One fact that is highlighted in this context is that the area of a field is popularly expressed by farmers in terms of the quantity of seed sown in it.

After familiarising children with the units for measuring area, exercises are done to measure the area of irregular shapes with the help of square-lined paper. In the process the link between the size of squares and the accuracy of the measurement is established. Several activities are then conducted to derive the formula for the area of a rectangle. The relationship between perimeter and area is also investigated and the children do a lot of exercises on area measurement. There is an exercise to find the area of the map made in the chapter "Making Maps".

The chapter in the 1987 edition remained more or less the same, with more exercises.

The chapter in the 2000 edition also began with the problem of comparing agricultural fields but the method for comparing them was not immediately disclosed. To find a solution to the problem, the children first did several activities that led up to an understanding of the concept of area and the methods of measuring area. Only after this were the fields compared. Squares are used to find the area of irregular figures and the formula for calculating the area of a rectangle was also derived. There were several activities connected to perimeter and area. There was also an area conservation activity.

Paper tiles were used in the *Lal Vaigyanik* chapter to cover surfaces and arrive at the concept of area. These tiles and surfaces had different patterns drawn on them to make it clear that area is linked only to the spread of the surface. Later, the tiles were replaced by square-lined paper.

9. Electricity – 2 (विद्युत - 2)

This chapter investigates bulbs and cells joined in series and parallel circuits, conductivity of liquids and the chemical effects of electricity. After highlighting precautions to be taken while conducting electricity experiments, a simple circuit is made. A beginning is also made in depicting circuits with symbols and notations. In experiment 1 a circuit is made with two bulbs and a cell: the bulbs are connected first in series and then in parallel. The brightness of the bulb in the two situations is compared. Then a bulb is joined with two cells first in series and then in parallel circuit. This is followed by joining two bulbs and two cells in different ways in a circuit. Activities such as flipping the poles of the cell in a simple circuit with one bulb and one cell, putting one cell reversed in a two-cell-one-bulb circuit, and then connecting an additional wire, without changing the orientation of cell, to light up the bulb help consolidating understanding of circuits.

Experiment 7 tests liquids for conductivity/non-conductivity. Children also observe whether an electric current causes a chemical reaction in the liquid that is a conductor. Experiments 8, 9 and 10 investigate the chemical effects of electric currents. Experiment 11 illustrates short circuiting while experiments 12 and 13 explain the function of a fuse.

The electricity chapter in the post-*Lal Vaigyanik* cards incorporated “Electricity – 2” and “Electricity – 3”. It discussed series and parallel circuits, conductivity of liquids, chemical effects of electricity and magnetic effects of electricity.

The chapter in the 1987 edition had the same topics as the 1978 edition but some of the experiments were simplified, some experiments were replaced by better alternatives and the presentation was modified. The switch was introduced in circuits and the symbols used to depict circuits were clearly explained. Three methods were given for assessing conductivity of liquids. The experiment to compare the brightness of a bulb in series and parallel circuits included a way to mark the bulb.

The chapter appeared to be even more different in terms of presentation in the 2000 edition. The story of discovery of the cell was added along with an activity – making your own cell.

10. Volume (आयतन)

This chapter in the measurement series begins by engaging children in a discussion of their personal conception of volume. Problems in using non-standard measuring scales are discussed to highlight the concept of a standard scale. Children make their own measuring cylinder by pasting a strip of paper on a beaker and calibrating it by pouring equal quantities of water contained in a matchbox until the beaker is full. Conceptual development is fostered by getting them to make measuring devices with different least counts using different containers (test tubes, bottles etc.) and then using these measuring cylinders to measure different volumes of liquids. The exercises help make a mental picture of volume.

Children then develop a way to measure volume of solids, based on displacement of liquids. They finally derive the formula for calculating the volume of a cube. Several numerical exercises further strengthen the understanding. Making all these measuring devices also helps developing manual skills.

The conceptual framework of the chapter in the 1987 edition was the same but children made fewer measuring devices.

In the 2000 edition, in addition to the activity of making measuring devices and deriving the formula for the volume of a cube, there were also some exercises on conservation of volume.

In *Lal Vaigyanik*, the volume chapter was titled "Volume and Capacity" (आयतन और धारिता). Displacement of liquids was used as a base for putting across the concept of volume and then to measure volume. The formula for the volume of a cube was then explained. Finally there were several experiments related to capacity.

11. External Structure of Animals (जंतुओं की बाह्य रचना)

This chapter is based on animals found in children's environment, the emphasis being on animals other than insects. It involves observing these animals, recognising key features of their external structure and then establishing patterns and correlations among these features. Apart from the observations they make, prior knowledge and experience are also drawn upon. It is interesting to note that the chapter does not include a field trip.

Attention is drawn to the diversity in the size and shape of animals. The features studied include eyes, ears, tails, skin coverings, external distinction between sexes, segmented/non-segmented bodies, number of limbs and their modifications, etc. Children try to derive laws from their investigation of correlations in animal features, one example being skin cover and number of legs. They are encouraged to think and derive other laws.

The 1987 edition combined two chapters – "World of Insects" and "External Structure of Animals" – into one titled "World of Animals" (जंतुओं की दुनिया). The study of animals in the new chapter was based on the same properties as in the earlier chapters. It attempted to establish the link between the number of legs and presence of wings in insects but the investigation of linkages in animal features to derive laws was left out.

In the 2000 edition the structure of the chapter was changed quite a bit and included detailed studies of three animals – earthworm, grasshopper and a fish. Children go on a field trip to observe as many animals as they can, studying where they live and what they eat. They group animals according to their food into carnivores, herbivores, etc. But there was no discussion on the linkages between properties/features of different animals. A narrative "Our Bodies: Refuge of Living Beings" (हमारा शरीरः जीवों का अड्डा) was added for additional reading.

12. Making graphs (ग्राफ बनाना सीखो)

The main objective of this chapter is to teach children how to make graphs. There are also some exercises on reading the information contained in graphs.

An experiment is done in which different weights are suspended on a spring and the data on weights and the length of the spring are noted. Strips of paper equal to the corresponding lengths of the spring are cut out and pasted to make a bar diagram. The limitations of this technique are highlighted and the discussion moves on to making graphs. The sides and diagonals of several squares are measured and a graph is made from the data. The children learn to draw the axes and the point of origin, plot the points on the graph and draw the graph line to join the points. They are told how to read the information from the graph. They also have to compare the data obtained from graphs with real data from experiments. They then make a graph of the data from the spring and weights experiment. They learn to choose a scale and the rules governing selection of axes. In drawing the graph line, they learn about approximation since some of the points may not fall on a straight line. An indication is given that all graphs are not necessarily straight line graphs. A few exercises are also done.

In the post-*Lal Vaigyanik* cards, the title of the chapter was "Graphs" (लेखाचित्र). It explained graphs as a means of understanding the relationship between two quantities. Children learnt that some quantities are linked while others are not. They then made a series of graphs – at least 20 of them, including straight-line and non-straight-line graphs.

In the 1987 edition, the discussion on graphs began with the diameter and circumference of a circle. The required data was given in the workbook so children didn't have to generate the data. Step-wise instructions of how a graph is constructed was given. The discussion covered extrapolation of data from the graph as well. Graphs were then made with data of the sides and diagonals of squares as well as the length of the spring and the suspended weights. A curved-line graph (sides of a square and its area) was also given as an exercise in obtaining information from a graph.

One change in the 2000 edition of the chapter was that it began with a discussion of ways to present data, graphs being one such method. Although the examples used were different, the chapter was more or less the same. The examples were mostly of graphs children are likely to come across, such as the rate of scoring runs in a cricket match. Some examples were also drawn from daily life, such as the changing proportion between total school enrolment and sex ratio. There were more exercises in reading graphs.

13. Growth (वृद्धि)

In this chapter, growth is studied as a characteristic of the living. There are three experiments. In experiment 1 two seeds are sown and their growth is monitored for around 20 days starting from the appearance of the first sprout, during which the length of the plants is regularly measured and compared. A graph is made for comparison. The graph is used to raise some questions about growth; attention is drawn to the sigmoid shape of the graph. It reveals the differences in growth rate in different time periods and the children discuss possible reasons for differences in the growth of the two plants.

Experiment 2 involves germinating three seeds and the discussion focuses on the necessary conditions for germination. Children have to design experiment 3 themselves to find out if sunlight is necessary for seed germination.

There was a separate chapter on "Development" (विकास).

The 1987 edition placed this chapter in class 8. Both the experiments related to seed germination were excluded and, instead, children were asked to compare the ages and heights of students in their class and look for reasons for differences, if any. The chapter at the outset differentiates between growth and development.

The 2000 edition saw the merger of chapters on growth and development. The discussion is placed in the context of changes taking place with age in animals. The discussion draws heavily on the observations of the experiments done in the chapter on life cycles of animals (जंतुओं का जीवन चक्र). Changes taking place during germination of seeds is studied to understand development in plants. The experiment on growth was retained sans the graph. After this, concepts such as limited and unlimited growth, symmetrical and allotropic growth, meristem in plants were discussed. Human growth is used as an example to highlight allotropic growth.

14. Air (हवा)

This chapter with 16 small and simple experiments begins by giving children a sense of the presence of air around us. There are two experiments in which air is collected by displacing water and is measured. There are some other experiments to help understand the concept of air pressure. One experiment shows that air can be compressed by applying pressure. Children then explain how ink is filled in a fountain pen (such a fountain pen is seldom available now) with the help of the conclusions of these experiments.

There are experiments to demonstrate how valves work and the discussion flows to the role of valves in a hand pump and in blood circulation in the body. The volume coefficient of expansion of air is also determined and children make a toy windmill as a game.

This chapter is like a collection of activities which rather than trying to explain various properties of air in detail, tries to give children a broad feel of these properties.

The chapter in the post-*Lal Vaigyanik* cards was similar to the one in the 1978 edition. There were two differences at the conceptual level. One experiment showed that air has weight, and in another, models were used to show the direction in which air or water is pushed by a whirligig or propeller. Two other experiments investigated the constituents of air. An attempt was also made to calculate the percentage of oxygen in air.

The structure of the chapter was almost the same in the 1987 edition. There were some additions and some points were discarded. For example, an experiment to illustrate air pressure was included in which air pressure was used to lift weights. An activity to make a hand pump model with a broken boiling tube was also included. On the other hand, there was no experiment to determine the volume coefficient of expansion of air, and only the observation of thermal expansion was retained. The precaution to equalise air pressure while measuring the volume of air was included in the text of this edition, whereas earlier it had been left to the discretion of the teacher to instruct the children.

In the 2000 edition the chapter was re-titled "Fun with Air" (हवा के खेल) and included some new experiments.

15. Looking at the Sky (आकाश की ओर -1 व -2)

In this chapter, children try to build a model of the universe by observing the motions of planets and stars in the sky. It has two parts: "Looking at the Sky – 1" in class 7 and "Looking at the Sky – 2" in class 8. The first part has experiments to understand the daily and yearly motion of the sun, which is used to explain the summer and winter solstice (actually *uttarayana* and *dakshinayana*). The Sun's movements are linked to everyday experiences of people. Children also make a sun dial. The chapter includes several physical as well as mental models as aids to developing conceptual understanding.

The post-*Lal Vaigyanik* cards had a single chapter titled

"Looking at the Sky" incorporating the content of both parts. One important difference in the cards was that the chapter does not present Occam's razor (simpler explanation is more acceptable) as a way to decide between competing models/ hypotheses. It adopts an approach that we draw some conclusions on the basis of logical reasoning and compare the conclusions with results obtained from experiments. If the two match, then the model based on the reasoning is correct.

The 1987 edition also had a single chapter which was in the class 8 syllabus.

The 2000 edition was similar to the 1987 edition.

16. Gases – 1 and Gases – 2 (गैसें - 1 व गैसें - 2)

After recalling properties of air, the chapters take up the study of the physical and chemical properties of carbon dioxide, oxygen, hydrogen and ammonia. The relationship between oxygen and carbon dioxide in the process of combustion is also investigated.

The chapter was the same in the post-*Lal Vaigyanik* cards.

The 1987 edition had only a single chapter titled "Gases" in class 7, which was the same except that it excluded hydrogen.

The chapter in the 2000 edition retained only the experiments with oxygen and carbon dioxide. It included experiments to show their linkage in the process of combustion.

17. Starch in Leaves and Sunlight (पत्तियों में मण्ड और सूर्य का प्रकाश)

This chapter, which investigates plant nutrition, initiates the discussion on plant nutrition with an experiment to study the role of cotyledons in the growth of seedlings. A part of this (absorption of water and minerals by roots) is already covered in the class 6 chapter "Food and Digestion" (भोजन और पाचन क्रिया). The experiments that follow investigate the role of leaves in plant nutrition. They include an experiment to study starch content in leaves and another in which a leaf is covered with black paper to show the role of sunlight in starch production. A series of questions follows that encourages children to think about the importance of starch production in leaves for life on earth. The chapter ends with a discussion of food chains and some related exercises.

The 1987 edition incorporated nutrition in plants in a class 6 chapter titled "Nutrition – 2" (पोषण - 2). This chapter was basically an amalgamation of part five of "Food and Digestion" (class 6, 1978) and "Starch in Plants and Sunlight".

In the 2000 edition the concept of nutrition in plants was given a fairly different treatment in the class 7 chapter "Nutrition in Plants" (पौधों में पोषण). It went into the history of explorations to understand the process of photosynthesis and children tried to analyse each step forward in the process. They also duplicated some of the historic experiments. The entire exercise was linked to the study of the internal structure of plants. Details of some historical experiments were narrated to the students and they were taught how to analyse these experiments. There was also some discussion about micronutrients.

18. Respiration (श्वसन)

This chapter basically compares inhaled and exhaled air in the process of respiration. To establish how crucial breathing is for life, the first experiment is about holding ones breath. This is followed by experiments to measure the respiratory rate and study it in different contexts. The differences in the temperature, humidity and chemical composition of inhaled and exhaled air are investigated. There are experiments on the respiration of soaked seeds. The relationship between oxygen and carbon dioxide in respiration is discussed and questions are posed to the children. They then observe the respiratory organs of a dissected rat and learn about human respiratory organs through diagrams and pictures.

The chapter in the 1987 edition did not contain the experiment on respiration in seeds. The rest of the chapter was more or less the same.

Some new aspects were added in the 2000 edition. One was an experiment to measure exhaled air. Experiments on respiration in plants and seeds were also included. A table was used to explain that inhaled and exhaled air both contain oxygen and carbon dioxide, only their proportion changes. The method of giving artificial respiration was also explained.

19. Development (विकास)

The chapter brings out the difference between growth and development through a series of questions. An experiment is conducted to study how seeds develop into plants. Twenty seeds each of two plant species are sown and each day one sapling from each species is uprooted to study the changes that take place over time. Some questions are posed to children to guess how the plants will develop in future, based on what they have observed in the experiment.

To understand development in animals, various stages of development of chicks in hen's eggs are studied.

In the 1987 edition, the chapter was titled "Development" (परिवर्धन) was included in the class 8 syllabus.

As mentioned earlier, the 2000 edition had an amalgamated chapter on growth and development for class 8.

There is an interesting fact about development that needs to be mentioned. The understanding of development at the time of preparing the first two editions of *Bal Vaigyanik* was that whenever a new organ developed in a plant or animal, it can be called development. At the time the 2000 edition was being prepared the life scientists in the resource group made it clear that the new organ we see in any animal is usually present at the time of birth itself in miniature form. That's why their visible appearance is an example of growth, not development. In animals, development after birth only occurs in animals that metamorphose. In all other animals, development is complete before birth in the embryo. As a result, the biology chapters related to growth and development in the 2000 edition were written on the basis of this new understanding.

20. Principle of Balance (तराजू का सिद्धांत)

This chapter is not just about weighing but also about the principle of balance. After beginning from common everyday ways of weighing things, the chapter focuses on the issue of what a true weighing balance is. Children are introduced to the weighing balance provided in the kit and then they make their own weights and balances. Many suggestions are given about how to go about this activity. Children then use a half-metre scale to conduct some experiments to learn the principle of balance and judge the truth of the balance they had made. They also learn the parts of a weighing scale such as beam, fulcrum, rider, etc., and understand why different kinds of balances are needed for measuring different weights. They do some exercises in weighing different things and applying the formula for pan balances.

Lal Vaigyanik had a similar chapter titled "Weight and Weighing Balance" (भार और तुला). Its focus was more on measuring weights than on analysing the principle of weighing scale. Weights were suspended from a spring and an illustration was made with strips of paper cut according to the length of the spring. There were a few more experiments, such as joining two springs one under the other, or placing two springs in parallel and weighing different things. The final activity was making a spring balance. There were also activities to understand the principle of the lever to introduce the children to a simple lever balance.

The 1987 and 2000 editions had this chapter in class 8 with some small changes.

Class 8, part I

1. Life cycle of animals (जंतुओं का जीवन चक्र)

Children conduct control experiments on the life cycles of four animals in this chapter which is woven around widespread beliefs about spontaneous generation. In the process they also learn the significance of control experiments.

The four investigations seek an answer to the question: Can an animal spontaneously appear in cow dung or rain? Experiment 1 traces the life cycle of flies from the egg laying stage to the development of adult fly. In the experiment children get to observe different stages in a fly's life cycle and also see that maggots cannot spontaneously appear in cow dung. The fly's eggs have to be present in dung. Instructions are given for making diagrams of each stage based on observations. The importance of controls is highlighted through the questions posed after the experiment.

Experiment 2 is a study of the life cycle of frog, while experiment 3 studies mosquito and experiment 4 either the kausam tree insect or a cotton plant insect. The important aspect of these experiments is that metamorphosis occurs in the life cycles observed in the first three animals while no metamorphosis occurs in the case of the kausam/cotton insect.

While doing these experiments, children see how important it is to make the experimental conditions as close to the natural conditions as possible. All four experiments are long-duration experiments; therefore children and the teachers have to attend to many management issues.

The chapter was more or less the same in the 1987 edition. A pictorial history of the life cycle of grasshoppers has been added, followed by some questions, as an introduction to development without metamorphosis, with the kausam/cotton insect experiment being made optional.

The chapter was more or less the same in the 2000 edition.

Lal Vaigyanik did not have any such chapter.

2. Flowers and Fruits (फूल और फल)

The external and internal structure of a veriety of flowers is studied in this chapter, the objective being to recognise patterns, establish the link between flowers and fruit and discuss some of the ways in which seeds are dispersed. Children study many flowers to identify similarities and differences among them.

The chapter is divided into five parts. The first part covers the study of parts of a common flower. It includes dissecting the flower and studying vertical and transverse sections of the ovary. Children observe ovules in the ovary to form an estimate of their total number. The diversity in the androecium and gynoecium is highlighted and pollen grains are examined under a microscope.

In part two children go on three field trips in different seasons, collect a range of flowers and fruits and study the collection. Their study shows that the parts of a flower are arranged in a specific order of whorls. Children also learn about complete/incomplete flowers, unisexual/bisexual flowers, etc. and find out that these whorls show some distinctive features in some flowers. Some compound flowers are studied as well as special flowers like those of wheat, fig and rice. Attention is paid to studying special characteristics of the legume family.

In the third part, children are made aware of variety of flowers in nature and how to study them.

In part four, flowers and fruits are studied together to get an idea about how fruits may develop from flowers. Comparisons are made between the ovary and the internal structure of the fruit. Children make an album of flowers as a corollary activity.

Part five discusses dispersal of seeds.

In the 1987 edition, while retaining the structure of the chapter, it was made more concise and placed in class 7. Number of examples studied was reduced and special flowers were not included. Diversity in different parts was left out and so was the idea of an album. Few mistakes in the case of compound flowers were rectified.

In the 2000 edition, the chapter was divided in two parts - 'Dispersal of Seeds' (बीजों का बिखरना, class 6) and 'Introduction to Flowers' (फूलों से जान-पहचान, class 7). The discussion and activities related to compound flowers were excluded.

3. Reproduction in Plants (पौधों में प्रजनन)

This chapter has long-duration, control experiments to investigate which part of the flower develops into fruit and the role of the male flower in the process of fruit formation. Another feature of this chapter is that the experiments are done *in situ*.

Children first recollect the connection between fruits and flowers brought out in the chapter "Flowers and Fruits", namely that fruits probably develop from the ovary of flowers. They are asked to think of an experiment to prove that a fruit cannot develop in the absence of flower. They are specifically asked to provide for control in this experiment.

Then follows experiment 1 performed on unisexual flowers (such as the bottle gourd, sponge gourd, bitter gourd, etc.). Different coloured threads are tied to male and female flowers and they are observed after a few days to see which flowers develops into fruits. Experiment 2 investigates the role of the male flower. In this, some female buds are artificially inseminated with pollen while some other buds are left untouched. Such experiments require several precautions to be taken, which children learn. After the experiment is completed, the ovary is closely examined to identify the changes that occur when it develops into a fruit. Finally, there is a discussion about natural pollination, hybridisation and sexual and asexual reproduction.

This chapter was given in more or less the same form in class 7 in the 1987 edition.

The chapter in 2000 edition begins with making distinction between sexual and asexual reproduction. Then the question is posed if fruits could develop without the flowers. Children are asked to think of an experiment. Next section starts with the question, can an ovary turn into a fruit by itself. In reply to this question, children read description of an experiment, which in earlier editions they were expected to perform. There are experiments to observe pollen grains and their germination. Asexual reproduction is explained with examples.

4. Living World Through a Microscope (सूक्ष्मदर्शी में से जीवजगत)

This chapter, based on the study of different micro-organisms seen under a microscope, has several activities linked to cells. Models are used to show the children that things seen under a microscope may appear two-dimensional and flat (in particular, cells) but they are not necessarily flat. All the experiments are done with a small, inexpensive microscope.

The chapter begins with instructions about using the microscope, describing its structure and use and maintenance. Instructions are also given on how to prepare slides for viewing under the microscope.

After this, a drop of water from a puddle or lake, the cells of an onion, a transverse section of a plant stem, a transverse section of the stem of a plant watered with red-dyed water, etc., are examined under the microscope. Attention is drawn to the diversity and function of cells.

Onion cells are examined to spot the nucleus, after which children examine their own cheek cells. They are told how to estimate the size of whatever they see under the microscope and several estimation exercises are done. They are then asked to imagine how vertical and transverse sections of large objects (such as *Bal Vaigyanik*, a bundle of chalk, a beaker filled with marbles, etc.) would look to make them realise that cells are neither flat nor two-dimensional. They also get some idea of the internal structure of the cell using the marbles model. Finally, there are some exercises related to the size of micro-organisms, after which they study blood cells and the flow of blood in a tadpole's tail.

The chapter in the 1987 edition was also based on microscopic observations but fewer observations were made and the model building to understand three-dimensional nature of cells was left out.

The structure of the chapter in the 2000 edition was the same but it was renamed "The World of Minute Things" (सूक्ष्म चीज़ों का संसार). Observations of a few new things were introduced, such as algae, starch in cells, and leaf peels. Information about a few other things was added (such as the internal structure of the stem).

5. Sound (ध्वनि)

In this chapter children do 14 experiments that show them how sound is produced. They also learn about its different qualities and about resonance.

In the first four experiments various things are used to produce sound and the link between vibration and sound is investigated.

In experiment 5, a one-metre scale is vibrated at different lengths to see what effect the rate of vibration has on the sound produced. Experiment 6 repeats this activity with a steel scale to see the effect of the rate of vibration on the pitch of the sound. In experiment 7, the tension is progressively increased to see the effect on the sound produced. Experiment 8 establishes the link between the length of a vibrating wire and the pitch of the sound. While doing this experiment care is taken to ensure that the tension of the wire remains unchanged as the length changes. In experiments 9 to 11 the discussion centres on the medium of propagation of sound. Children are asked to design an experiment in which sound is propagated through water. The final two experiments are related to resonance.

In the 1987 and 2000 editions, the chapter was included in class 7 without much change.

6. Rules of Classification (वर्गीकरण के नियम)

This is an important chapter in *Bal Vaigyanik.* It was developed on the understanding that classification is a fundamental activity in science and children should be familiar with it. The chapter is based on classifying items contained in their schoolbags. They learn the difference between grouping and classification through this activity and understand the three basic rules of classification: each class is an exclusive group; basis of grouping should not change at any particular step; every item should be grouped.

After this activity, the concepts of empty groups and hierarchy in classification are discussed. Finally, exercises are done on classifying insects.

This chapter was not included in the 1987 and 2000 editions.

7. Heat (ऊष्मा)

The chapter begins with ways of generating heat (experiments 1 to 5) and goes on to discuss limitations of assessing hotness with the help of our senses, the use of thermometers (experiments 6 and 7), conduction of heat in different substances (experiments 8 to 11), heating liquids (experiment 12), change of state (experiment 13) and heat transfer (experiments 14 to 19). There is also a graph-making exercise based on data of temperature and thermal expansion in water.

This chapter was slightly restructured in the 1987 edition under the title "Heat and Temperature" (गर्मी और तापमान). An experiment was included to highlight the difference between heat and temperature. Some changes were made in the experiments on heat conduction by metals, but thermal expansion of water was discussed only at a qualitative level. The section on ways of generating heat is left out while there were detailed discussions on conductors/non-conductors.

The chapter was there in the 2000 edition as well with a few more changes.

8. Reproduction (प्रजनन)

This chapter is about reproduction in animals and is carried forward on the basis of information gained in the experiments in "Life Cycle of Animals" and "Reproduction in Plants" as well as the prior knowledge and experience of children.

A series of questions is posed to highlight the fact that the birth of an animal is only possible if other animals of the same kind already exist. This process is explained in terms of reproduction and the question is then posed whether a male is necessary for reproduction. The answer to this question is coaxed out from the previous knowledge of children and the discussion moves on to artificial insemination. Finally, animals are classified into egg-laying and child-birth (oviparous and viviparous) groups. Attention is also drawn to the fact that some animals undergo metamorphosis, others don't, and that some animals care for and protect their young, others don't.

This chapter was renamed "Reproduction in Animals" (जंतुओं में प्रजनन) in the 1987 edition.

The structure of the chapter was changed quite a bit in the 2000 edition to highlight the diverse ways in which animals produce offspring. It discussed sexual and asexual reproduction, unisexual and bisexual animals, external and internal fertilisation, egg-laying and child-birth animals, and reproductive season, etc. The discussions were carried forward using examples, many of which were not from the immediate environment of the children.

9. Classification of Animals (जंतुओं का वर्गीकरण)

This chapter doesn't go into the standard classification of animals but classifies them according to their external structure and the common observations of children.

They are told how to determine whether an animal has a backbone by examining its external features. Children are then told to practise classifying some animals on this basis.

The next step is to list the names of all the animals children know. They are classified according to the presence/absence of backbone into vertebrates and invertebrates. The invertebrates are further separated into those with segmented and non-segmented bodies. The next division in the hierarchy is of segmented body animals with and without appendages and non-segmented body animals with and without a shell. The classification of vertebrates is also investigated in a similar manner. In this way a complete classification framework is developed. The importance of classification comes across when children learn how to extract information from the system. They are finally asked to come up with newer and different ways of classifying animals and put up pictures of their new classifications.

This chapter was not included in the 1987 and 2000 editions.

10. Electricity – 3 (Magnetic Effects of Electricity) (विद्युत - 3 - विद्युत के चुंबकीय प्रभाव)

This chapter has seven experiments and an activity to make an electric motor. It begins by defining the direction of electric current in a circuit. Children observe the effect of a bar magnet on compass needle in experiment 1. In experiment 2 they see the effect of a wire, through which electric current is flowing, on a compass. Children observe the direction in which the compass needle is deflected while the wire is placed above the compass, below the compass as well as after changing the direction of current. They then learn the right hand rule from the description given in *Bal Vaigyanik*. Experiment 3 repeats what is done in the previous experiment but this time with two double wires.

In experiment 4 the wire is coiled around the compass and the number of turns is progressively increased to see the effect on needle's deflection, angle of deflection being measured. They then draw a graph plotting the angle of deflection against the number of turns in the coil. In experiment 5 the wire is wrapped in an east-west direction but the rest of the experiment is the same as experiment 4. The right hand rule is applied in this case. Experiment 6 is to make an electromagnet with which children design a railway signal. In experiment 7 they shape a wire into a swing, hold a magnet steady under it and observe the deflection of the wire when an electric current is applied. To help them understand their observations better, they make a swinging electric acrobat to see the direction of the current and the direction in which the acrobat swings. They finally make an electric motor and try to understand its principle.

In the post-*Lal Vaigyanik* cards there was no attempt to arrive at the right hand rule nor was the principle of the electric motor explained. There was no electric swing, but they did make a model of an electric rider.

There were fewer experiments in the chapter in the 1987 edition. One casualty was the experiment in which the number of turns around a compass is progressively increased and the angle of the needle's deflection is measured. A different method was given for making the electric swing while the electric acrobat was not included. The rest of the chapter was the same.

The electricity chapters were restructured in the 2000 edition. Class 8 had a chapter titled "Various Effects of Electricity" (बिजली के प्रभाव तरह-तरह के) that covered the chemical, heating and magnetic effects of electric currents. The magnetic effects section did not include the electric swing but contained a simpler method of building an electric motor.

Class 8, part II

1. Chance and Probability

This chapter investigates the probability of events occurring, problems in calculating probability and the role of chance in the process. The discussion on probability highlights the law of large numbers. One important feature of the chapter is the tabulation and presentation of data.

It begins with a discussion about delays in the arrival/departure of a train at a station. The question of probability is raised and the role of chance and probability in our daily lives is highlighted. Next is a game, the 'Heads and Tails Race', in which children stand in a line and each one throws a coin, moving either forward or backward, depending on whether heads or tails comes up. They are taught to keep individual and collective record of the game. After the race, the heads and tails pattern of each child is discussed and the discussion leads up to the understanding that large amount of data (larger number of tosses) is needed to draw conclusions. The distribution of children in different rows after each throw in the game and their chances of winning are also discussed.

In experiment 1 children learn that pasting heads symbols on three faces of a cube makes it equivalent to a coin. In the next few experiments 10 such dices are rolled. In experiment 2, 100 such throws are made and a bar diagram drawn of the number of heads in each throw. The mode is determined and the emerging pattern is analysed. The mode of all the modes is also determined and a combined histogram compiling the data of all the groups is prepared. Children see that the combined bar diagram and the bar diagram of most groups reveal a similar pattern. They also see that the larger the number of moves the easier it is to predict the results.

Next follows the calculation of probability of heads or tails occurring. It becomes clear that it is still not possible to predict the outcome of the next move even after one has calculated the probablities. This inability to predict is called chance. Children then do an exercise to find the viability of seeds. Here they discuss why it is incorrect to draw a general conclusion if the germination experiment is done with only a few seeds.

In the next experiment the number of faces on the dice with the heads is increased or decreased and the probability of heads turning up is calculated in each situation. A graph of the number of dice faces with the heads on each dice and the probability in each case is drawn. This is followed up by several other exercises.

Finally, children discuss the difficulties in calculating probability in the case of everyday events and a few examples are analysed.

In the post-*Lal Vaigyanik* cards the chapter was titled "Chance and Possibility" (संयोग और संभावना). It did not contain the example of the arrival/departure of the train. The objective of the chapter was stated in two introductory questions: "If a coin is tossed several times, (a) will it turn up heads and tails alternately? If not, (b) will the number of heads and tails be equal?" The chapter then started with the heads and tails race. Each student tossed a coin 200 times and recorded the heads/tails in a table. They made a bar diagram of the number of times heads turns up for every 10 throws of the coin and then made a composite bar diagram of all the group bar diagrams to get the answer to question (b). To get the answer to question (a) they recorded the second throw only if the heads turned up in the first throw. Next was tossing dice to calculate the average number of heads and the probability. The importance of large numbers was continually emphasised through questions posed throughout these exercises and a graph of probability and the number of throws was made to clarify this.

The structure of the chapter was the same in the 1987 edition but many of the exercises were not given, such as the one in which the probability is calculated after changing the number of heads on a dice.

Several changes in the chapter were evident in the 2000 edition. Dice marked with heads were not used. Each child tossed a coin

100 times after the heads and tails game and recorded the data. They were first asked to guess the number of heads and then calculate the probability of heads/tails turning up. The same data was presented in different ways until a pattern was seen emerging as the number of throws increased. A horse race was included to show that the probability of any of two outcomes occurring is not always 50 percent. The chapter ended with an analysis of several everyday events.

2. Acids, Bases and Salts (अम्ल, क्षार और लवण)

This chapter requires a lot of apparatus and the teacher has to make a lot of preparations as well. Children learn about acids, bases and salts and their reactions through nine experiments. In experiments 1 to 4 various substances are tested with red and blue litmus paper and phenolphthalein indicator and grouped as acidic, basic and neutral. In experiment 5 children make indicator solution from *haldi* (turmeric). Experiment 6 shows the (neutralisation) reaction between acids and bases and introduces salts. Experiments 7 to 9 are quantitative neutralisation experiments and the concept of concentration of acids and bases is also brought up. Finally children are given a home assignment to prepare indicators from different flowers. Precautions to be taken when handling chemicals are highlighted in all the experiments.

In the post-*Lal Vaigyanik* cards the chapter introduced the children to acids and bases and included two neutralisation experiments.

A new experiment was added to the chapter in the 1987 edition. In it equal quantities of a solid acid and base were taken and dissolved in equal quantities of water. They were used to neutralise each other in order to show that equal weights of acid and base do not necessarily neutralise each other. The objective was to show that weight alone cannot be the basis for making comparisons in chemical reactions.

The chapter was presented in two parts in the 2000 edition. The experiments to test substances with indicators were included in the chapter titled "Identifying Acids and Bases" (अम्ल और क्षार की पहचान) in class 6 and the other chapter "The Relationship between Acids and Bases" (अम्ल और क्षार का आपसी सम्बंध) was in class 8. The experiment on quantitative comparisons that was introduced in 1987 was excluded.

3. Motion in Graphs (गति के ग्राफ)

This chapter explains motion, speed, average speed, acceleration, etc., with graphs. It begins by explaining average speed and then talks about a journey undertaken by a student. The chapter uses examples from everyday life to analyse motion. Children make several graphs from the data of different journeys and various concepts related to motion are progressively brought up for discussion. A range of exercises is done to show the link between the slope of the graph and speed, graph line during periods of rest and graphs of changing motion, etc.

The chapter was more or less the same in the 1987 and 2000 editions. The difference between graphs and maps was clarified and the method of making graphs was given in more detail. The 2000 edition also had more exercises.

4. Why Do Things Float? (चीज़ें क्यों तैरती हैं)

The title of the chapter states what is being investigated. It begins with a game in which children drop various objects into a boiling tube containing water and kerosene and see the level to which each item sinks. It is a teaser experiment to provoke interest in children to explore further. The difference between 'heavy' and 'dense' is clarified before the discussion is taken forward to examining why some things float and some sink. Experiments 1 and 2 find the relative density of solids while experiment 3 takes up liquids. Children are asked to find the unit for relative density themselves. The story of Archimedes is narrated and its link with experiments 1 and 2 is highlighted. Questions are then posed to establish the link beween relative density and floating/sinking. Experiments 4 and 5 are investigations of the Archimedes' principle while experiment 6 clarifies that floating/sinking depends on the object as well as the liquid in which it is put. In experiment 7 the children make a lactometer and the chapter concludes with some quiz-type exercises.

The chapter was retained in the same form in the 1987 edition.

It was divided into two parts – "Relative Density" (आपेक्षिक घनत्व) and "What Floats, What Sinks" (कौन तैरे, कौन डूबे) – in the 2000 edition.

The relative density part began with a game after which the relative densities of solids and liquids was calculated. The method used by Archimedes to detect impurities was explained in detail and the unit for relative density was derived. The lactometer-making activity was also there.

The second part began by revising the concept of relative density, after which the problem that some things with a relative density exceeding 1 can also float in water was posed. Three experiments were done in this context, in an attempt to discover the Archimedes' principle. Some everyday examples, such as *puris* inflating and floating in oil when fried, ice floating in water, etc., were also analysed.

5. Living and Non-living (सजीव और निर्जीव)

This chapter is based on children's prior knowledge. It includes their previous experience as well as their observations from experiments performed in previous years. It assumes that they know which things are living and which are non-living. So the first activity is grouping things found around them into living and non-living. The distinguishing properties of living creatures are listed and the entries in the two groups are analysed on the basis of these properties. Next a question is posed whether all living creatures need to have all the listed properties. Examples such as immovability of trees, dormancy in seeds, absence of growth in elderly people, hibernation of frogs, sadhus in *samadhi*, etc., are analysed.

The chapter does not present living and non-living as two independent and unrelated groups but sees the groups as mutually related and constantly changing. The living become non-living on dying and non-living substances are made use of by the living.

The chapter in *Lal Vaigyanik* differentiated between living and non-living things and classified them accordingly. Some properties of living creatures were illustrated through pictures. (An oddity here was the use of a family planning poster to show the property of reproduction.)

The chapter in the 1987 edition was similar. The 2000 edition added an experiment on respiration in dry seeds. It introduced a new dimension to the discussion on the process of evolution of living creatures from non-living things by pointing out that non-living substances cannot give rise to living by themselves.

6. Time and the pendulum (समय और दोलक)

The chapter begins by using everyday examples of telling time and goes on to constructing a water clock and candle clock. Experiments with pendulums are performed and the effect of weight of the bob and length of the pendulum on its time period is studied. In the end, there are two interesting experiments: one to make a coupled pendulum and another using a pendulum suspended from two strings.

Lal Vaigyanik had a similar chapter titled "Time and Oscillating Systems" (समय और पुनरावर्ती निकाय) in which children first learnt about oscillation and were then asked to estimate time. Examples of natural events useful for measuring time were given. After this an experiment was done in which equal quantities of water were made to flow from a burette in a fixed time interval. The children also made a spinning disc and the chapter ended with the pendulum experiment.

Only one change was made in the chapter in the 1987 and 2000 editions: instructions were given for making a sand clock with two injection bottles. The special pendulums were omitted.

7. Soil (मिट्टी)

Children collect soil samples from different places during a field trip and perform the following investigations: soil odour, texture, presence of living creatures or their remains, presence of different-sized particles, presence of water, quantity of water absorbed, capillary properties and presence of solutes. An attempt is made to link soil structure with the problems associated with the construction of the Tawa irrigation project in Hoshangabad district.

The chapter in the 1987 edition began with a discussion on the uses of soil and tried to link properties of soil with its uses. The field trip was also different. Children of each group were told to collect a soil sample from a particular place on their way to school. They were also asked to observe soil erosion. Some new experiments were added: percolation rate of soil, determining soil types, testing water content of soil, etc. Questions were asked to stimulate a discussion on the link between properties of soils and their uses.

The chapter in the 2000 edition was restructured a bit but was essentially the same.

8. Light (प्रकाश)

The chapter begins with shadow play and proceeds to a series of experiments to investigate propagation of light in a straight line, pin hole camera, the path of light, reflection and refraction, and making some optical instruments.

Experiments 1 and 2 are shadow play games. Experiment 3 uses three card sheets with pinholes lined up in a straight line to demonstrate that light propagates in a straight line. Experiments 4 and 5 show the spreading of rays from a light source. Ray diagrams are also given and children are asked to generate their own diagrams.

They make a cardboard box with a rectangular window, place a lighted bulb in front of it to project an image of the window onto a screen made from a sheet of graph paper. The size of the image is altered by changing the distance between the bulb and the window and the window and the screen. Children measure the size of the image with every change and make a graph of the distance and the height of the image. The experiment is repeated with the sun's rays to demonstrate their parallel propagation. A pinhole camera is also made.

Then follow experiments to demonstrate laws of reflection.

After observing the relationship between the angle of incidence and the angle of reflection, children make a periscope and a kaleidoscope. The next experiment is connected to refraction. Light is passed through water contained in a transparent container and the angles between the incident and refracted rays and the normal are measured. A game on refraction follows after which children make a lens camera and a telescope. A water prism is used to generate spectrum and finally instructions are given for making a projector.

After many cuts, this chapter was included in the 1987 edition of the class 7 book.

In 2000, except some changes in the procedure of experiments, the rest of the chapter was retained as in 1987.

9. Internal Organs and their Functions (शरीर के आंतरिक अंग और उनके कार्य)

In this chapter, observations of a dissected rat and some activities linked to their own bodies form the basis for understanding internal organs. Some information is also provided in *Bal Vaigyanik*. In some cases, diseases affecting certain organs/ systems are discussed to figure out how they function normally.

The following body systems are covered in the chapter: muscular system, digestive system, respiratory system, circulatory system, nervous system, excretory system, reproductive system and glands. The relationship between respiration and blood circulation is explained. The final activity in the chapter is building a model of the human body to understand the layered, three-dimensional arrangement of organs. The method of dissecting a rat is given as an appendix. The expectation is that teachers would arrange to dissect a rat in the class.

The structure of the chapter remained more or less the same in the 1987 and 2000 editions. However, the muscular system was shifted to the chapter "Internal Organs of the Body – 1" (शरीर के आंतरिक अंग - 1) in class 7, and there was no appendix giving instructions for dissecting a rat. A bottled specimen of a dissected rat was provided in the kit.

10. Machines (मशीनें)

Children are introduced to some simple machines in a chapter full of activities and making things. It begins with a story of how the hammer and needle were possibly invented. The thrust is to show that development of tools occurs gradually in response to needs and convenience.

After this there are experiments to investigate the lever, its principles, the relationship between levers and pulleys, making pulleys and studying the ways in which they are combined for use, transportation machines, making a van, bearings, inclined plane, screw, the relationship between inclined plane and screw, wedge, crank, belt, etc. The chapter focuses on studying machines in practical contexts and building models and apparatus using simple, easily available materials. That is its special quality.

Some of the theoretical aspects were removed from the chapter in the 1987 and 2000 editions; otherwise it was more or less the same. For example, explanations about pulleys being basically levers or screws being basically inclined planes were left out. Instructions to make a crank were also excluded.

Development of new chapters

When the third edition of the *Bal Vaigyanik* workbooks were prepared in 2000, some chapters were included for the first time. The catalyst for preparing these chapters was the process of revision that began in 1994, when attention was focused on developing some chapters in chemistry. The new chapters that emerged from this exercise are summarised ahead.

1. Solubility (घुलनशीलता, class 6)

In this chapter, three experiments are used to clarify that the solubility of different substances in a given liquid is fixed and usually the solubility of solids increases with increase in temperature though the amount of increase depends on the nature of the solid. There are also experiments to observe the solubility of one liquid in another.

2. Making Crystals (रवे बनाना, class 7)

Children make crystals of urea, benzoic acid and alum in three different experiments. Another experiment uses the evaporation method to make crystals of oxalic acid, urea, salt and copper sulphate. The experiment shows that crystals of each substance have a unique structure.

3. Chemical Reactions (रासायनिक क्रियाएं, class 7)

This chapter has three experiments in which three different chemical reactions are investigated: copper plating, reaction of urea and oxalic acid, and rusting of iron. The main feature brought out by these experiments is that new substances form during chemical reactions and different ways in which their formation becomes evident, such as change in colour, production of residue and bubbling, etc.

4. Rate of Chemical Reactions (रासायनिक क्रियाओं की गति, class 8)

In this chapter an investigation is made into the factors that affect the rate of chemical reactions. The experiments involve two chemical reactions. The first is the action of hydrochloric acid on marble, which is accompanied by the production of carbon dioxide and the action of sodium hydroxide on aluminium, during which hydrogen is produced. The bubbles generated are counted as a measure of the rate of the reaction. Three factors are investigated – concentration of the solution, size of particles of the solid substance, and temperature.

5. Structure of Substances and the Language of Symbols (पदार्थों की रचना और संकेतों की भाषा, class 8)

This chapter introduces children to elements, compounds and mixtures, atoms and molecules, and chemical symbols and formulae. The chapter begins by discussing differences between pure substances and mixtures using separation techniques as a basis. Pure substances are grouped under elements and compounds and the topic of atoms is brought up for discussion to differentiate between them. Next follows a discussion on symbols and formulae, with the symbol and formulae for some common elements and compounds being given. There is also some discussion on the grammar of formulae, following which children do some exercises. One special feature of the chapter is that it presents the groupings of elements, compounds and mixtures as tentative and dependent wholly on the methods of separation and chemical analysis available at the time.

7

EVOLVING *BAL VAIGYANIK*

The *Lal Vaigyanik* appeared in 1972. After this it was decided not to print any more books for the time being as the programme was still in the formative stage and a book gives a sense of finality. The chapters were developed one at a time between 1972 and 1977 and printed on separate cards that were given to children in the classroom. We have already discussed how the chapters evolved during this phase.

The chapters were distributed across classes 6, 7 and 8 on the basis of various criteria, including gradual progression from qualitative to quantitative, concrete to the abstract, level of experimental skills required, inter-linkages between chapters, etc.

In this way, the first edition of *Bal Vaigyanik* was prepared between 1978 and 1980. The first edition was published by the Madhya Pradesh Textbook Corporation in 1978 (class 6), 1979 (class 7) and 1980 (class 8). Each workbook was accompanied by a kit copy containing stationery needed for conducting the experiments, such as graph paper, square-lined paper and some material needed for microscopes, etc.

Bal Vaigyanik was revised twice after this. The first revision was mostly carried out from 1987 to 1990, while the second revision began in 1994, was halted for several years in between, and then completed in 2000-02.

Sources of feedback

Follow-up visits to the schools and the reports written by the follow-up persons were a major source of feedback. But the HSTP could not maintain the tempo and intensity of follow-up that was a feature of the 16-school phase once the programme was scaled up to the district level in 1978. Although many attempts were made to evolve a workable system, follow-up remained an Achilles heel of the programme. Nevertheless some feedback on teaching-learning material from the classroom was generated from the visits that did take place. Other sources of information on the status of the programme were the teacher training camps and monthly meetings of teachers organised at the *Sangam Kendra* (meeting point) level. Apart from this, the examinations also provided useful feedback.

Exploiting examinations as a source of feedback was a unique feature of the HSTP. A random sample of children's answer papers would be picked up after every examination and put through a rigorous analysis by a large group of teachers and resource persons. The collective analysis didn't just go into seeing whether the answers were right or wrong but tried to understand whether children were facing difficulties in answering questions, and if so what. In a way, the exercise was a periodic review of *Bal Vaigyanik*, and its teaching. If nothing else, it provided pointers to which chapters and concepts were difficult to transact and required more attention or needed research inputs.

Each revision of the workbooks was preceded by several preparatory activities. First, all the classroom observation notes and feedback reports from the teacher training camps were carefully studied to identify issues and areas that required attention in different chapters.

Next, all the follow-up and monthly meeting reports were examined to again list relevant issues. Focused group discussions with the teachers were then organised in which they gave suggestions for different chapters on the basis of their classroom experience. In addition, they gave important feedback on aspects like language, illustrations and the overall balance of the content. These suggestions have been especially useful in making the books more appropriate to school conditions.

Surveys were also conducted about some science concepts as well as other issues.

Teachers were invited during actual rewriting so that their regular participation in the process of revision and rewriting kept it connected to school realities.

All these processes helped make *Bal Vaigyanik* more in tune with conditions availing in the schools.

But the revision exercise was more than just adapting the workbooks to suit the classroom situation. New ideas about science and science teaching constantly emerge, understanding of the subject content evolves, new methods for fostering understanding of scientific concepts among children are developed, and new learnings emerge from other innovative science teaching programmes in other places. All these also demand revising the textbooks and teaching methods.

Preparing rough drafts of chapters based on all this feedback, taking teachers' opinion on the draft, revising them and field testing were integral to this process.

First revision of *Bal Vaigyanik*

A lot of feedback was available after the district level expansion of the programme. This necessitated revision in *Bal Vaigyanik*. Moreover, the HSTP group continued to discuss aspects of *Bal Vaigyanik* and many issues that were emerging.

The 1980s was a decade in which many pedagogical studies of innovative programmes conducted in different countries around the world were showing that learning science through a discovery approach almost exclusively based on experiments led to an incomplete understanding of science and its practice. The picture that was emerging was that a positivist approach was inadequate to understand the true nature of science itself. In fact, it was even being suggested that 'discovering' concepts and laws by performing classroom experiments gave an erroneous impression of the enterprise of science.

Experts voiced the opinion that there is a complex relationship between observation and concept formation and they do not always come in that order. Very often, an observation is overlooked if there is no prior expectation/notion of a law or a concept. In short, there was an upheaval in philosophy of science and its relation to education.

At the time of taking up the revision of *Bal Vaigyanik* these issues were the subject of intense discussion in the resource group, though not necessarily in this form.

There was another point to note in science teaching experiments from around the world. Most such experiments sought to introduce children to the methodology of science but suffered from a serious shortcoming. They paid no heed to the children's immediate environs, nor did they provide space to accommodate their prior knowledge and experiences. In contrast, the HSTP had from the very beginning stressed the importance of making the child's knowledge the starting point of the learning process.

However, the main concern at the time of 1985 revision was that the *Bal Vaigyanik* course (particularly for classes 7 and 8) could not be completed in a school year. At that time the syllabus for the three classes contained 59 chapters. The situation was particularly dismal for class 8 which had two voluminous workbooks to be completed. Feedback from the schools clearly showed that this content was too much to handle in an academic year. So the main concern in 1985 was to trim the syllabus and size of workbooks to suit the school calendar.

Demands to have a relook at *Bal Vaigyanik's* rigid experiment-based format also began surfacing around this time. There were suggestions to think again about giving adequate space to other methods of learning. This issue cropped up at a workshop to discuss *Bal Vaigyanik* organised in October 1985 at Pachmarhi, where many teachers and resource persons subjected *Bal Vaigyanik* to a critical review from different angles: the content, methodology, illustrations, presentation, structure of experiments, language, etc.

A sub-committee constituted to review the methodology raised several important questions in its report. Its first comment was that the attempt to reach many concepts strictly through activities had made many experiments difficult, boring and unclear. The question posed was whether it was at all necessary to 'discover' or evolve all concepts through activities. A related question was: Why can't other methods (such as simple and interesting narratives with evidence) be used to learn some topics?

There were some suggestions about the experiments as well. *Bal Vaigyanik* has many instances where a series of experiments is given to understand a single concept. The suggestion was to make the content more concise and focused by leaving out unnecessary experiments.

This suggestion appeared to clash with the common understanding of the group that "repeated observations are necessary to fully develop a concept. For example, it is not enough for children to do one experiment to understand the principle of the weighing balance. They need to perform many different kinds of experiments so that they can move ahead step by step." However, it was necessary to strike a balance between the syllabus and the time available in the school calendar to complete it.

Similarly, the assessment of long-duration experiments was that the teachers were seldom able to complete them in the classroom. The suggestion was that such experiments be removed from the workbook. (Long-duration experiments are those that require more than one school day to complete.)

However, the group was not fully prepared to sacrifice these experiments, some of which were very interesting and beautiful. For example, in one experiment the children in class 7 study the stages of embryonic development in hen's eggs in the chapter "Development". It required arranging for eggs at different stages of development on a single day for making comparisons. The teachers enjoyed doing the experiment during their training camps, provided proper arrangements were made. It was suggested that the experiment be retained in the teacher training camps and made optional in *Bal Vaigyanik*.

This highlights the need to relook at the role of the textbooks and the teacher in order to give children a comprehensive experience. If the textbook is looked at as something that needed to be completed 'cover to cover', there is strict limit to its size, even if such limits put a brake on logical development of concepts. But if the workbook is seen as just a reference material (for the teacher), then it could take a different form, opening up several possibilities.

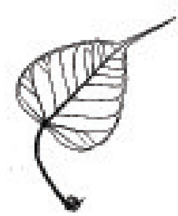
The methodology subcommittee felt that the objectives of several chapters were unclear. For example, it found the first activity in the class 6 chapter "Learn to Make Groups" (listing the names of children in the class) long, difficult and pointless. It felt that the activity neither highlighted grouping as a necessary procedure (why making groups is important or in what way grouping helps) nor qualified as an interesting activity or game. This sort of problem was recognised in several chapters.

It was felt that children were sometimes asked to do a mental activity on their own for which no background preparation was made. For example, in the chapter on groupings they are asked to choose properties to make their own groups without any prior exercise on how to choose properties. Other examples include magnetic/non-magnetic properties in the chapter on magnets and mixtures and solutions in the chapter on separation, etc.

The subcommittee was of the opinion that in many places the *Bal Vaigyanik* curriculum tended to thrust a few elements of the scientific method on children in a haphazard manner instead of giving them a real understanding of the method and gradually preparing them to apply it concretely in practice. For example, children go on a field trip in the class 6 chapter "Grouping of Leaves", collect leaf samples, study them and record their observations in a table (see below):

No.	Name	Petiole/ no petiole	Smooth/ rough	Hairy or not hairy	Long or round
1.	Pipal	Yes	Smooth	No	Round
2.	Wheat	No	Rough	No	Long
3.	–				

They then prepare another table based on the one above:

No.	Property	Diagram	Example (name of leaf)
1.	Pointed tip		Pipal, ..., ..., ...

The subcommittee saw entering data directly in the second table as easier and more interesting and felt that filling the first table was pointless exercise of the scientific method.

It was also asked if there was no need to have a sequential order, balance and variety in learning scientific method. One suggestion was that organisation, tabulation and presentation of data should begin with tables that are simpler, unambiguous and have definite objectives, and the format should be given in *Bal Vaigyanik* itself to simplify matters. Only then should children be gradually expected to formulate their own tables. Exercises in presenting the same set of data in different forms should be limited in the beginning and increased only later on.

The methodology subcommittee felt that it was important to make children realise that experiment-observation-conclusion sequence is not the only way scientific discoveries are made. They need to understand that it embraces much more, that it becomes possible only through the consolidation and incorporation of a host of skills (imagination, guessing, estimating, etc.). The subcommittee was of the opinion that children should be made aware of historical importance of some experiments (such as the experiment on the life cycle of the fly). Another aspect that needed to be highlighted was that of serendipity – accidental or chance discoveries in science. Not a chronological story but in a way that brings out the romance and diversity of method of science.

One more question that was raised was whether model building and using models for understanding difficult concepts was really feasible with children (the way scientists use imaginary models to solve difficult problems in a simple way). Are model-building activities in the HSTP (such as the cell structure model) actually useful for children or do they confuse them more? What improvements can be made in the way they are used? Where else in the curriculum could model building be introduced?

The syllabus subcommittee put in a lot of effort in this workshop, sifting through the syllabus with a fine comb, reviewing it and giving important suggestions for trimming the content load and reorganising chapters.

For the first time a professional team was involved in the workshop to review the illustrations, layout and presentation of the workbooks. This team from the Industrial Design Centre (IDC) of the Indian Institute of Technology, Mumbai, led by Kirti Trivedi, came out with a detailed review report on these aspects of *Bal Vaigyanik*.

The workshop thus had a long list of suggestions and recommendations for carrying out an intensive revision exercise. However, when it came to actual rewriting, the primary concern was how to streamline the syllabus so that it could be completed within the academic year. This was the most important outcome of the revision – a significant reduction in the length of chapters by reorganising and redistributing them to fit the school calendar. One reflection of this exercise was that "the class 8 *Bal Vaigyanik* was reduced to a single volume".

Some piecemeal attempts were made to incorporate the suggestions and answer the questions posed by the methodology subcommittee but the basic framework remained unchanged and no real space was created for incorporating other elements of the scientific method or new ways of learning. The irony was that the very tables in the "Grouping of Leaves" chapter that were considered "unnecessary additional exercises in scientific methodology" were retained in the same form. The revised edition stuck to the maxim of "evolving all concepts through activities" and contained only the odd "simple and interesting narratives".

Participation of teachers in this revision exercise was minimal. Some teachers were present at the Pachmarhi workshop but their contribution was limited to assessing the time needed to transact each chapter in the classroom, analysing problems in performing different experiments and explaining various concepts. Direction for the exercise was mostly provided by the reports of teacher's monthly meetings, follow up in schools and teacher training camps as well as informal discussions with teachers. There was no systematic study to find out which portions of *Bal Vaigyanik* children found difficult or uninteresting. Such assessment was mostly based on what the teachers felt.

Second revision of *Bal Vaigyanik*

The concerns of the methodology subcommittee were addressed only during the second revision exercise. Apparently, by 1994 when the second exercise began, the ideas and understanding articulated in 1985 were internalised by the group. In 1985, the group had neither the time nor the expertise to translate those ideas into reality in the chapters and other learning material.

The decade from 1985 to 1994 witnessed a significant event that opened up new possibilities for the HSTP. It was the second phase of expansion of the innovation and this process had a marked impact on the second revision exercise.

Expansion was a constant refrain in the HSTP. But the beginning of the decade of the 1990s saw the Madhya Pradesh government and Eklavya make serious efforts to explore the possibility of expanding the programme to the state level. The discussions were at two levels: evolving appropriate systems for teacher training and decentralising the administrative set up; and looking at the curriculum, syllabus and workbooks from a new perspective.

The Government of India's Ministry of Human Resources Development also set up a committee to assess the status of the programme in the context of a state-level expansion. The brief of the committee, set up under the chairmanship of Dr. B. Ganguly, chairman of NCERT's Department of Mathematics and Science Education, was to review the HSTP and give its recommendations vis-à-vis a possible state-level expansion. The committee expressed its solidarity with the fundamental tenets of the innovation and recommended that these should be adapted in higher classes (classes 9 and 10) as well. The committee, however, pointed out that while the HSTP elegantly brought out the 'process' component of science, the 'product' component ('facts', 'definitions', etc.) has been ignored and has not found adequate space in the curriculum. The committee recommended that the HSTP strike a proper balance between the 'process' and the 'product'.

The recommendation put the HSTP group in a dilemma because the basic understanding behind the innovation was that children would themselves 'discover' and articulate scientific laws and definitions. The group felt that the 'product' should be the outcome of the 'process' that children were engaged in during their study of science, not a readymade package fed to them. So following up on the recommendation would mean destroying the soul of the innovation.

One thing was apparent from the committee's recommendations, viz. mistaking the textbook for curriculum. Seen from this point of view, the product/process argument would hold true since *Bal Vaigyanik* did not contain the 'facts and information' of science. But as we have stated earlier, the workbook was only one part of the HSTP curriculum. It was only after the classroom activity was undertaken that the curriculum was completed and its objectives achieved.

In a meeting organised to consider the report and the future course of action, Dr. Anil Sadgopal commented on the issue in the following words:

> "I would like to interpret committee's process vs. product comment differently. (The question is) In how many classrooms, where HSTP is taught, process is taken forward from desired experimental observation and data, and students are guided to reach a stage where they arrive at conclusions or develop a concept? Or is it assumed that the HSTP's goals

> are fulfilled just because students do some hands on experiments or collect some specimens from outside the classroom? How many teachers are capable of taking the experimental results to the level of some conclusion and conceptual development?"

In the end, it was decided that the process aspect of the HSTP – i.e. using experiments and activities to take the discovery process forward – needed to be further strengthened. One element of this strengthening was that *Bal Vaigyanik* should be suitably modified to make the 'product' aspect more accessible.

Seen from this perspective, the significant change in the third revision exercise was the attempt to provide some background for the experiments before they were performed. This background was mostly in terms of explaining to the children (and the teachers) what they should focus on while performing the experiment or which questions the experiment sought to find answers to.

This approach can be seen in the following example of the same experiment on magnetic poles presented in the 1978 and the 2000 editions:

Class 6 (1978)

> *Experiment 2: The two poles of a magnet*
>
> Spread some iron filings on a sheet of paper. Touch them with a bar magnet and lift the magnet.
>
> What do you see? (2)

Class 6 (2000)

> *Experiment 2: The two poles of a magnet*
>
> Have you ever observed to which part of a magnet things

> stick most? Do all parts of the magnet attract magnetic things equally? To find the answer to this question do another experiment.
>
> Spread some iron filings on a sheet of paper. Place a bar magnet flat in the midst of the iron filings and shake it a bit. Now lift the magnet.
>
> What do you see? Draw a diagram in your exercise book. (2)
>
> Which part of the magnet has the most iron filings sticking to it? (3)
>
> Which part of the magnet has little or no iron filings sticking to it? (4)

The Ganguly committee report had also highlighted the second important aspect of the revision, though this was an aspect that predated the committee report, having been part of the continuing discourse since 1974-75. The concern used to be voiced at different levels that the HSTP curriculum did not link up seamlessly with the higher classes. We shall discuss this problem in greater detail in a separate section. But it is important to point out here that whenever comparisons were made between the *Bal Vaigyanik* and the 'government' science textbooks, the main difference pointed out was in the chemistry content. The finger was pointed in particular to the absence of topics such as atoms and molecules, chemical symbols, formulae and equations in *Bal Vaigyanik*, which supposedly caused problems for the students transiting to classes 9 and 10.

A group was set up for the third revision to address this issue of topics to be covered in chemistry. After a year of intensive work, it came up with several new chemistry chapters. The group concluded that atoms and molecules should not be taught until class 8. The group felt that children of this age must first be familiarised with chemical phenomena, reactions and changes that would help them understand such abstract concepts at a later stage.

Nevertheless, a chapter titled "Structure of Substances and the Language of Symbols" was introduced in class 8. It must be clarified here that this was not an academic decision but a compromise with the prevailing situation in school education. The HSTP group was apprehensive that the absence of just this one chapter in the HSTP syllabus raises questions in the public mind about the whole programme.

The new chapters developed by the chemistry group that eventually became part of *Bal Vaigyanik* included "Chemical Reactions", "Rate of Chemical Reactions", "Making Crystals", "Solubility", "Structure of Substances" "Language of Symbols".

The third dimension of the revision was an outcome of the HSTP group's own experiences and discussions. This dimension had come to the fore at the time of the 1985-89 revision, but was taken up in a concrete manner only in the third revision. The question asked in 1985 – should all concepts be 'discovered' through the medium of activities or is there space for introducing other ways of learning? – was addressed in this revision.

"Plant Nutrition", "Force, Force Everywhere" and "Questions and Answers about Our Crops" in two parts were some of the new chapters developed in this context. These three chapters were there in earlier editions of *Bal Vaigyanik* but they were now restructured with a totally new approach. "Force, Force Everywhere" was entirely based on analysing events in daily life and the children were introduced to the concept of thought experiments. This chapter was written in the context of Newton's first law of motion and the children were continuously engaged in searching for force in different situations. In some parts of the chapter a historical perspective was also included. “Plant Nutrition” was based on a discussion of the history of scientific investigation to find an answer to the question: What is the nutrition of plants? “Questions and Answers about Our Crops” used information given in *Bal Vaigyanik* to investigate different issues connected to crops.

Apart from these chapters with a totally new format, there was not much change in the conceptual framework of the chapters in both revisions. Many experiments were simplified, some new experiments were added and some existing experiments were dropped. Quite a bit of information was added to the chapters in the form of interesting stories, historical facts, descriptions of historical experiments and biographical sketches of scientists, etc. The idea was to ensure that children were able to view whatever they learned in a wider perspective and were given a glimpse into the lives of scientists. In this way the third revision strove to present a broader perspective of the scientific method.

Teachers were active participants in the second revision and played an important role in writing and testing chapters. In the third revision, a lot of organised field-testing of concepts was done with children and the outcomes of these tests had a big influence on the revision.

In the next section, we shall trace the development of a few chapters in greater detail which have witnessed some major conceptual upheavals. We shall discuss plant nutrition and force in this context. We shall also discuss another important chapter, “Looking at the Sky”, which brought out many elements of the scientific method but met with a dismal reception in the classroom. In addition, there is some discussion of the chemistry chapters because much work was done on them in the third edition and a draft chapter on atoms and molecules as well as chemical symbols was actually written, which represented an important change for the HSTP.

8

BIOGRAPHY OF A CHAPTER: LOOKING AT THE SKY

"Looking at the Sky" is a much-discussed chapter in *Bal Vaigyanik*. There are many reasons for this interest. Instead of writing a descriptive essay on the solar system and events linked to it, the chapter tries to move forward on the strength of a series of activities. It is thus considerably different from similar chapters in other science textbooks, even unique. Studies done across the world reveal that it isn't only children but adults as well who have mistaken notions about the motion of bodies in the solar system. That's why a question mark remains over the utility of descriptive chapters on this subject. And that's why it was felt that a better alternative is to use activities as a medium for children to get a better sense of these motions and other celestial events.

Another interesting facet of the chapter is that the concepts presented are linked to our daily life. Eclipses, phases of moon and other such events have a deep significance in our cultural life. In this sense, although the sun, moon, stars and planets are distant from us, they are still an important part of our immediate environment.

The third important aspect of this chapter is that it concerns a subject in which Indian scientists have made significant contributions from ancient times.

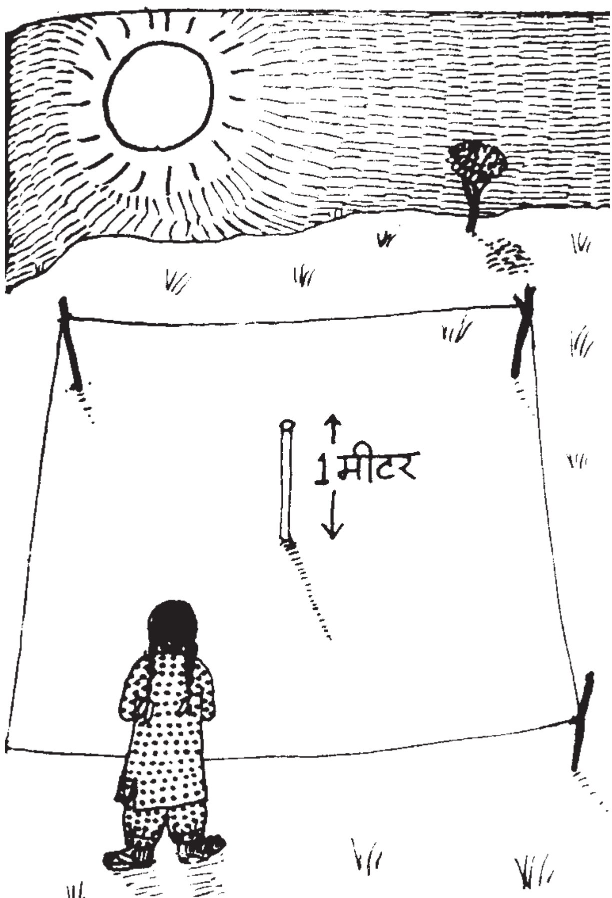
The number of different kinds of activities children undertake in this chapter is unprecedented. There are experiments that are done at night, experiments that continue all year long and attempts to get children to elicit relevant information from village elders.

What makes this chapter even more interesting is the level of abstract thinking expected from children. Some experiments are of the kind where conclusions can be drawn directly. But there is also a series of experiments where children have to contend with alternative explanations and decide which explanation is more correct since the results of the experiment satisfy both the explanations. The children develop two mental models of the relative motions of the sun and the earth on the basis of their observations and then decide which model is a better reflection of reality by applying a principle that states that the simpler explanation is more acceptable. This principle, known as 'Occam's razor' or the 'principle of parsimony', is a hallmark of modern scientific thought.

You can probably understand now why even the teachers found the chapter heavy going. Before going into that, however, let us have a look at the structure of the chapter in the first (1978) edition of *Bal Vaigyanik*. It is in two parts in this edition, part 1 in class 7 and part 2 in class 8.

Part 1 traces the motion of the sun in the sky from the shadows cast by objects and the attempt is to spot signs of regularity in the motion. The motions children try to understand include daily and annual motion. They are then presented with a challenge: can these motions form the basis for designing a solar calendar and solar clock and how will these be constructed? To begin with their understanding on the matter is brought out through a few questions.

Then, in experiment 1, a one-metre scale is planted upright in the ground and the shadow it casts is observed. After noting down changes in the length and direction of the shadow during the course of the day, children use their data of the time of the day and the length of the shadow to plot a graph and identify



the time of the day when the shadow is the shortest. They are also asked to make a note of the direction in which this smallest shadow falls. Noon is explained in this way and they are told that the smallest shadow is always cast in north-south direction. Being the way they are, children are not unduly surprised by the results of this experiment, but the teachers most certainly are, almost always. Because they find that the length of the smallest shadow is not always zero nor does it always occur at 12 noon, which runs counter to what is most commonly accepted.

This experiment is repeated with the same scale at the same spot the following day and then once again after a gap of two weeks. Children observe that the shadows at the specified times do not fall on the same markings with each passing day. They try to think up an explanation for their observations.

The next experiment (experiment 2) is even more ambitious. Children mark the shadow cast by a pole once a week and are told to note the date along with their marking. On the basis of their markings, they are expected to reach the understanding that the direction of the sun changes day by day.

Experiment 3 is a home assignment that is somewhat similar. Children plant a wooden stick upright in the ground, take a sheet of paper, make a hole in its centre, and ease the sheet down the rod through the hole to lie flat on the ground, the rod at its centre. The shadows cast by the rod on the paper are marked at fixed time intervals (between 9 am and 4 pm), with instructions to:

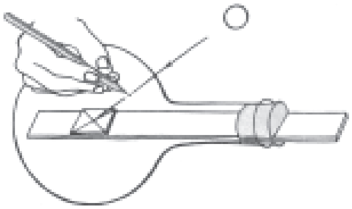
> Repeat this experiment at home every alternate Sunday. Use a fresh sheet of paper for each new experiment and don't forget to mark the date you conduct the experiment on the paper.

Children compare the shadow markings on the sheets of paper after the experiment is completed and are asked to answer the following on the basis of their observations:

> During the course of the experiment, in what way did the path of the sun in the sky change?
>
> Is it possible to tell whether summer or winter is approaching by observing the changing length of the shadows?

In experiment 4, children make a sun dial.

Part 2 of the chapter is ambitious not just from the point of view of its experiments but also its conceptual depth.



The first experiment is done to understand the paths of the sun and the moon in the sky. It can be performed in two ways. In the post-*Lal Vaigyanik* cards a scale with a mirror pasted on it was fitted into a round-bottomed flask. Markings were made on the outer surface of the flask where the mirror reflected the image of the sun at different times of the day.

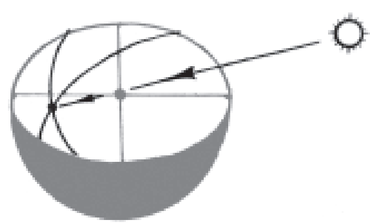
The second way is to use an earthen pot (*matka*). The instructions given are as follows:

> Take an earthen pot and carefully break it across the middle (horizontal) to get a hemisphere. Or to simplify the task, ask the village potter to make and bake a hemisphere. To make

> the observation easier, paint the inner side of the hemisphere white with lime. Tie two strings at right angles to each other across the diameter of its open mouth so that they bisect exactly at its centre-point.

Imagine conceiving such an experiment in a school syllabus in today's educational climate, let alone performing it. Does anyone ever think of using the skills of a village potter to bake a hemisphere from clay to enable a child to set up an experiment in a village school? The instructions continue:

> Stick a ball made from wet clay on the strings at the point where they bisect each other at the centre of the hemisphere.



Once the apparatus is ready and set up, the child is given the following instructions:

> Make a marking of the shadow of the mud ball falling on the inner surface of the hemisphere at half-hour intervals and note down the time as well. Continue making markings throughout the day till the time the shadow is visible.

Experiment 2 repeats this activity with the shadow cast by moonlight. Obviously, such an experiment will run the course of a night. That's why a note is written for the teacher in a box in the text to inform the students to do the experiment at their homes. But they are also asked to arrange for at least one hemisphere to do experiments 1 and 2 at school as well.

Picture the scene. Experiments to track the path of the sun and moon in the sky are being done in every house in the village that has a child studying in class 8. And believe it or not, when the HSTP was in the 16-school phase, the resource persons camped in the villages to assist in conducting the experiment through the night.

Once the experiment is performed, children analyse different properties of the sun's and the moon's paths, simultaneously comparing the two paths.

There is a provision to repeat the experiment at 10-day intervals throughout the year so that a sun dial can be prepared. The only concession is:

> If you can't perform the experiment every 10 days then try and do it at least six times in the entire year.

In the four experiments children see that the daily paths of the sun and the moon are more or less parallel to each other but their annual paths intersect.

Such experiments truly demand a commitment to the pursuit of knowledge. Halkevir Patel, a teacher participating in the programme, voices this commitment when he comments that the strong message emanating from the HSTP is that one needs to put in considerable effort to acquire knowledge.

After the sun and the moon it is the turn of the stars. Their paths are traced in experiment 4, which is performed at night as a home assignment. First, the Ursa Major (Saptarishi or Great Bear) and Cassiopiea (Kashyapi) constellations and the Pole Star are identified and a map is made to specify their position. The map is redrawn at hourly intervals to show the changing positions of the constellations and the Pole Star in the night sky. The children are asked some questions, such as "Which is the path they follow in the sky?" To answer such questions they have to look more closely at their mapping observations.

In the next experiment (experiment 5) all materials to carry out the activities are provided in the kit and great care is taken to explain every detail of what is to be done to ensure that the experiment is performed. Children are expected to find out "how many degrees some star or constellation has moved in an hour". It is obviously observed that they must have figured out that the star and the constellations follow circular paths.

For this experiment, they make a polar scale with materials provided in the kit copy. This is an instrument that can tell you the angle of a star from the zenith when its tip is pointed towards the star. When children figure out how many degrees a star moves in an hour, they have to calculate "how much time the star would approximately take to make one full revolution around the pole star". Children are also advised to "simultaneously measure the motion of another star circling the pole star during the experiment" in order to ensure that their calculation is not based on any chance observation. The conclusions drawn from the experiment depend critically on the accuracy of their observations.

Arguably, this is perhaps the only example one finds at this level of school education of a discussion on the motion of stars not just in an east-west direction but also circling the pole star.

After these experiments are performed a question is posed:

> How do the sun, moon and the stars move from one spot and return to that spot in approximately 24 hours?

Children take the help of models to find an answer to this question. They use a candle and a lemon to make a model of the sun and the earth and observe that it is day in some parts of the earth and night in other parts. They also see that the length of day and night can be changed by changing the inclination of the lemon. They are then asked to decide:

> The model showed us that day and night could possibly occur when the earth rotates on its axis. But it appears as if day and night are the result of the sun's revolution around the earth. Is it possible that it is the earth's rotation that makes it seem as if the sun is moving across the sky?

Experiment 6 is then done to help children understand what is being said. They are asked to "stand in a room, focus your eyes on a point on the roof directly above your head and then spin around." They are told to observe how one point remains stationary even as everything else appears to be moving. Another question is then posed:

> Is it possible that the sun and all the other stars are actually stationary and it is because the earth is spinning on its axis that they appear to be moving across the sky?

One thing should be noted: there is no mention of the moon in this question. Children are then asked to think about the following, keeping in mind their answer to the previous question:

> If this is what actually happens, what similarities do you think there could be in the observed paths of the sun, the moon and the stars? Now use your imagination and logic to answer the following questions.
>
> What do you think could be the shape of the daily paths of the sun, the moon and the stars – square, circular, straight line, elliptical or zigzag?
>
> Will their paths intersect in some places, move further apart from each other or run parallel to each other?
>
> Will all three take more or less the same time to make a full circle across the sky or will the time each takes differ?

Then follows another question:

> If the earth actually rotates on its axis will everything in the sky appear to be moving?

Children's attention is now drawn to the stationary point they had observed in experiment 6 and they are asked:

> Now imagine you are standing on your earth model at Hoshangabad and the earth is rotating on its axis.
>
> When you look up, which point would appear to be stationary?
>
> Have you seen any star in the sky that always appears to be stationary?
>
> What could be the connection between this star and the earth's axis?
>
> When we stand on earth we feel that the earth is stationary and it is the sun, the moon and the stars that are moving around us. However, from what we see in our model and experiment 6, it seems that the earth is rotating on its axis and that's why everything else seems to be revolving around it.
>
> Which is the correct conclusion? How would you decide?

Just imagine, children and teachers of class 8 are pondering about questions that astronomers like Kepler and Copernicus once struggled to find answers to. This is the kind of mental churning that goes on in the classroom. The children have to decide which explanation is correct, based on their observations, analysis and reasoning. Is this not excellence in science education?

There is a scene in Brecht's play "Life of Galileo" where Galileo seats a child on a chair and places a lamp to his side. He then moves the child and the chair in a circle around the lamp and tries to explain his viewpoint. It is this scene that springs to the mind when one sees children performing this series of experiments.

The chapter moves on. Children now compare the motions of the sun and the moon. Models are used to explain the phases of the moon. Finally, an activity is done to understand eclipses. But all this now appears easy in comparison.

The issue of practicality

It is difficult to assess how much time is required to complete the two chapters, especially some of the home assignments that children are asked to do. If we leave aside the night-time experiments and assume that all the day experiments are performed in school, then most would require a full day to complete. The school has morning and afternoon sessions. Leaving out the earliest phase of the programme, the teachers who regularly performed the experiments had decided, on the basis of their experience, to start the experiment around 11 am and continued till around 2 pm. This time span covers the time when the smallest shadow is cast, which is around 12 noon.

The class 8 chapter has more practical problems because several experiments have to be done at night to observe the movement of the stars around the Pole Star. The observations from these experiments are crucial to build up the logic of the argument. The teachers of the 16-school phase say they did these experiments a few times but the feedback points to the experiments not being done in the later expansion phases. The teachers at the 1985 Pachmarhi workshop said that most schools left the chapter out completely. One reason for dropping it was that no questions were asked from it in the examinations. So the conclusion one can reach is that the chapter was neglected because of practical problems in transacting it.

But it wasn't only the practical problems that made "Looking at the Sky" a hotly debated chapter. It also demanded a high level of abstract thinking from the children. So it isn't easy to decide why the chapter fell into neglect. The feedback from the schools was that the chapter wasn't being done. The HSTP group continued to debate it, one important debate taking place in October 1983.

Dr. Sadgopal, who had earlier observed that one objective of the HSTP curriculum was to encourage abstract thinking in the children, adds the following when talking about this chapter:

> But this [abstract thinking] is taken to an unrealistic limit in "Looking at the Sky". Children have to combine their observations of 6-7 experiments before drawing conclusions. There are two ways of understanding the mass of data generated in the experiments. One of them is simpler and therefore is the better solution . But explaining this very basic scientific concept that the simpler solution is preferable solution proved very difficult. Even teachers found it difficult to grasp. The chapter uses models to try and explain some difficult concepts. This approach has been tried in other chapters as well but it wasn't very successful in "Looking at the Sky", so the entire chapter had to be dropped.

But not everyone in the group agreed. For example, Dr. Vijaya Varma voiced the following opinion at the same meeting (held in Kishore Bharati in October 1983):

> "The objective of the chapter is not just to help children understand that the earth rotates on its axis. There are many other aspects to it, for instance how do the phases of the moon occur, why do eclipses occur? So if at the end of the chapter they still don't understand that the earth rotates on its axis, this is not sufficient reason to drop the chapter. If there are

practical problems, we must decide to revise it accordingly."

Most people agreed that the chapter was useful in life. It was felt that if practical difficulties were not there, we could have gradually simplified its logic to make it easier to generate a dialogue with children. But this was not possible with experiments that took all day to perform or that could be taken up only at night.

The level of abstraction required in the chapter was always a point of debate. One view was that there is no hard evidence to show that 13- to 14-year-olds are not mentally equipped to deal with such abstraction. Linked to this was the argument whether a curriculum should contain only the material that all children in the class can easily understand. What was being said was that there should be some challenge for children to grapple with.

The debate also centred on what exactly we should expect from children when such challenges are thrown at them. Such clarity is needed in the case of any difficult concept, especially from the perspective of what should be asked in examinations.

The level of abstraction was also debated in the context of another chapter, "Chance and Probability". In this chapter the observations from a single experiment are insufficient to draw a conclusion. Many experiments have to be done and the data from all of them need to be seen together to draw a conclusion. The experiments themselves are made up of smaller segments, each of which requires a coin or dice to be repeatedly tossed to generate data. A pattern emerges only after the data on heads and tails is collated in a bar diagram or the average is calculated. Conclusions can then be drawn from this pattern. But the conclusions cannot help in predicting what will happen in the next throw of the coin because the outcome is still determined by chance.

That's why it's important for us to be clear in our minds about what we should expect from children in terms of learning. If they even get a broad sense of what is happening or what lies behind an event, it should suffice. For example, if they know which patterns are highly unlikely to occur in tossing a coin, it should be sufficient.

Today's examination-based education cannot be reconciled with such an understanding. But retaining some amount of flexibility in a curriculum is important because it provides the space for 'aspect of challenge'.

When the time came for the first revision of *Bal Vaigyanik,* the syllabus sub-committee made the following summary suggestion about "Looking at the Sky": "Experiment 5 [in class 8] should be transferred to class 7 chapter and the rest of the chapter should be dropped." Experiment 5 is about the motion of constellations.

One cannot say whether this suggestion was a response to practical concerns or the level of abstraction. But when the issue of completing the science course in the available time came up for discussion and estimates had to be made of the time required to transact different chapters, especially in class 8, this chapter was almost unanimously selected for trimming.

However, this recommendation was not fully accepted. The HSTP group had a special fondness for the chapter because where else would one get a better opportunity to showcase the method of science. In fact, this has been a subject which had historically contributed in defining method of science to a great extent. Moreover, the subject is deeply woven in daily life and affects it. It has influenced our world view.

The conception of the chapter so beautifully materialises the

HSTP approach and therefore, it had a special place in the textbook. It includes several elements of method of science. And above all else, 'learning by doing' is at its zenith here. The importance of not giving information also became evident in this chapter. Not giving information is not an objective in itself, but it is a way to encourage (even force) children to think. Every step in the chapter is full of opportunities for children to think. Every question can lead to a full-fledged discussion. Although, this can be seen in every *Bal Vaigyanik* chapter, but it is very dense in "Looking at the Sky". Maybe, this density was the 'problem' of this chapter.

Now let us look at the form the chapter took when the revision process got underway in 1986.

The first change was to combine the two parts into a single chapter, which was included in class 8. But the biggest change was in its theoretical framework. There were no questions and answers on what revolved around what. The focus was totally on observations. The idea was to draw children's attention to some of the main features of the sky, probably in the hope that it would provide a solid base when they investigated the theoretical aspects later. It no longer tried to challenge them mentally and force them to think for themselves.

The second change was that most of the experiments to observe the night sky were removed. The only experiment that was retained was a qualitative study of the motion of constellations.

As earlier, the stick and shadow experiment is done after giving some background and asking some questions. Repeating the experiment the next day and two weeks later is only a suggestion.

Children are then asked to observe the changing position of the rising sun on the horizon, after which they make a sun dial.

Next follows an experiment linked to the motion of the moon. It cannot be called an experiment in the real sense because all they have to do is note the time at which the moon rises and sets. They are expected to understand the motion of the sun and the moon on the basis of this data, even though all that it shows is that the time between two sunrises or sunsets and two moonrises or moonsets changes. This information has not been linked to any theoretical model.

The same activities are retained to understand the phases of the moon and the lunar eclipse. The final experiment is to observe the motion of the constellations, the only expectation from the children being that they use the Pole Star as a reference point to observe that the constellations moved around the Pole Star.

In this way the three main concerns of the revision were addressed: adapting the chapter to the school conditions, lowering the level of abstraction, and removing impractical activities.

Problems still remained with this chapter which again surfaced at the time of the next revision. But for some reason it was left untouched. The final edition (which remained unpublished) retained the chapter in this form because no practical alternative could be finalised even though many attempts were made.

9

BIOGRAPHY OF A CHAPTER: NUTRITION IN PLANTS

Everybody will agree that the question of plant nutrition is central to the very existence of the biosphere. Any biology curriculum will contain some material on photosynthesis. However, mainstream textbooks deal with photosynthesis in the same way they deal with the earth rotating on its axis or revolving around the sun.

Carbon dioxide + water = carbohydrate + oxygen. This equation embraces an entire history. It's not just the history of biology but the history of fundamental discoveries in chemistry too. It took 400 years of investigation of leaves and plants to understand how and from where plants get their nutrition. True, this history did not become a religious cause célèbre the way the earth's rotation did. But the investigation of photosynthesis is an equally rich treasure chest of the evolution of the scientific method.

Plant nutrition posed a challenge for the HSTP. The kind of experiments, logic, guesswork and leaps of imagination that the investigation of photosynthesis requires do not fit easily into the *Bal Vaigyanik* framework, especially if one sticks to the

HSTP stipulation of learning through experiments. But before going deeper into this issue, let's first take a look at what *Bal Vaigyanik* has to say about plant nutrition.

The subject is covered in two chapters in the 1978 edition: the fifth part of "Food and Digestion" in class 6 and "Starch in Leaves and Sunlight" in class 7. Dividing the concept in this way leads to an incomplete picture of plant nutrition which could even be considered misleading. Let's see how.

Let's first take up "Starch in Leaves and Sunlight".

Starch in leaves and Sunlight

For some reason this chapter begins with the role of seed cotyledons in plant growth. Children do a germination experiment (experiment 1) in which they sow three seeds whose germination is epigeal. They leave the first germinated seedling untouched, snip one cotyledon of the second seedling, remove both cotyledons of the third seedling and then compare their growth over a period of seven days.

After the experiment, they are asked to recall what they had learned in the class 6 chapter "Seeds and Their Grouping": that the cotyledons contain starch for nutrition. They are now led on to conclude that germinated seedlings use this food for their growth.

A question is then posed:

> Once the withered cotyledons drop off where does the plant get its food from?

(Here we need to note that not all cotyledons contain nutrition in the form of starch. Some have it in the form of fat. So the conclusion reached in the class 6 chapter that the seedling's nutrition is only in the form of starch is incorrect. The question asked now only reinforces this conclusion. It also gives rise to another misconception, that cotyledons are the only source of nutrition for growth, so that's perhaps the reason why they must emerge above the soil surface. In many seeds the food is contained in the endosperm.)

Children then launch into experiment 2 to find an answer to the above question without being given any background. They collect different kinds of leaves, remove their green pigment and use iodine to see that starch is present. They then perform a variation of the same experiment (experiment 3). They cover part of the surface of a leaf (still attached to the plant) with black paper. After a few days they check to see that starch is present in the portion of the leaf that receives no sunlight.

But there is a problem. Before children do the experiment, they are asked a question:

> Is it possible that starch is produced in the leaf? If yes, then how is it produced?

The scientific logic gets garbled here. How does the black paper experiment help in answering the question? If the presence of starch in a leaf is evidence of it being produced there, the experiment isn't needed at all. This experiment is not going to provide the answer. The experiment can only tell you about the link between sunlight and starch production. But even here there are gaps because the design of the experiment has no provision for a control. Is starch production affected merely by covering the leaf with paper? Or maybe a babool thorn? Who knows?

Even if you overlook this, the only conclusion you can really reach is that if sunlight does not fall on part of a leaf, no starch is found in that part. But that does not prove that starch is produced there.

The questions asked after the experiment should also be noted:

> What is the link between sunlight and the presence of starch in a leaf? Is it correct to say that sunlight is needed for starch production in leaves?

The questions show that the authors of the chapter knew that the experiment cannot prove that starch is produced in the leaf. In any case, the way these questions push a child towards one single answer is very unlike *Bal Vaigyanik*.

Again, departing from the *Bal Vaigyanik* style, the following information is given:

> You found out that sunlight is needed for starch production in leaves. Scientists have conducted experiments that show that only green leaves produce starch in the entire living world. Without the green pigment, leaves cannot produce starch. But it is not possible for us to do these experiments in the classroom.

It would have been better if more details of the experiments conducted by 'scientists' had been given. Instead, the children are left to the mercy of the prestige of scientists. Instead of the information being woven into the chapter, it appears as patchwork.

Next follows a discussion on food chains.

With the benefit of hindsight, the chapter strikes us as a good example of a 'pseudo experiment-based' approach. The example of crotons and their multi-hued leaves could very easily have been used to show the role of chlorophyll. Also, the chapter makes no mention of water, which is an important component of plant nutrition. This aspect was probably omitted because it is discussed in part 5 of the class 6 chapter "Food and Digestion".

Food and digestion – part 5

The role of water is brought out in experiment 5 (red-dyed water absorbed by roots rises inside plants). In this experiment children learn that plants get their nutrition through their roots. Before they perform the experiment, they are asked a few questions, such as:

> If plants consume food, where does it come from and in what form? Think about it.
>
> If the roots of a tree are cut, can the tree stay alive?

In searching for the answers, children observe that water travels from the roots of the plant to its stem and leaves. What conclusion can they reach from this observation? Probably that plants get their food from the soil through water. The next question seems to confirm this understanding:

> Farmers sprinkle this substance [urea] in the soil. How are its effects seen in the leaves?

The chapter also discusses parasitic plants. Here again attention is drawn to their roots.

In sum, the class 6 chapter suggests that plants get their food through their roots. In class 7 they are told that leaves produce starch. Nowhere does a consolidated picture of plant nutrition emerge.

1987 edition

The problem of piecemeal explanations was addressed in the 1987 revision when a single chapter titled "Nutrition in Plants" was prepared by incorporating the relevant portions of chapters from class 6 and 7. The revision took into account the following recommendations made at the *Bal Vaigyanik* revision workshop (Pachmarhi 1985), where the problem was discussed in depth:

1. A new chapter on plant nutrition should be prepared by incorporating the final part of the class 6 chapter "Food and Digestion" into the chapter "Sunlight and Starch in Leaves". The sequence should be: (a) absorption of water and minerals in plants, (b) starch in seed cotyledons, (c) production of food with the help of sunlight, and (d) parasitic plants.

2. An attempt should be made to supply alcohol to schools. [The main experiment in this chapter is testing for the presence of starch in leaves and this requires removing chlorophyll from the leaves with the help of alcohol. Government rules make it difficult to obtain alcohol.]

3. Can the experiment be repeated with crotons to test the thesis that starch is produced only in green leaves?

4. A simple food chain should be given as an example of food chains.

5. A game based on food chains, prepared by the Lok Vigyan Sanghatna, could be added as a teaching supplement.

However, no questions were asked about the conceptual framework of the chapter. Nor was any question raised about whether the chapter eventually helps children to understand that plants manufacture their own food. As a result, the new chapter, which took into consideration the committee's recommendations, only served to combine piecemeal explanations of plant nutrition from two chapters into a single chapter.

The framework of the reworked chapter was as follows. It begins with an invitation and a question:

> Let's find out whether plants consume food or not. If they do, how and in what form is the food consumed?

After this the role of roots in water uptake by plants is investigated in Experiment 1.

The expectation is that children will understand that "plants absorb water and dissolved nutrients through their roots".

The next question is:

> Is water and the nutrients dissolved in it the only nutrition of plants or is there something more?

In a way, the question indicates that water is a nutrient. But the children are still caught up in investigating nutrients absorbed by plants, with no mention being made of plants manufacturing their own food.

To address this question, they now use alcohol to remove the leaf chlorophyll and test for the presence of starch. (Our feedback from schools showed that this experiment was not usually performed because getting alcohol was a problem. One teacher from a school in the Shahpur *Sangam Kendra* in Betul district got a quarter bottle of country liquor from a local liquor shop but such cases are more the exception than the rule.) After starch is detected in the leaf, children are asked:

> Could the starch have been produced in the leaf itself? If so, how?

This does not appear to be a very good question because it could be asked about a potato as well. More astonishing is the experiment that is suggested to look for an answer: the same 'leaf wrapped in black paper' experiment that shows that starch is not present in the wrapped portions! How exactly this experiment proves that starch is manufactured in the leaf is difficult to imagine.

Equally dismaying are the leaps in reasoning. In the beginning the question was: "Could the starch have been produced in the leaf itself?" And after the experiment children are told:

> You found out that sunlight is needed for plants to manufacture starch.

The question with which they started, however, was, "Could the starch have been produced in the leaf itself? If so, how?" And the answer they get is:

> Sunlight is essential to manufacture starch in leaves.

Next, they are told:

> In the entire living world only the green parts of leaves can manufacture starch.

After which they are asked the following question:

> Can you now tell the difference between nutrition in plants and animals?

What answer are the children expected to give?

The chapter then moves on to parasitic plants, after glossing over this important question about nutrition in the living world.

Even after going through the entire chapter, the only thing children may, perhaps, come to believe is that plants get their nutrition through their roots (water and dissolved substances), and their leaves manufacture starch. The fact that there is some connection between these two facts, fails to emerge in the discussion.

In a way the chapter can be seen as a victim of dogma of 'learning by doing'. Most people know that plant nutrition is difficult to fully understand by doing an experiment or two. Understanding this complex process took several decades of research and investigation, with scientists borrowing heavily from developments in many related fields. More importantly, it took many educated and imaginative guesses on their part to decipher the underlying mechanisms. To expect two experiments in the classroom to convey this understanding is unrealistic.

In fact, the study of photosynthesis provides an excellent opportunity to showcase various components of the scientific method but, however, it does not fit comfortably into the 'experiment-based learning' mould.

Third Attempt

The third attempt saw the classroom investigation of plant nutrition go onto an entirely different track, which had two distinguishing features. First, the insistence to answer all questions about plant nutrition only through experiments was given up. Second, the question of plant nutrition was presented in a historical perspective.

The first question asked to launch the discussion was:

> "How do plants grow so big if they don't eat or drink anything? How is so much wheat, straw and fruit produced? From the water that irrigates the fields or from the air?"

The search for an answer proceeds with a narration of history of the research on this question. Children learn about and are asked to critically ponder over the twists and turns in the investigation and the conclusions that scientists reached at every stage. In the process they learn how the state of available knowledge at any given stage limits the conclusions that can be reached. For example, after reading a narrative of Von Helmont's five-year experiment, children are asked:

> What conclusions can you draw from this experiment? Can you assume that all the nutrients for plant growth came from the soil? Give reasons for your answer.

They are then told:

> Whatever may be your conclusion, Von Helmont drew two conclusions from his experiment: (1) the nutrients for plant growth do not come from the soil, and (2) the plant grows because of the water it receives. Are his conclusions entirely correct? You will discover as you proceed.

The narrative makes it clear that an understanding of plant nutrition did not emerge solely on the basis of the experiments that were done with that purpose in mind. Insights came from many other unrelated experiments, or investigations carried out with different objectives in mind. For example:

> The experiments Joseph Priestley did in 1771 added much new information. Priestley did not do his experiments to find out about plant nutrition but to find out what gases are present in air.

Another important fact that emerges in the narrative is that scientists make ample use of their imagination during their research:

> His experiments raised a dilemma in Priestley's mind. The world is full of living creatures. The world also has countless fires burning everywhere. So why doesn't all the air on earth become impure?

Along with the narrative, children also do some of these historic experiments in a modified form. This helps to carry the discussions forward. More importantly, they begin to realise how deep and far-reaching conclusions can be drawn from seemingly simple experiments.

In this way, the discussion moves forward to the role of sunlight in starch production from water and carbon dioxide in the presence of chlorophyll. Then follows an experiment to show absorption of water from the soil by the roots, after which the exchange of air in the leaves comes up for discussion.

Children are not expected to do the sunlight-photosynthesis experiment, given the practical difficulties involved. Instead, they read a detailed description of the experiment and discuss its conclusions. But they do perform an indirect experiment to understand the importance of sunlight in the process: they collect oxygen produced by an aquatic plant. They first see that if the plant is kept in the dark, the leaves do not give out bubbles of oxygen. So if oxygen production is seen as an indicator that photosynthesis is taking place, it means the process stops when the plant is in the dark. Of course, the argument has not been presented in this way. Rather, the utilisation of carbon dioxide and the release of oxygen in photosynthesis are used as proxy to study the process.

The chapter ends with a discussion of food chains. But this is taken up only after children learn that plants manufacture food not only for themselves but for the entire animal kingdom.

The chapter provides many insights into the way scientists work and function. For example:

> Whenever a scientist does an important experiment such as this one, other scientists also do the experiment to see for themselves...It was another scientist who investigated the whole process in detail.

This chapter was introduced in the 2000 revised edition of *Bal Vaigyanik* but no feedback is available about how it was transacted in the classroom, as the programme was shut down before this edition could reach the classrooms.

10

BIOGRAPHY OF A CHAPTER: FORCE AND WEIGHT

This is another chapter that has seen many important changes over time, especially in its structure, from the original *Lal Vaigyanik* edition to the third *Bal Vaigyanik* edition.

Lal Vaigyanik, in its two chapters titled "Force and Weight" and "Force and the Weighing Balance", gave a range of experiments and activities to understand the concept of force, along with the measurement of weight.

The first chapter "Force and Weight" begins by giving children a sense of the concept of force through acts of pulling and pushing: they stretch a spring and then place a brick on it. Force is defined as the interaction between two bodies. After this several activities are done to show different kinds of forces: such as stirring two liquids of different viscosity, drawing a figure on a rubber tube and then stretching the tube to see how the figure changes shape, plunging the piston of a cycle pump to feel the force exerted, rubbing two dry glass slides together and then two wet slides together and experiencing the difference in force that needs to be applied, etc.

The next step is observing the action of force without contact –

the interaction between a magnet and a piece of iron and then between two magnets.

Weight is also explained as a force, after which there is a discussion on units of force. A spring balance is used to familiarise children with a unit force and then they are asked to estimate the force exerted by different objects placed on their palms. The downward force exerted by the objects is defined as weight.

Children then find out the weight and volume of several cubes and learn that a unit volume of any material has a fixed weight. It should be noted that the concept of density is not introduced at this stage.

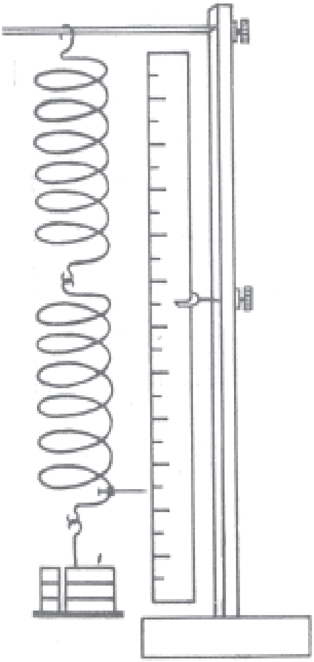
Children are asked an interesting question about the concept of conservation of volume and its measurement:

> Think about the following problem:
>
> An aluminium block is 5 cm long and its breadth and height are both 1 cm. What is the weight of the block?
>
> Suppose a machine is used to trim the block into the shape of a screw. The weight of the screw is 8 gm-force. What is its volume?
>
> What is the weight and volume of the aluminium shavings trimmed while making the screw?

Finally, there are activities to find the weight of liquids.

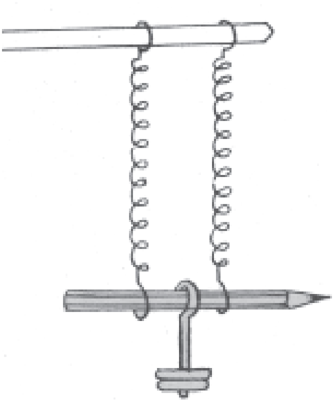
The chapter focuses on giving children both a qualitative and a quantitative feel of force and weight. But nowhere is a definition of force given.

The next chapter "Mass and the Weighing Balance" discusses how weight can be measured with the help of a spring and lever, followed by some fairly difficult activities.



First, a wire is coiled to make a spring. Different known weights are then hung from the spring and the changes in its length are noted. A paper-strip diagram of these lengths is drawn. Children are then asked whether the spring would stretch more or less if it was made of copper or iron.

Some more spring experiments follow. For example, two springs are joined in series and weights are attached to them to check how much they stretch and whether both stretch equally. The springs are then joined in parallel and the children are asked to note their observations and answer some questions:



> Note down the changes in length of both the springs.
>
> What weight should you hang from the pencil to make both springs stretch to the same length as a single spring stretches if a 150 gm-force weight is hung from it?
>
> Now do the experiment to find out how correct your estimate is.

Children then make a spring balance after which they do some activities with a lever mainly to discover the principle of balance.

First, a scale is balanced after putting weights at different distances on either side of the pivot and the data on the weights (discs) and their distance from the pivot is noted in a table. No calculations are made using this data but a conclusion is drawn:

> In this way we can conclude that when the scale is horizontal, the number of discs on the left side multiplied by their distances from the pivot equals the number of discs on the right side multiplied by their distances from the pivot.

Finally, children are familiarised with a common weighing balance and several experiments are given as home assignments.

The chapter serves its purpose even if a few experiments are not performed. For example, the two-spring experiment isn't really required for a basic understanding of force.

Another feature is that conclusions are often given after the experiments/activities are performed. In fact there is no prohibition on this score in *Lal Vaigyanik*. Several conclusions are given and the process for reaching a conclusion is also not always clearly specified. For example, in the experiment cited above there is no mention of actually doing the calculation to get the answer. But some hints about the process are given in some places. For instance, after finding the weight and volume of different aluminium blocks of different sizes, children are asked to find the weight of 1 cm^3 of this substance. They are then told:

> It is now clear that the mass of a unit volume of any substance will always be the same regardless of whether you calculate the unit mass with a large or a small block of the substance.

It seems special contribution of the HSTP was to avoid giving conclusions after an activity or experiment. It is likely that this decision was taken on the basis of the experience with the 16-school pilot project.

Let us now look at this chapter in the first edition (1978) of *Bal Vaigyanik*.

First edition of *Bal Vaigyanik*

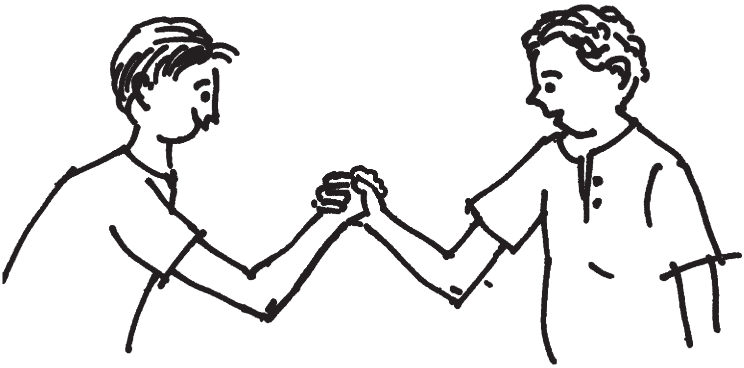
One big change in the first edition of *Bal Vaigyanik* was that force and weight were included in class 6 while the weighing scale and the principle of balance were transferred to class 7.

The chapter in the 1978 edition seems much simpler than the *Lal Vaigyanik* chapter.

Everyday examples are used to give an idea of what force is – lifting a sack of grain, drawing water from a well, pulling a handcart, etc. This is followed by experiments to illustrate force and weight in different situations: between two magnets, plunging the piston of a cycle pump, between two dry and two wet glass slides and between a magnet and iron. The experiments are mostly the same as in *Lal Vaigyanik*, although a few have been left out, such as stretching and compressing a spring, hanging weights from a spring to observe changes in its length, finding the weight of a unit volume of a substance, finding the weight of a liquid, etc.

Force is defined in terms of push, pull; change in shape by force is excluded. There are also many experiments and questions to estimate force and weight.

The chapter on measurement of weight was transferred to class 7 under the title "Principle of Balance" but it focuses more on finding the principle of balance rather than measuring weight. Children make their own weighing scales and weights and perform experiments with them to discover the principle of balance but we shall not go into further details here.



The second edition

Many changes were made in the chapter in the second edition (1987). For example, instead of the sack of grain and the handcart, the game of *kabbadi* was used as an example to explain force. It begins by introducing the concept of force:

> You observed the attractive and repulsive forces of magnets in the chapter on magnetism. You must also have seen fruit falling to the ground from trees. Things fall to the ground because of the earth's gravity. You may also have noticed that force is needed to hit the ball or *gilli* far while playing *gilli danda* and to grab hold of an opponent in *kabbadi*. So there are many different kinds of force – magnetic, gravitational, force applied by humans, etc.

Intuitive understanding of force is assumed in the chapter. In the part "What is Force?" instead of trying to define force the chapter states:

> You may have seen that if you want to hit a ball or *gilli* from one spot to another you have to apply force.

Thus, implicit assumption is that children know what force is.

Arm wrestling is then used as an example to discuss direction of force. After illustrating force without contact, through activities with two magnets and a magnet and iron, gravity is discussed and a feel of weight is given. Finally, different weights are hung from a rubber band and changes in its length are noted, after which units of weight are told.

The 1987 edition attempted to give not only the conclusions but some explanations as well. For example, after the magnet and iron activity, children are told:

> The magnet experiments show that force can be experienced by two bodies even if they are not in direct contact.

Similarly, they are instructed to do an activity and then given the conclusion:

> Drop a ball from a height. It falls to the ground. This means some force is pulling the ball towards the earth.

If we examine this statement more closely, we find it is a bit strange. True, objects fall to the earth but can you conclude that the earth exerts a force on the ball? May be, something is pushing it downwards. Or maybe Aristotle was right when he observed that the natural place for all things is on the earth, hence all things tend to reach their natural place.

Again, the experiment with the rubber band stretched by marbles hanging from it is followed by the statement:

> You saw that the more marbles there are, the greater is the gravitational force (or weight) and the more the rubber band stretches.

Even here the explanation isn't fully satisfactory. Children do see the rubber band stretching but where do they see the gravitational force increasing!

Force is an abstract concept. We can see its effect but it is difficult to grasp. Maybe one should move more slowly in trying to explain it. This approach is more evident in *Lal Vaigyanik* and the first edition of *Bal Vaigyanik* but somehow the second edition seems to be a bit hasty in telling children about gravity and tell it in a way that it seems to emerge from the experiments.

The third edition

The chapter was titled “Force, Force Everywhere” in the third edition. Major modification was a change in the format and the purpose of experiments and activities. Second modification was to try and identify and analyse forces in a variety of situations after providing a general feel for force. Third thing is that the chapter amply uses illustrations in the process of analysis. Lastly, it uses a relatively informal language.

The chapter begins by presenting force in the form of a problem. Children are asked:

> Where do scientists see force in this situation [of a person standing at ease]?

Then follows a search for force in different situations and in the process we learn that force has a direction and that it doesn’t mean there is no force if there is no motion. This is followed by Galileo’s thought experiment: rolling marbles down an inclined plane and increasing and decreasing the friction to see the marbles rolling to different distances. The discussion of this thought experiment leads to Newton’s first law of motion as well as the concept of friction.

Next there is a discussion on gravity based on analysing the force applied in dropping a ball or throwing it in the air. Several interesting contexts are used to help children imagine a situation of zero gravity. The concept of weight is also examined, with weight on the moon included in the discussion.

Finally, the chapter moves to the problem of balancing forces in different situations and, to some extent, also takes up measurement of force.

The objective of the chapter is to familiarise children with the concept of force and help them analyse force in different situations, with information being provided wherever required. In the process, they are introduced to frictional force, gravitational force, inertia, balancing of forces and other related concepts. In sum, the logic that emerges is that all things are subjected to gravitational force at all times and if they do not fall to the earth there is some other force that is 'neutralising' gravitational attraction. The children extend this logic to other situations and see that if an object is motionless, it means that the forces acting on it balance each other. To clarify this, they are told:

> What we need to understand is that when the speed of an object slows down, it means that a force acting in the opposite direction is definitely trying to stop it. And if the speed of an object increases, it means that a force is either pulling or pushing it in the direction of motion.

In other words, force is linked to acceleration.

No feedback is available on this revised chapter because the HSTP was shut down before this edition of *Bal Vaigyanik* was published.

11

LINKAGES WITH HIGHER CLASSES

The teachers often voiced their concern that the HSTP curriculum was radically different from the way science is taught in other schools. Their main worry was whether children who are 'taught' this science from class 6 to 8 would face problems when they entered classes 9 and 10. They raised this question in many forums. The education bureaucracy was also worried about this aspect. So were many high school and higher secondary school teachers who were associated with the HSTP as resource teachers or follow up personnel.

Of course, there were many teachers for whom this was not a major concern but many of them did worry.

When the government permitted the HSTP to run as a pilot project in 16 schools it laid down one condition: no changes should be made in the existing curriculum. The reference was basically to topics in the syllabus. The Madhya Pradesh Textbook Review Committee (MPTRC) compared the science topics covered in the mainstream textbooks with those in *Bal Vaigyanik* in 1977, when the proposal for expanding the HSTP to the district level was first mooted. It gave the green signal for the expansion when it found no major differences in the content.

The HSTP teachers did not think that there was any big difference between the HSTP and science in classes 9 and 10. Only a few teachers voiced the opinion that returning to rote learning after this active learning experience would cause problems. Many high school teachers pointed out that the HSTP students asked more questions than other students and were more willing to do experiments. But the fear was that they would not match up to the others in the class 10 Board examinations and would be 'beaten'.

This fear first raised its head in 1975. At that time the marks obtained by the HSTP students from the 16 experimental schools and by the students from other schools in class 9 science exams were compared and the HSTP students were not found to be trailing in any way.

The study[1] conducted by Friends Rural Centre and Kishore Bharati evaluated the performance of the students in two ways. First, a workshop was organised in November 1975 with principals, lecturers and teachers from higher secondary schools in Bankhedi and Hoshangabad blocks. (The first batch of the HSTP students studying in these blocks had entered class 9 in these schools in July 1975).

The higher secondary school teachers said they could not distinguish between students from the 'Rasulia' science and those from the mainstream science. At that time the HSTP group felt that "this (that is not noticing any difference) was

[1] "An Evaluation of Educational Progress and Adjustment in Class 9 of Students who Studied Experiment-based Science in Middle School under the HSTP Programme", December 1977. The study was conducted by Friends Rural Centre and Kishore Bharati prior to the district-level expansion of the HSTP programme by the government of Madhya Pradesh and the NCERT.

natural as some teachers admitted that they did not have discussions, analysis, experiment and other creative activities in the classroom on which to base any judgment about these qualities of students coming from a discovery based learning environment."

The teachers also stated that, in any case, they had very little faith in the science taught in middle schools. So they always started from scratch, believing that students entering class 9 had zero understanding of the subject.

The second way in which performance of the students was judged was the marks obtained in the class 9 examinations. A statistical analysis was done of the marks obtained in class 9 by both the HSTP and the other students of three higher secondary schools in Bankhedi and Hoshangabad blocks. No statistically significant difference was found between the two groups.

After the district-level expansion, a similar analysis was done of the marks obtained by students in the class 11 examinations. This analysis covered examination results from 1982 to 1985. The 1982 and 1983 batches of students were those who had studied the mainstream science while the 1984 and 1985 batches included students who had studied the HSTP science. The comparison showed that the HSTP students in no way trailed the students studying the mainstream science.

However, these studies failed to put at rest the doubts about the HSTP students' performance in higher classes. The issue kept surfacing every 2-3 years. The questions were seldom about differences in understanding science concepts, experimental skills, curiosity about and understanding the environment, etc. They were solely about performance in the Board examinations. Every time a question was raised the HSTP group put forward the comparative assessment of examination results. The group itself was not very happy about giving such a response because it felt the Board examinations did not really evaluate conceptual understanding and scientific thinking of the students. The only thing the comparative study 'proved' was that the students studying 'learning by doing' science could cope with information-laden questions in the traditional examinations. But such comparisons could no longer be made after the district-level expansion because all the students in Hoshangabad district appearing for the class 10 Board examinations were from the HSTP stream.

The same question was raised after the HSTP was expanded through School Complexes to 13 districts (one Complex per district). Once again the comparison of examination results of the students from both the streams showed the doubts about performance to be baseless. Take the example of a study of classes 9 and 10 examination results in the Harsud School Complex of Khandwa district, which was done in December 2000. Like in the other School Complexes in Harsud, too, some schools taught the HSTP science while most others taught mainstream science. So the higher secondary schools of the Complex had students from both the streams. Here again, there was no significant difference in the performance in the classes 9 and 10 examinations between the HSTP and the other students.

Another study conducted sometime after 1983 is worth noting. A group of children were asked to answer three questions each in biology, chemistry and physics from the class 8 syllabus. The study didn't specify which class the children were studying in, although all were at the higher secondary school level and had studied mainstream science in the middle school.

Of the 609 students from Shajapur, Dhar, Ujjain, Ratlam and

Mandsaur districts included in the study only 23 students passed the test, 9 in the second division and 14 in the third division. This study showed that topics covered in the mainstream science syllabus (which were not covered in the HSTP curriculum) did not give these students any particular advantage in the higher classes. The results must not have come as surprise for most teachers as they are aware that most children forget whatever they study once the examination is over.

However the doubts still lingered. There could have been many reasons for this. Perhaps a look at *Bal Vaigyanik* gave a feeling of lack of content and gave rise to doubts about the outcome in terms of learning. Perhaps, given the generally accepted concept of learning – memorising facts, terminology, laws, equations and information – it seemed as if the HSTP students did not learn much science. That's why many people felt that the HSTP children were being harmed in some way.

Anyway, the question about the link between the HSTP and classes 9 and 10 slowly boiled down to a few science topics. Few teachers and some others identified differences between *Bal Vaigyanik* and the mainstream textbook *Science* taught in other districts. Some topics covered in *Science* were not there in the *Bal Vaigyanik*, but there were also some topics in *Bal Vaigyanik* that were not there in *Science*. However, it was the topics that were not found in *Bal Vaigyanik* that gradually formed the basis of the anti-HSTP campaign, figuring prominently in all subsequent protests.

The fact that children learned many new and fundamental things in *Bal Vaigyanik* that were absent in the mainstream science never figured in these protests. The HSTP was seen as just a small experimental programme, so it had to strike a proper balance with the mainstream, which was considered the 'standard'. That's why many teachers wanted to know why topics like "Chance and Probability" and "Diversity in the Living World" were taught in HSTP.

The topics not found in *Bal Vaigyanik* included the following:

1. Mass and density
2. Standard classification of living creatures
3. Atoms, molecules, symbols, formulae, equations and valency

Of these, the last set of topics was seen as the major omission. For some reason people did not consider mass or classification of living creatures as equally important. The so-called disadvantage of the HSTP students was mostly linked to the absence of atoms, molecules, symbols, formulae, equations and valency in *Bal Vaigyanik*.

Interestingly, when the revised edition of *Bal Vaigyanik* was submitted to the textbook review committee in 2000, the question of differences in content was once again raised. A comparison done at the time showed that the following topics were not covered in *Bal Vaigyanik*:

1. Chemical symbols, formulae, equations
2. Electric charge
3. Carbon
4. Carbon compounds
5. Rocks, minerals and metals
6. Metals and their properties
7. Artificial (man-made) things
8. Organic Evolution

However, the committee showed little interest in the topics included in *Bal Vaigyanik* that were not there in the mainstream science textbook, making no effort to identify these topics or find out the reasons for their inclusion.

Since most of the topics in *Bal Vaigyanik* were chemistry related, we shall now focus on this subject.

Evolution of the chemistry curriculum in *Bal Vaigyanik*

It is not easy to include chemistry topics in the syllabus for middle schools. If we look for chemistry-related topics from the environment, we find that they are mostly linked to farming, health, pollution, quality of water, etc. If 'learning by doing' is the touchstone for science teaching, things get even more difficult. Understanding the chemical properties of various substances requires the use of special chemicals and special equipment. These chemicals are not usually available at the district level. They are also expensive. That's why things become 'easy' and simplified if you decide to 'explain' everything in the textbook itself. You are not forced to accept any limits then. This is the approach taken in the mainstream science textbooks.

HSTP had to put in a lot of hard work and thinking to see how one can familiarise children with chemical reactions and the chemical nature of various substances. At the time of the district-level expansion, *Bal Vaigyanik* contained the following chemistry related topics:

1. Separating substances from mixtures ("Separation")
2. Producing substances and investigating their properties ("Gases")
3. Identifying substances on the basis of their chemical properties ("Acids, Bases and Salts")
4. Chemical reactions – semi-quantitative analysis ("Acids, Bases and Salts" and "Water – Hard and Soft")
5. Chemical effects of electricity
6. Chemical changes in physiological processes ("Digestion",

"Respiration", "Photosynthesis")

7. Chemical effects of substances ("Water – Hard and Soft")

Initially, a lot of preliminary work was put in to develop several chapters around these themes. Their content was worked out but it appears that it was either rejected or parts of the content were included in other chapters. A brief look at these discarded chapters might be of interest.

Let's begin with the contents of an untitled chapter written in May 1973. It was mostly concerned with testing the chemical properties of substances. It starts in a very interesting manner and then attempts to show how chemical properties differ from physical properties.

The problem posed to children is to find out whether substances that appear to be similar are actually similar. They are given three liquids, a, b and c, that look like water and they have to find out if all three are water or not. A small portion of solution a is added to solution b, which heats up. A question is then posed: Will water heat up if a little more water is added to it? The conclusion is that a and b contain something in addition to water. Children find out by doing such experiments that substances that look alike can be different:

> "When we cannot identify substances on the basis of their physical appearance, we can identify them on the basis of their reaction to each other."

Ten tests are then given to identify these substances. They include the flame test, silver nitrate test for chlorides, litmus test, carbohydrate test (alpha-naphthylamine sulphuric acid) and protein test (ninhydrin), etc. Most of these tests require special chemicals. And tests of the chloride group are anyway meaningless because children are not familiar with them. That may be the reason why this chapter never reached the field-testing stage.

Another draft chapter on chemical properties had experiments linked to boiling point, melting point, solubility and other such properties. This too did not progress beyond the initial phase. There was also a chapter on the states of matter and the changes of the states that did not find a place in *Bal Vaigyanik*.

These examples make it clear that familiarising children with chemical properties and chemical reactions of substances was not high on the HSTP agenda.

We had said earlier that the main concern during the first revision was trimming the content in the *Bal Vaigyanik* syllabus so that it could be covered in the school year. But at the time of the second revision the focus shifted to expanding the chemistry portions in *Bal Vaigyanik*. As a first step, the chemistry sub-group of the HSTP resource group systematically reviewed the chemistry content. It found a few chemistry chapters strewn around *Bal Vaigyanik*, while some other chapters had chemistry portions wherever and whenever needed. When seen together, the chemistry chapters showed serious logical gaps in moving in a step-wise manner from simple qualitative analysis to a more difficult quantitative study of chemistry. The reason for these gaps was obvious: the HSTP group strongly felt that nothing more than what was included could be done with so few chemicals and such little equipment.

The sub-group decided to take a totally new approach in developing the chemistry segment. The main challenge was to use the experimental method to familiarise children with basic concepts of chemical properties and chemical changes so that they had a sound base for studying fundamental chemical theories in higher classes. But all this had to be done keeping two constraints in mind: keeping the chemicals and apparatus needed in the kit to a minimum and not increasing the overall curricular load of *Bal Vaigyanik*.

The sub-group identified the following basic concepts that could be taken up within these constraints: solubility, the states of matter, chemical reactions, chemical equivalence and crystallisation. A whole lot of experiments were proposed. After two years of hard work, five chemistry chapters were prepared. They were "Solubility", "Chemical Reactions", "Rate of Chemical Reactions", "Making Crystals" and "Relationship between Acids and Bases". This was a truly exhilarating experience for the chemistry sub-group because it showed how much more could be done in chemistry at this level with such limited resources.

The aim of "Relationship between Acids and Bases" was to introduce children to the concept of chemical equivalence. The sub-group felt that this would give them a base for understanding atoms, molecules, symbols, formulae and equations in higher classes. It felt that such abstract concepts should not be included in the class 8 curriculum. However, owing to subsequent pressures a chapter on these concepts was eventually included in the class 8 textbook. It was the culmination of efforts that had been going on in this direction for many years, so it would be useful to take a brief look at these attempts.

Atoms and molecules: a continuing debate

One topic that inevitably raised its head in any discussion of the HSTP curriculum was the concept of atoms and molecules. The exclusion of this concept from *Bal Vaigyanik* (elements, compounds, mixtures, molecules, atoms, symbols, formulae, equations and valency) was a constant source of worry for teachers, parents and others. Their concern was that children doing 'Hoshangabad Vigyan' were at a disadvantage. The concern mostly centred on what these children would do when they reached class 9 without any basic understanding of these topics. Many people felt that these concepts are the base of modern chemistry and if children do not learn them early, they will not be able to learn many things at a later stage.

However, major argument for inclusion of these topics was not based on an understanding of the subject, assessment of children's preparedness or the practice of teaching and learning. The only argument was that these things should be included because they were there in the science textbook of other districts, so *Bal Vaigyanik* should also have them.

Despite this insistent and widespread demand the HSTP group did not include these topics in the textbook. So it is important to understand the reason for this adamant stand.

If we look at the curricular discussions in the HSTP group we come across two related reasons. Atoms and molecules are difficult, abstract concepts. There are experiments to understand the concept but these cannot be done at the middle school level and, in any case, atoms and molecules are not a product of one single experiment in modern chemistry.

The concept emerged at some stage when scientists were trying to make sense of the nature of matter and it's internal structure and interaction. It was in the latter half of the 18th century that the quantitative chemical investigations were coming more and more into focus. Measurements became the basis of studying chemical changes and it was from this approach that the modern definition of elements emerged. Interpreting 50 years of such quantitative observations and accumulated data Dalton arrived at his concept of atom as a physical, not philosophical, unit. It took another 50 years to accept the concept of molecule.

To understand the atomic nature of matter in the modern sense it is essential for children to first observe chemical changes and understand their quantitative aspects. It is meaningless to talk about atoms and molecules before such prior grounding. Talking about the curriculum in this context, Vijaya Varma once observed:

> "We did not include atomic structure and chemical formulae because we seriously doubted whether children of this age had the mental ability to understand atomic structure. Another thing is that if atomic structure is to be taught, we must be able to demonstrate through experiments that solid things which they see are actually made of minute atoms. There are experiments which provide a basis to atomic structure but there are difficulties. Firstly, one has to be at a stage in intellectual development to comprehend these experiments and, two, the equipment required is very expensive. We did not want the teacher to somehow tell the children that proof of atomic structure is available on the basis of models. On the basis of all this, we decided not to include these things." (Kishore Bharati meeting, October 1983.)

According to the HSTP group:

> ...to introduce the concept of molecules, the two experiments to be performed are (a) laws of chemical combination, and (b) Brownian 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 a finite size...We prefer delaying such concepts till skills of experimentation and deduction are

> sufficiently developed for children to appreciate the experiments of others. ("The Hoshangabad Vigyan", *Science Today*, December 1977)

As mentioned earlier, the reason given by the HSTP group was that it was impossible to give this kind of experience to middle school children. Children in the 11 to 13-year age-group cannot be expected to have the level of skills required to perform these experiments.

However, there is one thing which needs mention. The atomic nature of matter is such an integral part of our psyche today, that it might be difficult to understand continuous nature of matter. Therefore, the more important question is whether the middle school students would be able to understand atomic nature while analysing the laws of chemical combination. Thus, it is not a question of merely doing the experiments, but also about preparedness to analyse results of such experiments.

The second reason given by the HSTP group was that children need to be familiar with the chemical phenomena if they have to meaningfully learn about atoms, symbols, formulae, equations, etc. They need to investigate the chemical properties of substances and group them on this basis, conduct and observe chemical reactions, understand the factors influencing these changes and, to some extent, study the quantitative aspects of chemical reactions. Only after this is it meaningful to discuss atomic models. The situation here is similar to that in the chapter "Looking at the Sky": you accept the concept of atom because that makes it easier to explain chemical results.

Moreover, the atom is not just a particle in modern chemistry. It is a unit that determines the way substances interact with each other. Children require a lot of background preparation to understand all this. They need to understand statistical data, recognise patterns in the data, do complex reasoning, etc.

Textbooks usually explain the concept of atom by stating that if you divide a substance and then keep on dividing it you will reach a stage where it is impossible to divide it further. This is the smallest particle of the substance that contains all its properties. This is an atom. But this explanation raises several misconceptions in children's minds. For example, they tend to believe that the atoms of metals are solid particles that can conduct electricity. The modern conception of the atom is not based on such arguments.

The third reason offered by the group was a bit roundabout. An analysis of the textbooks used in class 9 during the 1980s shows that the topic of atoms and molecules was taken up from scratch in this class on the assumption that children have no previous knowledge of the topic. So if this topic was excluded in classes 6 to 8, children would suffer no real disadvantage. Instead, they could be taught some other topics at this stage. This argument was presented in the following way in the Sawaliram letter printed in the class 8 *Bal Vaigyanik* (1981):

> You know that this textbook does not make any reference to chemical formulae and atomic structure. You may also have heard that both these topics are covered in the older science textbooks. Let me tell you something. Many higher secondary school teachers have told me that most students entering class 9 have practically no knowledge of these topics even though they had studied them in the earlier textbooks. That's why these topics have to be taught once again in class 9. Anyway, these topics are part of the class 9 syllabus. So why should we waste time in teaching them in middle school? That's why we have included some other topics in place of these in our

textbook which we feel are necessary in learning science and which have never before been taught in middle schools or higher secondary schools.

The statement "Many higher secondary school teachers have told me..." is not based on informal discussions with the teachers but emerged in a workshop conducted in 1975 with higher secondary school teachers and principals. The purpose of the workshop was to try to understand the differences, if there were any, between the children passing out of the HSTP schools and the mainstream schools.

Among all the reasons given by the HSTP group for excluding atomic structure and chemical symbols, one reason needs to be highlighted: "We did not include atomic structure and chemical formulae because we seriously doubted whether children of this age had the mental ability to understand atomic structure."

But the group doesn't seem to have undertaken any research or survey on this aspect. If such a study had been done, it would have been possible to conduct a more serious dialogue with teachers. That would have taken the process of teacher participation in curriculum development and selecting topics for the syllabus to a different level. It was only in 1990 that a limited study was conducted with class 9 students. This study showed that there were definite gaps in their understanding of these concepts. Apart from other things, this was a result of their basic inability to visualise or comprehend such minute particles.

There is another point that needs to be noted. When an innovative programme seeks to run within the system, it is subjected to several pressures. In a way, this could be seen as a continuing dialogue. An inherent objective of an innovation is to initiate a dialogue and raise questions about prevalent practices and teaching methodologies, drawing as many people into the process as possible. But several compromises also have to be made along the way.

Actually, the HSTP group was feeling the pressure and somewhere within the group a stream of thought was surfacing that it was possible to teach 'atoms and molecules' and it was possible to teach it at the middle school level. But there was an equally strong opposing stream of thought which contended that it was not possible to teach the topic in classes 6 to 8, nor was it necessary to do so. A third school of thought was also emerging, which felt that children should be given some exposure to chemical experience – such as the behaviour of gases, states of matter, titration of acids and bases, etc. – in order to prepare the ground for them to learn about atoms and molecules at a later stage.

The dialogue on this topic with teachers and other concerned people was a continuing one. It was comforting that the discussions on the intricacies of atoms and molecules as well as children's abilities to grasp abstract concepts took place in open meetings with parents, where both agreement and disagreement were freely voiced.

It was during this time that some members of the HSTP group began preparing a chapter on teaching atoms and molecules.

This chapter titled "The Story of Atoms and Molecules", written sometime in 1987-88, began with a discussion of the ideas of Democritus, the ancient Greek philosopher – the same thought experiment in which one imagines dividing a fruit into smaller and smaller pieces until one gets the smallest piece possible and whether this piece has all the properties of the fruit. This discussion was followed by an experiment of dissolving ink in water and diluting the solution to the stage where the colour of ink is no longer visible. Children were then asked to imagine whether there could possibly be such minute particles that are not even visible under a microscope. A picture of the DNA molecule, magnified 50 lakh times, was also given. Then, abruptly, definition of a molecule followed:

> The smallest possible particle of a substance, which contains all the properties of the substance, is called molecule of that substance. If this molecule is turned into even smaller pieces, these pieces would not have the properties of the substance.

It is necessary to point out two things here. First, it is difficult to define an atom/molecule without first going into the basic differences between elements, compounds and mixtures. Second, it is inappropriate to give the example of a macro-molecule like DNA because its chemical properties remain intact even after it is split into two pieces. Such molecules are polymers and modular in many senses.

It is also necessary to say that the chapter was begun with a statement that a historical story is going to be told. However, it doesn't maintain this style once the atom is defined in this manner:

> Molecules are also made up of pieces. Molecule of any given substance is made up by combining one or more types of atoms.

This is not correct. Not all substances contain molecules.

Anyway, after this, symbols, the rules of writing symbols, formulae, the differences between symbols and formulae, an explanation of formulae, chemical equations and balanced equations, etc., are discussed.

This chapter was trialled with the teachers but the trialling was not very successful, even though the teachers were able to answer the questions posed after reading it. Its most serious shortcoming was that it had no scope for thinking or doing anything, except for dissolving ink in water.

Secondly, like in mainstream textbooks, this chapter also gave a feeling that the ideas of atoms and molecules, chemical formulae and equations, etc. were a given. It did not give the feeling that these formulae and equations had anything to do with actual substances or that they had been derived from an investigation and analysis of actual substances.

Finally, an attempt was made to give a different perspective to the chapter:

> This chapter talks about many things that cannot be explained by experiments. Writing O for oxygen is merely a matter of language. You saw a picture of a molecule, which you had to accept, even though it was not a picture you made yourself!
>
> There are many such things and theories that we cannot prove in a laboratory but they have been accepted on the basis of different experiments done by many people and the conclusions reached from these experiments. That's why we are prepared to accept these things. What do you think about this?

There is no feedback available on this last statement but it is a bit objectionable. After all, the minimum condition to accept the experiments and conclusions of others is that we know what those experiments, conclusions and reasoning are.

The topic of atoms and molecules was again put in cold storage after this trial chapter. No one from the group sought to make any attempt in this direction for quite some time. But the demand for including the topic continued to be voiced. As a result, a fresh academic attempt was made to take the debate to a more concrete meaningful level. The idea was to involve teachers in an informed debate on the concepts and their teaching. Monthly meeting was made the forum for this debate. The development of the atom-molecule concept was studied in depth over the course of five such meetings.

This sustained course of study helped teachers achieve greater clarity on the issue. The discussions covered the laws of chemical reactions, establishing Dalton's atomic theory on their basis, experimental verification of Dalton's theories (law of multiple proportions), atomic mass, Dalton-GayLussac-Avogadro debate, Dulong-Petit Law, etc. Introducing phlogiston into the discussion helped establish the foundation of modern chemistry.

The discussions, which extended over five months, helped clarify why we have come to accept the existence of atoms and molecules, and why atomic mass, formulae, etc., are not concepts that have dropped from the skies. No experiments were done during the course of these discussions. At the end of the series, many teachers understood and appreciated why it was inappropriate to teach such concepts to middle school children. It also became clear to them that the manner in which the topic of atoms and molecules is normally taught in schools is based purely on information and not on understanding.

There was one more attempt made in this direction. At the time of the district-level expansion the HSTP group felt that the teachers' resource group set up to take over the training and other responsibilities needed an intensive course to prepare them for the job. So a special training programme was organised. In two such workshops, a seven-day course on atoms and molecules was also included. The course was experiment-based and every attempt was made to go into the depth of the topic to foster understanding. It included experiments to generate gases and measure their densities, study gaseous reactions and finally determine Avogadro number.

Nevertheless, several teachers and most parents continued to feel that *Bal Vaigyanik* was incomplete without incorporating these concepts. Even within the HSTP group, a section felt that if the entire programme was being opposed for this reason, then the topic should be included. The State Council for Educational Research and Training (SCERT) also advised that it be included.

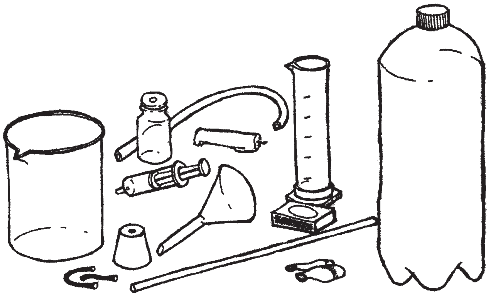
So yet another attempt was made and the chapter was included in the class 8 syllabus of the third edition of *Bal Vaigyanik*. Unfortunately, or fortunately, this edition was not published. The chapter was titled “Structure of Substances and the Language of Symbols”.

The chapter began with a discussion of what a pure substance is and elements, compounds and mixtures were categorised on this basis. Next, elements and compounds were looked at from the perspective of particles. Symbols and formulae were introduced purely in the form of a language. This chapter was basically an introduction to basic grammar of the language of chemistry. Nowhere did it explicitly seek to clarify the concept of atoms and molecules. Chemical equations were excluded. A compromise is, after all, a compromise.

What is of interest is that after a 30-year battle, the HSTP group decided to give the topic a place in *Bal Vaigyanik* more as a compromise than anything else. On the other hand, the NCERT finally accepted (in NCF 2005) that the topic should not be part of the syllabus of middle school science.

Even today, the HSTP group feels that it is necessary for children to make a quantitative study of chemical reactions and understand the mathematical relationships involved if they are to study the concept of atoms and molecules in a meaningful way. They should also develop their mathematical skills to the extent that they can do simple decimal calculations with ease. Otherwise, they would find themselves trapped in a maze of calculations without ever reaching any conceptual understanding.

Atoms, molecules and other related topics serve as a model to understand the structure of substances. A model becomes meaningful only if it is linked to reality. Only then is it possible to use the model to interpret reality. If there is no understanding that formulae and equations symbolize actual substances and their reactions, they will remain an eternal riddle. The only way to reach such understanding is via the path of chemical experiences. These topics used to be included in the class 7 syllabus in the NCERT textbooks. They now figure in class 9. In both instances they are presented in such a mysterious and cryptic way that one doubts whether children will at all understand anything.



12

'LOW COST' SCIENCE: DEVELOPING THE KIT

When Kishore Bharati and Friends Rural Centre sought permission for launching their science teaching innovation as a pilot project in 16 schools of Hoshangabad district, the NCERT field advisor raised an objection, saying: "This science cannot be taught in a poor country like India, which does not have the resources or money. This science is for resource-rich countries."

Indeed, a major challenge for any experiment-based science education programme is to ensure that children can perform experiments in the classroom. For this, they must have access to the required apparatus at the local level, or some arrangement is put in place to ensure that the apparatus is made available to them from outside. The HSTP took up the challenge in several ways at different levels.

The words 'science kit' brings to mind the image of shining glass apparatus, digital equipment replete with glowing LEDs and so on. The first step the HSTP took was to modify this image because it doesn't always require expensive equipment to do sophisticated science experiments, as shown in the Bombay Municipal Corporation (BMC) schools science project carried out in the early 1970s. The kit evolved for this project was fairly simple, as Prof. Yash Pal observed:

> The first teacher orientation workshop [for the BMC school teachers] was organised at the beginning of 1970. This was possibly the first time most of these teachers got the chance to handle science equipment, although they were quite surprised by the very simple apparatus that we had provided.

Thus, a tradition was being established that experiments could be performed with apparatus that did not alienate the users or make them fearful about using it. This is especially important if we are talking of school children performing experiments themselves.

The kit required for *Lal Vaigyanik* did contain items that would have qualified as 'laboratory type', such as burettes, pipettes, round-bottom flasks, etc. From that point on, the kit evolved continuously and considerably, and the teachers played an increasingly important role in its development.

Children in an HSTP classroom worked in groups of four. So this group was the basic unit for calculating kit requirements for a class. But working in groups wasn't a stratagem developed solely to reduce kit requirements. As mentioned earlier, there were many reasons behind opting for such a system.

Groups of four meant that a class of 40 students would have 10 groups, so 10 sets of apparatus would be needed. In the initial phase of the HSTP, the cost of the kit for three classes (120 children, 30 groups) averaged Rs 1,200. At the time of the district-level expansion of the programme in 1978, the kit cost per school came down to Rs 800, with an additional Rs 200 for transport. This figure did not include the cost of the almirah for storing the kit.

There were two reasons for the drop in costs. First, many kit items had been replaced as and when cheaper alternatives were found. Second, the kit was initially procured by Kishore Bharati and Friends Rural Centre but the government took over the process later, applying its minimum tender rules. Also, costs came down because of the larger scale of purchases at the district level.

An estimate was made at that time of the cost of providing kits to all schools in Madhya Pradesh. The figure arrived at was Rs 19 crore, which included the cost of almirahs to store the kit.

Thus, the arguments of such innovation being expensive and unaffordable was shattered right in the beginning.

One more point is worth noting. Providing an experiment kit was not a one-time affair. This was clear from the beginning. Each kit set had around 125 items. Of these several (especially chemicals) were used up in experiments. Several others were breakable items. There was also the possibility of kit items being stolen or destroyed. If such items were not periodically replenished the whole system of performing experiments would break down. That's why there was an in-built provision for annual kit replenishment. The replenishment cost worked out to Rs 1.25 per student per year at that time. And even if the cost is a little higher, provision for this must be made for the sake of improving science education.

The HSTP was run by two voluntary organisations from 1972 to 1977. They were responsible for providing and replenishing the kit. The system was simple at that time. The teachers were given the kit after they completed their training. They would then inform the resource persons reaching their schools for follow-up about their periodic kit replenishment requirements, which would be given to them on the next follow-up visit. All materials were always available in sufficient quantities.

One more point needs to be mentioned. At the time of the district-level expansion, *Bal Vaigyanik* for the three classes contained a total of 59 chapters. Of these, 12 chapters did not require any kit while 14 chapters could be taught with materials collected from local sources. Which meant that materials from outside sources were required for only 50 percent of the chapters. A look at the problem from a different angle showed that only a third of the chapters in *Bal Vaigyanik* needed materials that were not available in the local markets. Some chapters required only a few such items. So providing kits for experiment-based science teaching in middle schools was not really a big problem.

However, it has not been easy to organise regular supply of kit material to schools. Many a time, teaching was affected due to unavailability of kit. In fact, between 1982 and 1985, lack of kit materials was a major agenda item in the monthly meetings of the teachers at the *Sangam Kendras*.

The NCERT took up the responsibility of distributing the kit during district-level expansion. For the first three years (1978 to 1980) this task was done by the Divisional Education Office under the supervision of the Regional College of Education. A system to purchase and distribute the kit was set up. But it broke down when it came to replenishing the kit materials year by year. Replenishment proved to be a herculean task. The responsibility lay with the government but pushing it to perform its duty was difficult, not because money was not available but at the level of procedures too.

With time, some important processes were established for supplying kits to schools. The kit was divided into three parts. One part comprised materials that were locally available and did not have to be purchased. The second comprised materials that could be obtained locally but the schools required permission to purchase them. The remaining 20 to 25 items had to be purchased from outside and supplied to the schools. The government took an important decision by permitting schools to purchase kit items from their Activity Fund (AF). Subsequently, it levied a science fee of 50 paise per student and permitted the schools to utilise the money so collected.

It took 10-15 years of hard work to implement these processes outlined in a single paragraph here. Equally difficult was getting almirahs for storing the kit. The limiting factor again was not the availability of funds.

Many efforts were made to find alternatives to get around these problems. One suggestion was to take a second look at the conceptual framework of chapters requiring a kit item that was difficult to procure. For example, studying dissected rats was an important activity in the chapter on the structure of human body. But it was a problem supplying preserved specimens of dissected rats. But removing the item was possible only if the chapter was modified. Similarly, the chapter on photosynthesis required alcohol to remove chlorophyll from leaves. The problem could have been solved by removing the experiment from the chapter but this was not acceptable to the group.

A suggestion was also made to set up a parallel kit supply system. Some initiatives were taken in this direction with encouraging results. The collection of the science fee from the students saw the schools accumulating a fair amount of money for kit replenishment. Many schools were keen to use this money to buy kit items. But many of these items were not available locally and it would have become expensive for individual schools to purchase them from cities like Bhopal and Indore. Also, items like chemicals could only be purchased in a fixed minimum quantity whereas the requirement of individual schools was much less. Keeping this in mind, Eklavya decided to purchase such items centrally and redistribute them in the required quantities to the schools. This arrangement worked well and schools made good use of this facility.

But pressurising the government to replenish kit materials remained an important aspect. One could even write a book on the efforts put in over 30 years of the HSTP. But there was one other aspect that should be highlighted: the innovative thinking of the teachers and students. They made many contributions to evolving the kit, even as the struggle to streamline the replenishment was on. We shall now take a look at some of these contributions.

The teachers quickly learned to appreciate the fact that although special items such as magnifying lens, microscope, magnetic compass, boiling tubes, etc., are needed, many excellent science experiments can be conducted with simple apparatus and materials. Both students and teachers came up with many alternative suggestions for kit items, many of which became part of the *Bal Vaigyanik* kit.

The search for alternatives had two aspects. One was to find an alternative for an item used in an experiment. The second was to alter the design of the experiment itself to make that item redundant. In both processes, one saw glimpses of ingenuity as well as in-depth understanding of the purpose of the particular experiment. The alternatives proposed were either cheaper or available locally.

Let's begin with an oft-quoted example. Dissecting needles are required to dissect flowers to study their internal structure. One child observed that the thorn of the *babool* tree could do the job equally well. The idea quickly spread and soon the *babool* thorn replaced the dissecting needle in the *Bal Vaigyanik* kit. And, most importantly, it proved better than the original. The *babool* thorn was subsequently used for many other purposes. For example, a divider was made with *babool* thorns and pieces of cycle valve tubes.

Another example was phenolphthalein. It is used as an indicator for acids and bases. A teacher found out that pills of a common laxative 'Vaculax' or 'Purgolax' contained pure phenolphthalein. So the pill replaced phenolphthalein in the kit. However, the pill was banned in allopathic medicine after medical experts found that it was not a safe drug. But another teacher found out that it was still in use in ayurvedic purgative preparations such as '*Virechani*' on which there was no ban, so the local alternative continued to be available.

Similarly, safranin and methylene blue are used as stains in cytology to observe the cell nucleus under a microscope. A teacher found out during a training session that ordinary red ink was equally effective as a stain for the cell nucleus. In this way an alternative was found for a chemical that was difficult to provide.

There are a host of such examples. At one time, a booklet titled "When the kit did not reach the school" was published, listing such alternatives. They included using discarded injection bottles in place of test tubes, empty ball pen refills and valve tubes in place of delivery tubes and corks and several other such examples.

Another innovation was using a single item for many purposes. One such example is the plastic cube. These cubes have a volume of 1 cc and were originally used as a basic unit for volume measurements. But someone felt that since each cube surface had 1 cm sides, it could be used equally well as the basic unit for area measurements. Then it was found that the weight of a cube was approximately 1 gm, so it was then used as a unit of weight for weighing things. And after the "Chance and Probability" chapter was developed, it found use as dice.

The HSTP provided the right kind of environment for such innovative ideas to emerge and flourish. It wasn't as if the teachers were not creative before this. It was just that the HSTP became a source of inspiration to catalyse such creativity because it gave space for creative ideas and recognised them.

Special mention should be made of the matchbox microscope in this series of innovations. The first edition of *Bal Vaigyanik* detailed a method for constructing a microscope with an empty matchbox. Many variations of this basic model were developed subsequently. In fact, the craze for making new models reached a stage where one teacher, Badri Prasad Maithil, even came out with a booklet of the models he had developed, which was published by Eklavya under the title *Apna Jugadi Sookshmadarshi* (Your Home-made Microscope).

Whether it was making a hand-pump model from a broken boiling tube, or improving the design of the electric motor model, such innovations were a source of joy for the HSTP because they point to the success of the programme.

13

TEACHERS' GUIDES

As we have said before, *Bal Vaigyanik* is not complete in itself. It basically gives instructions for conducting experiments and asks leading questions. These are questions which are expected to come up after an experiment is performed. Some point to the observations children are expected to make while doing the experiments. Others help in analysing these observations. A good teacher can use these questions to initiate processes that help children learn as they go along. Moreover, it is inherent in the process that the nature and meaning of a question will depend on mutual understanding between teacher and students.

However, teachers often find themselves unable to perform the role expected of them to move the process forward. There could be several reasons for this sense of inadequacy. It could be that they do not understand the topics in the syllabus, or have only a partial understanding. Or they do not understand what needs to be done after an experiment is performed. Or it could just be poor experimental skills and their lack of self-confidence.

Many teachers have only a sketchy understanding of the overall conceptual framework of a chapter. They may be able to answer questions raised by the experiments but they often find it difficult to grasp the common conceptual thread that weaves it all together to reach a conclusion. Even more difficult is seeing the links between different chapters. They are often unaware of how a concept they are teaching is linked to other concepts and phenomena.

The three-week orientation trainings the teachers underwent each year did try to address this issue. But a one-time interaction wasn't enough. That's why the HSTP sought to establish a system of continuous interaction with them throughout the year through monthly meetings and school follow-up visits. On their part, teachers participated enthusiastically in both the trainings and the monthly meetings but at the end of the day all they had to fall back on was the notes they took during these interactions. Hence, when faced with difficult situations while teaching in the classroom, they had nothing more than these notes for immediate reference.

The need to prepare teachers' guides to fill this gap was, therefore, a necessary input. The first attempt to prepare teacher's guides was made when the first edition of *Bal Vaigyanik* was being written. But the experience in preparing these guides and using them was, at best, mixed.

To begin with, there was widespread doubt in the HSTP group about teachers' guides. One fear was that they could be looked at as 'keys' to *Bal Vaigyanik*, especially if they gave all the answers to all the questions raised by the experiments in serial order. That would undermine the spirit of discovery. So the first question that needed to be answered was: What kind of teachers' guide should a textbook like the *Bal Vaigyanik* have? The question was sought to be answered in the following guidelines that were specified for preparing these guides:

1. No attempt should be made to answer all the questions posed

in *Bal Vaigyanik*. The teachers' guide is not a key. Giving answers to questions would mean that experiments would not be done in the classroom, so there would be little scope left for independent thinking.

2. The first step should be to discuss each chapter to clarify its educational and scientific objectives. Discussing the educational objectives is important because this is something the teachers generally tend to ignore or overlook.

3. The guides should outline the precautions and safeguards needed to perform experiments successfully. These should be carefully thought out and explained.

4. The links between different experiments in a chapter and between chapters should be explained to help teachers take the discussion forward in the classroom. Experience shows that such inter-linkage were ignored.

5. Wherever necessary, importance of letting children express their conclusions in their own words should also be made clear to the teachers.

6. Clear guidelines should be given to the teachers on how to take the discussion forward after every experiment or a set of experiments.

7. The guide should point out the complexity levels of different parts of the chapter in terms of the children's ability to grasp the concepts being discussed. This would help teachers rearrange the chapter according to their own perception of children's mental and conceptual levels.

8. Since children may find it difficult to analyse the data generated in some experiments, additional experiments should be suggested to help them in this task.

9. In cases of open-ended experiments with more than one

possible answer, alternative experiments should be suggested to take the investigation forward.

10. Suggestions should be given for making fuller and more comprehensive use of the rural environment in terms of using local materials for conducting experiments, projects and field trips.
11. The guides should specify where children should be encouraged to draw diagrams because this helps them express their ideas better and aids comprehension. In the absence of such instructions, many opportunities of articulation are lost.

Teachers' guides for most of the chapters were prepared but only a few reached the stage where they could be given to the teachers. Most of these were from the class 8 syllabus. They were published in draft form and distributed to teachers. The idea was to finalise them and publish them in book form after receiving feedback on their use and usefulness.

However, most of the teachers did not use the guides. One reason could be that there is no tradition in the school system of making preparations for teaching a lesson. The concept of thinking about the day's teaching agenda the previous day doesn't exist. Most teachers think about what they should teach only after entering the classroom. In fact, it is not uncommon for them to ask children how far they had reached in the topic currently under study.

This happened even in the HSTP classrooms. Children were usually seen running around getting the kit materials to perform the experiments for the day because there was no prior preparation. The teachers did not think about how they should go about transacting a chapter, the kind of questions they should expect, what preparations they needed to make for which experiment, and so on. Even after the lesson was over, they seldom spent time in thinking about which questions remained unanswered, what aspects remained unclear or what problems came up while performing experiments.

In such a situation, there was little chance of a teachers' guide being of any use. An HSTP teacher M.L. Patel even questioned their utility: "An experienced teacher does not require a teachers' guide. If a teacher has not undergone training, then perhaps she would require it." Perhaps what he was trying to say was that experience not only prepares teachers to anticipate most possible situations but makes them fairly conversant with the subject matter.

But there was a contrary view, expressed by an HSTP resource teacher: "Teachers' guide would have opened up and helped clarify every chapter in *Bal Vaigyanik*, which are not so easy to interpret and teach."

Apart from the few draft guides prepared for class 8, no further guides reached the teachers even though many more had been prepared. Guides for some chapters were written when the third revision of *Bal Vaigyanik* was under way, but here again the effort did not progress further.

Since there was no useful feedback on the teachers' guides, there was little enthusiasm to carry forward the task of finalising them. The fact that the teachers could not be made aware of this aspect of the process, can be seen as one of the shortcomings of the implementation of the HSTP.

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SAWALIRAM

Children studying science by a discovery approach will ask a lot of questions because this is not a process in which everything is pre-determined. This was very clear to the HSTP group from the very beginning. The group saw the process of learning starting from children's curiosity about their immediate environment and it felt that this unbridled curiosity should be stimulated, not reined in.

Now, children's curiosity does not see any limits. It is not bound by a curriculum and cannot be structured in the form of a curriculum. However, the least an educational programme can do is not to treat children's questions as illegitimate, but be flexible enough to give space to such questions. This implies that there should be space for investigation of children's questions and the teacher should be prepared for this, both academically and culturally. One way to do this is to weave the syllabus around common questions children ask. However, one cannot pre-empt all the questions children might ask and prepare the teacher with all the answers or ways to investigate all such questions.

It is also possible that some questions a child asks might not be directly related to the topic under discussion and the teacher may like to avoid it right then as it may prove to be an 'unnecessary' distraction.

Where do children go with these questions? Should they just keep these to themselves?

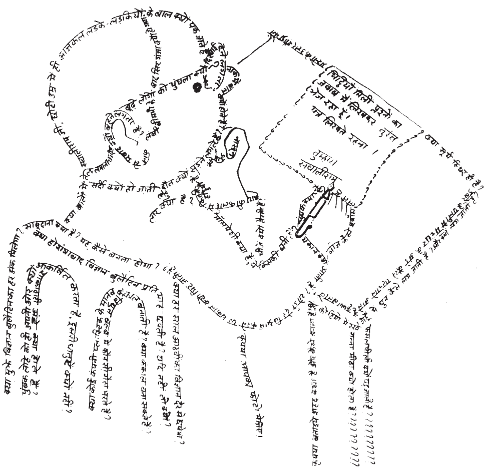
The HSTP visualised 'Sawaliram' as a possible way of addressing such questions. Sawaliram was a fictitious character to whom the children wrote letters, asking any question they wished, seeking advice on any problems they faced in the curriculum, even sometimes complaining about their teachers.

'Sawaliram, c/o District Education Officer, Hoshangabad-461001' soon became a well-known address to hundreds of children in Hoshangabad, Harda and 13 other districts of Madhya Pradesh. So much so that many former HSTP students continued to remain in touch with the character long after passing out of the HSTP classroom.

Sawaliram was open to any kind of question that arose in children's minds, even outside the classroom, never labelling them as 'useless' and 'pointless' as the traditional classroom does. After all, learning is a continuing process and it is foolish to assume that children learn or ask questions only when they enter a classroom. Ordinarily, children keep these questions to themsleves finding no place to raise them. Traditional classrooms anyway treats them as 'useless'. But a programme seeking to link curriculum to environment cannot label any question 'pointless'.

This is exactly what he wrote in a letter addressed to children published in the first edition (1978) of *Bal Vaigyanik*:

> Whenever a question comes to your mind, ask your teacher and discuss it with your friends. No question is irrelevant. You may not get answers to some questions immediately. So note them down in your exercise book.



You may get a chance to ask someone else and get an answer. Maybe you yourself may find the answer sometime later or think up a new experiment to discover it.

You can also write to me and tell me about all your new questions.

Sawaliram tried to establish a dialogue with the children on different aspects of science education. They would write postcards to him, asking questions that cropped up in class or their daily life. Many of these questions were not connected to the *Bal Vaigyanik* content.

Most of the children believed that Sawaliram was a real flesh-and-blood character who answered their questions. That's why they often addressed him as 'Sawaliram chacha' or 'Sawaliram bhaiyya'. When they faced problems in doing *Bal Vaigyanik* experiments, they often cursed him for writing such a difficult textbook. They also wrote about the problems they would face in class 9 because the *Bal Vaigyanik* syllabus did not cover many important topics (such as atoms and molecules). Since they took him to be a real-life character, they would even ask for his photograph. One teacher was so inspired by this demand that he drew Sawaliram's facial portrait using the innumerable questions children had asked.

A review of the Sawaliram questions was once conducted to find out the most important ones as well as their nature and pattern. Children's questions can be categorised into five types:

1. *Questions asked from the* Bal Vaigyanik**:** Most of these questions were copied from the textbook, which the children were supposed to investigate and answer themselves. There were probably two reasons why these questions were asked. First, the experiments were not done in their schools, so they couldn't answer them. Second, they could not find the answers even after doing the experiments. Or, possibly, they were just eager to write to Sawaliram but did not know what questions to ask. Anyway, Sawaliram usually replied to such letters by asking the children to 'discover' the answers themselves and to write to him about any problems they may encounter in the process.

2. *Children's own questions linked to the classroom*: These were usually the questions that were raised in the class during the discussions to which they did not get satisfactory answers. In such cases, Sawaliram's approach was to suggest another experiment or some other method that could help them look for an answer. Sometimes, a direct answer was also given.

3. *Questions arising from the everyday experiences of children*: The policy in such cases was the same as for the questions raised in the classroom. The only difference was that the children were told about the concept linked to the question and the experiments required to find answers.

4. *Questions from Sawaliram's portrait*: Sawaliram's portrait (see previous page) was first published as the back cover of the second edition (1987) of *Bal Vaigyanik*. Many of

the questions asked by children were lifted straight from this portrait.

5. *Complaints*: There were very few letters of complaints from children.

During the school term, Sawaliram normally received around 25 letters every month. Their number went up to over 150 per month during the phases when replies were sent regularly to children. Most letters contained more than one question, some having as many as 20. The flow of letters usually decreased during examination time.

Getting a reply from Sawaliram was an 'event' in most villages, so many children were inspired to ask questions in the hope and excitement of receiving a reply. Just imagine the scenario: a child aged 11 to 14 years in a remote village gets a letter addressed in his or her name, where arrival of a letter itself is a big event.

Whatever the reason, children wrote hundreds of letters to Sawaliram. Wouldn't it be wonderful if every child had access to a Sawaliram.

Let us now have a look at the mechanisms involved in answering the letters.

Answering the questions

The district-level expansion of the HSTP was seen as a step to integrate the programme into the mainstream, with the Regional College of Education taking up teacher training and the Divisional Education Office being responsible for in-service training, evaluation and other aspects.

The Science Cell set up at the Divisional Superintendent of Education office was visualised as the body that would take up the academic responsibilities, so Sawaliram's address was c/o Divisional Superintendent of Education Office. But the cell wasn't equipped to take up the challenging task. That's why the task of answering Sawaliram letters was first done by Kishore Bharati and later by Eklavya.

A child had asked: "I have noticed that creepers twine (around their support) in one particular direction only. Please tell me whether my observation is correct. And if it is correct, then why does this happen?"

This letter raised a storm because nobody knew the answer. The question was promptly sent to two professors of life science and one scientist at the Centre for Cellular and Molecular Biology at Hyderabad.

The answers, when they came one by one, excited everyone and the debate continued. Two of the resource persons had confirmed the child's observation and clarified that the creepers climb one way in the northern hemisphere and in the opposite way in the southern hemisphere.

At this time a physicist joined the discussion. He explained that the phenomenon is due to the Coriolis Effect generated by the rotation of the earth around its axis. According to him, Einstein had written about water swirling in a basin along the same lines.

Almost at this same time, another answer turned up which was exactly the opposite of the earlier two. It said that the direction of twining of the creepers depended on the species: some of them twine clockwise and some others anti-clockwise. There was a third answer proclaiming that the question is frontier research topic in life sciences and physics. Probability of a creeper twining in both the directions was equal.

So, what could poor Sawaliram do? He wrote a summary of all the answers and sent it to the child with a note that science progressed through such observations and hypothesising.

Kishore Bharati never had sufficient staff to take up this work in a proper manner. Even in Eklavya, the pressure of other work saw answering Sawaliram letters becoming a low priority. That's why every time the letters piled up to unmanageable levels, the task of answering them was taken up in campaign mode. Of course, there were times when Eklavya deputed a staffer to answer the letters. That's when answers went out regularly. But the regularity always brought in a fresh flood of letters that made the task of responding even more difficult.

While appointing a staffer to answer letters brought some regularity, answers tended to become monotonous and uninteresting. Answering Sawaliram letters demanded creativity. But answering 10 to 12 letters daily was beyond the physical, mental and creative limits of an individual. Moreover, the questions weren't limited to a single topic, often ranging across several disciplines. That made it even more difficult for a single person to handle this task. What was needed was a cross-disciplinary team, which never got formed. Some attempts were also made to discuss the questions in a group and then have an individual write the answers, but even this could not be done in an organised manner.

The answers had to be as diverse as the questions. Sometimes a straight answer may be needed, sometimes the child may be asked to clarify her/his question, sometimes an experiment could be suggested and sometimes the question may be answered by posing another question. Sometimes children were scolded for asking stupid questions and sometimes they were assured that the concerned person would be contacted regarding their complaints. The main thing was establishing live contact and dialogue with children. All this was too much for a single person to handle.

Sawaliram workshops were also organised during which resource persons would sit with college and university teachers and students to answer piles of letters within a span of three to four days. This helped a lot in clearing the backlog. Many such workshops were organised. We shall discuss one particular workshop in which not only was the backlog dealt with but a serious attempt was made to set up a permanent facility for answering Sawaliram letters.

This three-day workshop was organised in 2000 at the Environment Management and Plant Science Institute of Vikram University, Ujjain. Students and lecturers from the university's biology, chemistry and physics faculties participated in large numbers. The discussions highlighted the fact that it isn't easy answering children's questions. For example, why is iron attracted to a magnet while wood isn't? Even the physicists in the group could not give an adequate answer to what seemed like a simple question. They pointed out that the way the concept of magnetism is dealt with in mainstream science textbooks leaves a lot to be desired yet they continue to repeat this faulty description and even give proofs for it. They finally had this to say about the magnetism question:

> We cannot explain the concept of magnetism to children (and perhaps not even to ourselves), so the only answer we can give them is that iron is attracted to a magnet because it is a property of iron. Wood does not have this property, hence it is not attracted to a magnet.

The questions raised many more such discussions, all pointing to the need for deeper and more specialised knowledge of concepts. It was also felt that many a time we mistake terminology to be the answer, which is not true. Answers to around 80-85 questions were prepared during the workshop and the participants promised to cooperate on a regular basis in answering Sawaliram questions. But this initiative came fairly late in the HSTP (which closed down in 2002) and could not be carried forward because of lack of coordination.

Many such efforts were made to make Sawaliram a lively institution. The overall experience was that Sawaliram proved to be a good platform although adequate attention was never paid to it to derive the full benefits it could have conferred on the HSTP.

Distribution of Sawaliram questions

Class	Original questions	Questions about *Bal Vaigyanik*	Questions from Sawaliram's portrait
6	67%	8%	25%
7	60%	16%	24%
8	79%	12%	9%

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PREPARING AND SUPPORTING TEACHERS FOR PARTICIPATION

Teachers played a central role in the HSTP. This was expected and necessary in a discovery-based teaching-learning method because the open-ended nature of the approach meant that a chapter could follow different paths in different classrooms. One could never really predict the questions children would ask or what would happen in the classroom. So the teacher had to intervene at every step to weave children's questions into the learning process without derailing it altogether.

In traditional classrooms, the role of a teacher is limited. (S)he is at best expected to explain what is written in the textbook, supplementing the explanation with examples or analogies. Otherwise, reading out the textbook aloud is taken as teaching and dictating the answers to questions given at the end of the chapter is the ultimate purpose of such teaching.

Expecting children to do the experiments themselves, discuss their observations, derive conclusions, analyse these conclusions collectively and then explain everything in their own words is something totally off the beaten track. Even if the process proceeds along expected lines, helping them to reach conclusions is a difficult task that requires special abilities; abilities that extend beyond the topic being taught.

It also requires patience to allow children the time to draw their own conclusions. Getting impatient and telling them the answers short circuits the process, even if it may appear the easier way forward. The teacher must have faith in the abilities of children. Unfortunately, our educational system has little faith even in teachers and given this distrust our textbooks leave nothing to a teacher's discretion. The sad fact is that the teachers have very little faith in their own abilities. This is not surprising because education is seen as a product by the mainstream while the HSTP saw it as a process.

Teachers have often complained that if children skipped an HSTP class it created continuity problems because the discovery approach demands the active participation of children, not just reading and memorising the textbook content. In this context, it makes one wonder how did private students cope in this scenario.

The discovery approach is child-centred, as opposed to traditional teaching methods that are textbook-centred. In a traditional classroom what different children think or do is of little consequence. They may be at different levels (even that is often ignored in such classrooms) but they cannot choose to follow different paths. In a child-centred methodology, on the other hand, a single experience in the classroom can raise different kinds of questions in the minds of children, with each possibly reaching a different conclusion. At least, they may take different routes to reach, may be, the same conclusion.

That's why the HSTP had high expectations of teachers. They should know the subject well, have faith in the discovery approach and be familiar with its different aspects. They should also have faith in children and their ability to discover things on their own and to decide what is right or wrong. They should be clear in their mind that no one, including themselves, can know everything, so they shouldn't be ashamed to admit to children that they do not know, so let's investigate.

Teachers should also understand that the textbook is not the only or ultimate source of knowledge. They should have the ability to design new activities and experiments apart from those given in the textbook. (Unfortunately, teachers are often themselves unclear about various concepts, so they are unable to apply them in new contexts.) And most important, they should be sensitive to diversity within the classroom.

Wherever possible, the HSTP sought to structure the syllabus around the environment. The teachers then became responsible for relating whatever learning was taking place to the child's milieu.

This had several implications for teacher training. Apart from familiarising teachers with the syllabus, they needed to be oriented in the discovery approach and all its aspects. The HSTP teacher training was developed keeping these two aspects in mind. In addition, four other aspects were also considered important and taken into consideration.

First was the cultural aspect. A teaching-learning process is not just studying a particular topic. It is an interaction with a world view. Ignoring this cultural aspect gives rise to the problem encountered every day. Teachers and children learn to live with two types of knowledge. One is textbook or school learning and the other is everyday, experiential or practical knowledge. Unfortunately, mainstream education provides no space for engagement with cultural values and traditional concepts in learning. In fact, it negates their very existence. As a result, while the earth rotates on its axis in textbooks, it doesn't rotate in real life.

Second, it is commonly assumed that a one-time training of teachers is sufficient for life-long teaching. This is a wrong assumption. When teachers begin teaching in a classroom, they are confronted with many questions and problems. They have no platform to discuss these problems, so they gradually begin to take refuge between the safe covers of the textbook. It is a very easy choice for them to make in textbook-centred learning, though not really a desirable one. But making such a choice in discovery-based learning could prove disastrous.

Third, whenever anything new is attempted in the classroom, the teachers will need continuous support and consultation. Otherwise (s)he feels isolated. Teachers are often victims of such isolation, that's why they seldom show any enthusiasm for trying out something new. When the HSTP project proposal submitted in 1972 asked for two teachers from each school, it was precisely to avoid the sense of despair caused by isolation.

Fourth, in most teacher trainings, including subject training, there is little discussion on working conditions in schools. What is the state of the school building? How many children are there in each class? Is there an almirah to store laboratory kits? Is the kit useable? What are the living conditions of teachers during the trainings? Do they get their travel and daily allowances, etc.? Such issues are never discussed in trainings, even though they have a serious impact on teaching.

It cannot be said that these things were thought out in precisely this manner in the beginning, but what is clear is that they were part of the first training camp itself. The HSTP group saw teacher trainings as open dialogues with teachers, a two-way exchange on all these things. That's why it would be more appropriate to call them interactions rather than trainings. The interaction was an attempt to make the teachers an integral part of all facets of the programme.

The teachers' role was never seen limited to classroom management. The idea was to make them active participants in every aspect of the programme including development of curriculum and preparing the textbooks, developing children's assessment and evaluation system etc. However, participation of teachers in the preparation of curriculum and textbooks is a complex issue. Obviously, it cannot be limited to including a couple of token teachers in creating teaching-learning materials. At the same time, it has to be recognised, to begin with, that most teachers in the present circumstances may not be able to contribute to creation of such materials. Experience shows that left to themselves, most teachers would produce materials similar to (if not worse than) what is currently in vogue. Therefore, the HSTP looked at teacher's participation in material preparation as an opportunity for teachers to learn and translate it creatively into materials.

Teacher training: the first workshop (1972)

The first HSTP training workshop began on May 22, 1972 at the Friends Rural Centre, Rasulia campus. The workshop was crucially important in the sense that it exposed the HSTP group to almost all the significant issues related to science education in a rural scenario.

There was no workbook or textbook ready for use in this workshop (*Lal Vaigyanik* was published only in September 1972). So some chapters and experiments from the book published by the Physics Study Group and a few biology experiments and concepts were used. That made it a truly open workshop since the teaching-learning materials were being tested for the first time. It also set the pattern for all subsequent material development.

An article (*Science Today* in December 1977) written by the HSTP group illustrates this process with several anecdotes from the workshop. Some excerpts of it are given here:

> In an orientation camp, a teacher raised a question, 'Is there variation in living things?' A biologist challenged the teacher 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 further proved that variations were inescapable. The faculty was excited. It had material for a new chapter which the teachers promptly named '*Jeev Jagat me Vividhata*'.
>
> ...The teachers generally exhibited an implicit faith in destiny. This was an impediment in logical analysis, and had a spillover effect on 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 fields. Factors like soil types, seed rate, fertiliser use, etc., were totally ignored. This lack of rationality had serious implication on their ability to moderate discussions. A physicist, therefore, developed a unique chapter on chance and probability.
>
> ...The basic issues of discovery approach soon began surfacing. For example, discussing plant life in a biology session, a teacher-farmer raised the question, 'How do fertilisers 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 skeptical, 'How can we be sure? Perhaps the veins

> turned red because we cut the twig. I have seen apples turning brown after cutting.'
>
> Although the question appeared trivial to us, it could not be ignored. Such questions form the backbone of discovery approach, providing links to further experimentation. A heated debate followed. It was decided to modify the experiment by including a second twig placed in plain water. The concept of using 'controls' was born.
>
> The teachers were by now thoroughly engrossed in the spirit of enquiry. 'What would happen if we use 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 Ph.D. if you do not know such simple things?' It was a jolt to their value system. To them a Ph.D. 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 implication of discovery approach only then dawned upon the teachers. They began to realise that they, too, would often be forced into a spot when they would have to admit, 'I do not know, let us find out.' It was a negation of the traditional pre-eminence of the teacher.

Chandrakant Dixit,[1] a teacher from Doon School, also captures the essence and atmosphere of the first HSTP orientation camp in a report:

> "The summer programme thus provided a unique confluence

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[1] Chandrakant Dixit, "Today's Education for the Needs of Tomorrow", Physics Study Group, December 1972. Dixit was one of the Doon School teachers who wrote *Physics Through Experiments*.

of rural and urban ideology, while the faculty and participants worked together, argued, shared food and relaxed together in the campus. The sole objective of these inspired souls was to explore the feasibility of an experimental, open-ended approach to the teaching of science to rural children.

“The task was arduous. Besides bearing the heat of the sun and shortage of water, it was essential to cross the administrative, psychological and cultural hurdles before any fruitful communication could be established. As it happens, at the start of the course, we were not even aware of some of the problems we had to face, and many myths that were exploded. Poor conditions under which the teachers had to work in rural schools had contributed a lot to their lack of enthusiasm for anything new; lack of faith in their competency to try out a new syllabus was only one of many reasons. They were afraid of maintaining a stock of equipment in schools which hardly had doors in classrooms to lock it up. How could a required curriculum be covered in a scheduled time when flooded seasonal rivers kept students away from classes for several days? Would the educational authorities not toss them from school to school, if they become annoyed by the problems which any untraditional approach to teaching science is bound to create?

“The schedule of work and activities were so planned as to provide ample and deliberate opportunities to participants for a free exchange of ideas and opinions with faculty members. There was a marked difference in the initial attitudes of the faculty and participants, which were based on their views on science, religious and cultural practices, and logic. This resulted in many debatable issues that cropped almost every day during academic sessions.

"At the start of the first experimental session, Shri Kulkarni[2] felt the need to emphasise the significance of experimental evidence. He quoted from one of the schools of thought (*mimamsa darshan - मीमांसा दर्शन*) to suggest that there is no proof greater than direct observation. He pointed out that in the absence of direct proof we rely on logic or reason, and guess. The evidence based on oral tradition (*shruti* evidence - श्रुति प्रमाण) comes in the end. Experiments provide personal experience as they are based on direct observations. Hence, by this one single reference to the *shatdarshan (षटदर्शन),* Shri Kulkarni succeeded in striking the first blow for a discovery approach to science teaching...On many other occasions, cultural and religious traditions helped a lot in the scientific explanation and interpretation of observed facts.

"References to rural environment were found equally helpful in driving home certain concepts. Bombay is the home of cricket in India, and Shri Pitre[3] had experienced no difficulty in referencing to the game while talking about the Polar Co-ordinate system for locating the position of objects. The game provides a reference point, the origin, as the position of the batsman, and a reference direction, the bowling pitch. When dealing with the topic in Rasulia, he anticipated the futility of using this example to village children. The idea of citing गोफन (sling for throwing stones to scare away birds) as an example to elucidate the concept occurred to him spontaneously and clicked instantly in the minds of the

[2] V. G. Kulkarni was a scientist from TIFR who was a key resource person of the Bombay Municipal Schools experimental programme. He later became director of the Homi Bhabha Centre for Science Education.

[3] B. G. Pitre was one of the Doon School teachers who wrote *Physics Through Experiments.*

participants. His mention of Rectangular Co-ordinate system was then enthusiastically taken up, and many participants related it to the bigger and smaller canals in fields which cross each other at right angles.

"In one of the late night sessions under the sky, Yash Pal[4] referred to the sun in a casual manner. Shastriji, one of the participants, gathered courage to ask, '*क्या आप सूरज को भगवान नहीं मानते?*' (Do you not consider the sun a god?) Professor Yash Pal elaborated on how much we owe to the sun. The light and heat we receive now (and millions of years gone by) sustains life on earth. No wonder the gratitude towards this source of life finds expression in the worship of the sun. Shastriji was thus softened, his faith in religion affirmed and attitude towards science more positive, as Professor Yash Pal progressed with his talk on elementary astronomy.

"On one occasion, Dr. Anil Sadgopal was trying to classify the living world in broad categories depending upon the mode of birth. *अण्डज* (born from an egg) and *पिण्डज* (born from the body) were two groups mentioned on the board. Some participants stated that a third category *स्वेदज* (born from perspiration) is also mentioned in mythology. In this category they included lice and fleas. Shastriji stood up to recite a couplet in which reference was made to four categories of living beings on earth: *अण्डज, पिण्डज, स्वेदज* and *उद्भिज* — the first three to cover the fauna and *उद्भिज* to cover the flora. Dr. Sadgopal had a real tough time (he almost perspired) to bring home the point that perspiration may provide the favourable environment for growth, but it is not the origin of these organisms.

[4] Yash Pal was a scientist at TIFR at the time and an active resource person of the Bombay Municipal Schools programme.

"One morning when the word तत्व was used for elements in the Periodic Table, a participant expressed amazement at the statement that their number is as large as a hundred. He had the impression that the five elements sky, air, fire, water and earth formed the ब्रह्माण्ड of which the whole universe was made. I drew upon my knowledge of *Sankhya Darshan* according to which all our interactions with the external world give rise to five basic stimuli which are experienced with the five sense organs. The जल तत्व exists in all objects which affect our tongue. Similarly, objects that excite our sense of smell are said to have पृथ्वी. It was only after this deliberation that the word तत्व was accepted in its new usage in the Periodic Table.

"It was evident at the termination of the course that the seed of rational outlook had taken roots in the minds of our teachers."

The lessons of the first workshop

Yash Pal drew attention to many key aspects of this workshop in an article he wrote:

"1. In order to generate valid materials, a combination of working school teachers and men [sic] from universities and research scientists is ideal.

"2. We have come to believe that investigatory approach to science learning is the very approach we need to follow if we want science education to take roots in a soil seeded with beliefs, myths and experience which in the traditional way of learning are never contacted, much less made use of.

"3. We also find that it is very injurious in designing materials, to assume that the big city children and teachers, because of their greater exposure to gadgets and technology, are necessarily ready to receive science at higher level. On the other hand, we find that the experience of the village teachers and students is in many respects richer; only our traditional curricula do not draw upon this experience. Much of the work therefore has to be done in the environment for which the material is intended.

Behind the terminology

Resource group: The group that gave shape to the HSTP. Its members were drawn from Kishore Bharati, Friends Rural Centre, various universities and colleges as well as research institutions. It was responsible for conducting all the teacher trainings prior to the district-level expansion of the programme.

Follow up group or operational group: The group comprising teachers from high and higher secondary schools as well as middle schools. It was responsible for conducting follow up in schools. The group was constituted at the time of the district-level expansion, as per the requirements of the expanded programme.

Resource teachers: After the district-level expansion, the HSTP was running in around 250 schools. It was not feasible for the resource group to conduct teacher trainings on this scale. So around 20-25 trained teachers who had fully internalised the HSTP spirit and values were selected to take over the responsibility of training and orienting other teachers. Known as resource teachers, their numbers grew to over 200 as the programme expanded. They subsequently conducted the HSTP-style teacher trainings in other states and made important contributions to the programme in many other ways.

> "4. We have found that the teaching of science in the new way involves continuous confrontation with ethical and social values. In this respect, in a country like India a national effort to improve science education is much more than just science teaching; it is a major revolution in the lives of people. One of the purposes should be to gain acceptance of the fact that the world of science does not exist apart from their daily lives and beliefs. To achieve this one does not need to disprove their 'unscientific' beliefs but to show how these beliefs could have arisen. One cannot just ignore the questions which are continuously posed by students and teachers.
>
> "5. We have been overwhelmed with the magnitude of this task. On the other hand, if all efforts are not centralised, the problem may not be intractable.
>
> "6. Like many other programmes we have also found that a continuous interaction with teachers and schools is needed to keep them from lapsing into traditional habits. One of the problems is that their own fund of knowledge and their daily lives do not provide most of them enough stimulation to sustain the open-ended nature of the programme."

The framework for working with teachers

Teacher interactions in the HSTP were not limited to teacher training. This is clearly brought out in an observation of a teacher, R.N. Sharma, from Piparia:

> "In my experience no other programme has seen teachers being such active participants in every aspect – from developing curriculum to creating an evaluation system. The HSTP gave teachers dignity."

Teachers were seen as equal participants, so no effort was spared to prepare them for their new role. Whether it was classroom management, evaluation of students, follow-up in schools, helping fellow teachers, developing curriculum and other educational materials, or developing kit materials, they were active participants. And every participation was taken as an opportunity for further training and orientation.

For the sake of convenience, we can club teacher development efforts into three parts:

1. Nine-weeks of in-service training conducted over three years.
2. Continuous follow-up and monthly meetings, teachers' guides, the *Hoshangabad Vigyan* bulletin.
3. Participation in other components of the HSTP.

In-service training

As mentioned earlier, preparing teachers for their new role in the classroom was a major thrust area of the HSTP resource group. When the programme started, most teachers had no background in science. Most had studied upto class 10 or class 12. One or two were graduates.

This may not be a serious obstacle in a teaching methodology based on reciting the textbooks. The new approach, however, requires teachers to not just be familiar with the content in the syllabus but to understand it well.

As mentioned earlier, a teacher in the HSTP classroom was not expected to provide explanation to children's observations. Expectation, on the contrary, was that the teacher would help children to explain their observation and reach conclusions as well as decide about what is right and what is wrong.

To be able to do this, the teachers themselves need to go through the experience they are expected to guide in the classroom. They must know and anticipate what to expect: the kind of observations that could arise from experiments, possible sources of errors, alternative methods to look for answers, etc. They must also understand the experiments and their purpose well enough to be able to suggest modifications or alternatives.

This requires in-depth understanding of the topic being investigated because conclusions drawn from experiments cannot be analysed without understanding the background and their linkages to other concepts.

It was also important that the teachers experience a democratic classroom and get a feeling of what a classroom based on learner participation looks like, where decisions are taken on the basis of reason and evidence free from an ultimate or autocratic power.

This is not an easy task, especially in a classroom adopting a methodology like the discovery approach. The teachers may know the outcome of an experiment but they cannot impose it on children. Rather they are expected to give them the opportunity to go through the experience themselves and guide them to the conclusions through a chain of reasoning.

All this meant that the HSTP teacher training had to be structured to give teachers the opportunity to polish their experimental skills and get a more in-depth understanding of science. They also had to be convinced about the discovery approach and learn how to implement it in the classroom.

It is not clear if it was a well-thought strategy or happenned just like that, but role play was the model adopted for the orientation sessions. The interaction during a training session would be organised as if it was a school classroom. The idea was to let the teachers go through a process – performing experiments, noting down observations, explaining them, discussing and reaching a conclusion – which they are expected to lead in their own classrooms. During this process, the role played by the resource persons gave them an idea that the teacher is a facilitator, catalyst and all questions about the content and pedagogy emerged from this concrete context. In this sense, the training was an effort to consolidate the understanding of the subject as well as give them a glimpse of the methodology.

In traditional teacher training sessions, teachers would be lectured on each of these aspects. They would be told that they should allow children to do experiments, should engage them in discussions. And, finally, they would be informed that this is called 'discovery approach' or 'learning by doing approach', so that they could write a 'short note' if required.

All teachers had to participate in training sessions spread over three years, the orientation camps being organised every summer. The first year was for the class 6 syllabus, the second year for class 7 and the third for class 8. The camps were residential and lasted for around three weeks. So every teacher went through nine weeks of in-service training. Around 3,000 teachers are estimated to have undergone this training during the lifespan of the HSTP.

There was no selection of teachers for the training; the schools decided who to send. The only stipulation was about the number of teachers each school should send, which was linked to the number of students in each class.

On the first day of the training, teachers were registered in appropriate classes (6, 7 or 8) divided into groups of four. Each training class had about 40 teachers and they were expected to work with their groups throughout the training. (They were expected to divide their classes into similar four member groups when they returned to school.)

The teachers spent five hours daily in the classroom. Thus they had a total of 90 hours of formal instruction time each year. Apart from studying *Bal Vaigyanik* chapters, they were exposed to other elements of the HSTP methodology, such as evaluation, examinations, kit maintenance, follow up and so on.

A series of training sessions

Teacher training was organised every year from the time the HSTP began in 1972, barring one year. After the programme was seeded in 13 districts in 1983, with a School Complex in each district, sometimes two simultaneous training camps were organised in a year. These School Complexes were spread over a very wide geographical area.

There were several reasons why large-scale training continued to be organised every year. They included expansion of the HSTP to new areas, opening of new schools, promotion or transfer of trained teachers and appointment of new untrained teachers.

A rapid expansion of private schools gave rise to new problems. For example, many of these schools were not too keen to invest in in-service training of their teachers, so the teachers often spent money from their own pockets to attend the training. Another related problem was that private schools mostly do not employ/appoint teachers during the summer vacation. So there were no teachers to be sent to summer training camps.

To address these problems, two changes were made in the scheme of the training. The first change was to organise smaller training camps instead of a single large camp at the divisional level. Each such decentralised training camp catered to around 150 schools from around 2-3 blocks. The advantage was that the training didn't have to be residential. Most teachers could stay at home and come daily for the sessions. But there were several disadvantages as well. For example, there was little scope for informal interaction with teachers after the formal sessions, which was possible when the training was residential.

Another disadvantage was that the resource group had to be divided across a larger number of training camps. In the divisional training the presence of the full team of resource persons at a single venue had a special impact on the educational activities. Teachers could interact with subject experts, new volunteers and resource teachers to discuss and try out ideas on all aspects of the programme.

The second change was that the training camps were organised during the school year itself. So teachers had to absent themselves from school to attend the camps, which affected teaching time in the schools. College and university resource persons also faced a similar problem, finding it difficult to take time out to attend the trainings.

So while the decentralised training did solve some problems, it gave rise to new ones. Getting resource persons and organising the daily training timetable became a complicated exercise. Tapping local colleges did not help much, so sessions on different topics had to be arranged according to the availability of subject experts rather than in the more logical conceptually graded manner.

Academic discussions and exchange of views were hallmarks of training camps . These camps were appropriate occasions for developing new experiments and revising the old ones as any new experiment or equipment could immediately be tested with the teachers. Kishore Panwar has given a sample of this process in an article in *Sandarbh*.

"The problem was to find out whether dry seeds are living or non-living. The only solution was to show that dry seeds breathe. Usually the process of respiration is inferred by carbon dioxide produced during the process. This is what was attempted during the 1988 training camp. Four or five types of seeds were placed in separate test tubes along with pink phenolphthalein indicator solution. One test tube had only indicator solution and another also had some marbles in it. After some time the indicator solution started losing its colour in the test tubes which had seeds in them. And someone said, so it is clear that seeds breathe.

"However, a teacher took another test tube and put some indicator solution in it alongwith some dry leaves and pieces of tree bark. After some time the solution lost its colour here as well. So, do dry leaves and bark also breathe? The problem was that phenolphthalein is an acid-base indicator. Dry leaves and bark etc. also increase acidity and the indicator loses its colour.

"Another problem was that the seeds become wet when placed in the indicator solution. So how to decide whether or not dry seeds breathe? The solution for both these problems was found in a training camp in Gujarat. In an experiment done there the indicator solution was placed in the test tubes and a wad of cotton was placed over it in such a way that it did not touch the solution. Seeds, dry leaves and bark etc. were placed on the cotton wad and it became clear that dry seeds also breathe."

Another casualty was interaction between teachers and resource persons. Given the HSTP's climate of openness, teachers still came up with all sorts of questions but since fewer resource persons attended the smaller camps, there was less scope for debates, discussions and trying out new experiments.

Another organisational problem was providing the kit materials. Managing kit supply at the divisional training was always a difficult task. It became even more complicated when the number of venues multiplied.

However, the block-level camps did have their positive side for teachers from private schools.

There is a reason for going into details about these problems. Such a programme requires strong structures for teacher training and continuous support. It also requires high-quality resources and creative resource persons to breathe life into these structures.

In the context of teacher training, the extent of decentralisation possible is an issue, which depends on several factors. Foremost is how successful are the attempts to involve colleges and universities. Two, how successful are the attempts to involve high/higher secondary teachers and prepare them to take up the role of resource persons. Time also is a factor as it takes time to set up these processes and structures. This cannot be done by creating master trainers and key resource persons overnight. This question is particularly important in the context of an innovative programme.

Although, switching to block level training camps did have positive outcomes in terms of number of teachers, especially private school teachers, attending the trainings, the HSTP group rued the loss of the learning environment that large-scale training camps created. It means that the group considered the activities outside the formal classroom vitally important from the point of view of the programme. This was usually the time when teachers tried out many new experiments, learned many new things, did library research, prepared wall papers, viewed films or attended lectures on various subjects.

Seen from the perspective of the resource group, large-scale workshop gave ample scope for preparation, feedback, discussions on chapters and concepts. Moreover, discussion amongst senior resource persons opened up a variety of aspects concerning the programme and science education, benefitting the volunteers and teachers alike. And it was felt that such get-togethers are essential for maintaining the rigour and intensity. Smaller camps never achieved the 'critical mass' of resource group to make these things possible.

This is why large-scale training continued to be organised occasionally at the divisional level even after the switchover to decentralised block-level training.

Whatever the case, describing the training and the preparatory process is an interesting exercise in itself because it gives insights into how seriously the HSTP dealt with the issue of teacher training.

The training model

The HSTP teacher training model was based on the premise that if the teacher gets personally involved in a self-learning process during the training, (s)he would be able to inspire the students to adopt and internalise this approach in the classroom. A person who is not a learner him/herself cannot inspire others to learn.

It's a matter of great pride that teachers who participated in the HSTP accepted this fact wholeheartedly. This is clearly brought out in the comments of teachers from Pipariya at a meeting organised on August 20, 2006, some years after the closure of the HSTP. They pointed out that the learning process in children cannot be seen in isolation from their own self-learning. When asked about the learning experiences of children in the HSTP, they tended to include their own personal learning experiences in their explanations, so much so that it was sometimes difficult to tell whether they were talking about children or themselves.

Take, for example, what Shashikala Soni, a retired teacher, had to say:

> "I collected tadpoles from a nullah near the Dudhi river near Kishore Bharati for the reproduction chapter [she was probably referring to the chapter 'Life Cycle of Animals'], kept in water, they developed into frogs. Just like when I had asked children to conduct the fly experiment (life cycle of the house fly), when the fly emerged, they shrieked with joy".

It is a positive attitudinal change that the teachers visualized children's development and their own development as closely linked processes. The resource persons also learned a lot in the process. In fact, it was the excitement of learning new things that drew so many people from different institutions to the resource group.

Bharat Poorey (who was a professor in a college at the time), explains it best:

> "Whenever we returned home after a training session it was with a pleasurable sense of satisfaction that we had got the chance to learn something new. The training made me aware

> of the yawning gaps in my subject knowledge. The simple and everyday questions the teachers asked, to which I couldn't give an adequate reply, made me realise how much more I needed to learn about my subject. It was the teachers who gave me the courage to admit I did not know."

Ultimately, every person participating in this programme was simultaneously involved in teaching and learning. That is why it was a festival – a festival of learning.

The second premise of the HSTP training was that the teacher must have a deep understanding of the subject she teaches. Understanding did not mean familiarity with technical words, definitions, formulae and so on. What she needed to know was the logical structure of the subject, its linkages with other disciplines and the methods to gain insights in it.

The third premise of the HSTP training was that the teacher should believe in her own capabilities and the capabilities of children.

Teachers were expected to learn about different aspects of the methodology and its implementation. Most important, they had to understand and appreciate their new role in the classroom, the open-endedness of the teaching methodology and the excitement of discovering things for oneself.

And, of course, teachers must be good at what is to be done in the classroom.

Another important aspect of the training was to create an environment in which teachers realise that saying "I don't know" will not attract ridicule but will become a step towards learning. They should realise that it is not a crime to commit a mistake and that people here would help rather than laugh at a mistake.

This feeling was most appropriately expressed by teachers at the Pipariya meeting when they pointed out that the HSTP training demolished the deeply ingrained image of an 'omniscient' teacher. They saw this as a positive development. The HSTP gave them the courage and confidence to stand before their students and say, "I don't know. Let's try. Perhaps, we can find the answer."

Another eye-opener was that their observations from the experiments they performed during their training often did not tally with their own beliefs and understanding based on theoretical knowledge.

The HSTP training tried to address all such issues.

Perhaps, we can understand this better by describing what happened in an HSTP training session. But before that, let's see the kind of preparations needed for the teacher training sessions.

The resource group used to gather at the training venue three days before the training started to make the necessary preparations. There would be many jobs to be done and everyone pitched in. These included getting the accommodation for resource teachers and trainees ready, checking the lights/fans, arranging drinking water and food, getting *dhurries* for the classrooms, organising the kit and setting up a kit room, making the three-week timetable for the training, dividing the resource group into smaller groups to take up different chapters, preparing the chapters, and so on.

The resource group did these jobs collectively, including the most routine administrative and management tasks which acquired urgency at times.

However, we'll stick to describing only the academic tasks here.

In the first three days the resource group would prepare a rough framework of the chapters to be dealt with during the training, along with the kit required. The list of kit materials for each chapter would be given to those in charge of the kit room so that the daily kit for each class could be arranged in advance. If a new experiment was to be tried out, the kit room would be informed. In fact, the kit room became a kind of clearing house during the training.

Preparations for long duration experiments were also done in the first three days. For example, conducting the artificial pollination experiment in plant reproduction required selecting a farm or garden and getting the permission of the owner. In the same way, prior preparations were needed to get fertilised eggs at different developmental stages on the day the growth and development chapter was taken up.

There were experiments requiring preparation many days before they were conducted. A checklist of such experiments was prepared as a ready reference.

Unfortunately, trainee teachers could not participate in this preparatory phase because they would arrive only on the day the training began. This was a drawback, considering that they themselves were expected to undertake such preparations when they returned to their schools.

The next step was preparing for each chapter. The resource group had to perform and assess all the experiments in advance with the available kit materials. This may seem a bit excessive considering that most of the experiments have been done several times by various people to leave no lingering doubts about their 'success'. Yet this stipulation was there for two reasons. First, every training session had new resource group members who needed to be familiarised with and convinced about every dimension of each experiment. Second, experience had shown that it was imperative to check the experiment with the material available in the kit room at the moment because things may not work.

Another important aspect was deciding how to present the chapter to the trainees in the classroom. This included introducing the chapter, giving its background, anticipating the kind of questions that could arise, thinking up additional experiments, and so on. There was also the question of how to evaluate the learning outcomes once the chapter was completed.

After the resource teachers took over the responsibility of conducting the training, another step was added to the preparatory stage. A resource group member had to first sit with the resource teacher teams to discuss and finalise the training framework and schedule which was shared with a larger group.

Each day the resource group team would arrive in the classroom with the required kit materials.

Five hours per day

The average training class consisted of around 40 to 50 teachers. They would be divided into groups of four on the first day itself, with most of the work in the coming days being performed in these groups. Each teacher would get a copy of *Bal Vaigyanik* and other materials. The report of the previous day's activities would then be read out before commencing the day's session. This became the standard practice for all training sessions.

The session would normally begin around 7-7.30 am and continue till 1-1.30 pm, with a half-hour break in between.

Just as the teachers were divided into groups, the resource group would also be divided into smaller groups of 4-5 members, with one of them coordinating and leading the session. This person would give a brief introduction of the chapter. The introduction could take different forms. Some preferred starting with a striking, attention-catching experiment. Others preferred bringing out the prior knowledge of teachers on the topic as a starting point. Or a question could be raised which is fundamental to the topic, paving the way for investigation and study. Whatever the option used, the message put across to the teachers was that they may also adapt their approach to the chapter to suit the classroom situation.

The experiments would then get under way. Each group would have at least one resource person to help out, the idea being to ensure that every teacher understood how to conduct the experiments. Each group would perform the experiment, note down the observations and discuss the findings within the group. A general classroom discussion would then follow to analyse the observations of different groups. The core thread of the discussion would usually be the questions posed in *Bal Vaigyanik*, although all attempts would be made to keep it as open-ended as possible.

Proceeding in this manner had its pitfalls. Initially, teachers usually think that they know all the answers, or could get the answers just by reading or listening. This is what happens most of the time in traditional teacher training. So they would hesitate or try to avoid doing the experiments. Take the example of the very first teacher training in 1972. The teachers were asked to measure the length of a table. Their immediate response was, "This is child's play. Give us something more serious to do." They began measuring only after Yash Pal cajoled them, saying, "*Arre* *yaar*, just do it and see." And they were astounded when they realised they didn't really know how to measure.

As it is, teachers are reluctant to work with their hands and accept it as a way to learn. They believed that knowledge encapsulated in books is the ideal learning source. So there is not much interest in searching for and discovering knowledge. This reluctance was most marked in teachers with a bachelor's or master's degree in science. They had no exposure to seeking knowledge in an open-ended manner, so they were totally ignorant about the process. That's why it took them some time to actually perform experiments, think for themselves, faithfully note down their observations and believe in what they actually saw.

Another problem was that they believed that all the experiments are very easy and they thought they knew all the observations. So they felt that doing the experiments was a waste of time. Take the boiling point of water as an example. Even children know that water boils at 100^0 C. But not once in the 30-year history of the HSTP did water boil at 100^0 C when the teachers actually did the experiment. When after a lot of cajoling, they finally did the experiment, the excitement was palpable. Then came the attempt to try and understand why water was not 'behaving'. It was only then that they would recollect that the 'correct boiling point' of water had several provisos like its 'purity' and 'normal pressure'.

A similar kind of reaction could be noted when a magnet with north poles on both ends was placed in their hands.

Inevitably, there would be a marked change in their attitude as the training proceeded. They would begin performing the experiments, most enthusiastically, some with a bit of nudging.

Once the apparatus and kit were in their hands it was difficult to stop them. New ideas would emerge, new experiments were performed. The hope was that they would let their classrooms function in the same open-ended and free manner. Unfortunately, despite creating such an exciting environment during the training, a few teachers still went home without performing any experiments.

Apart from reluctance to do experiments, there was one other problem. As pointed out earlier, most teachers had never done experiments, or had done them a long time ago. So they did not have the skill to perform even the simplest experiments.

Moreover, whatever experiments they had done in high school or while qualifying for their degree were done with a totally different purpose in mind: usually to verify or prove something, or to arrive at an expected answer, such as the boiling point of water is 100^0 C. Experience shows that the teachers had little skill in performing even the simplest of experiments. The trainings, therefore, focused on teaching them how to do experiments.

After experiments came the recording of observations which included narrating and writing them down in simple and clear language, tabulating them, drawing diagrams to illustrate them and so on.

Making diagrams was especially difficult for most teachers. They had no practice whatsoever in depicting what they saw in diagrammatic form. This proved a stumbling block, especially in biology. For example, in seed germination they would draw a real-size diagram of the seed or if they draw an enlarged diagram, it will be disproportionate. Microscopic observation was a special experience in more than one ways. It highlights one important aspect of the training. Everyone of us tends to draw something on the basis of its image imprinted in our minds rather than what we actually see. No matter which leaf it is, we tend to draw a typical a leaf.

It is here that the meaning of 'observations' gets clarified. The importance of noting observations faithfully was repeatedly stressed and was one of the important aspects of training.

The next step was even more problematic: reaching a conclusion through group discussion. This was where the trainer ideally played the role of a facilitator. The teachers were expected to collectively discuss the observations in a logical manner to reach a conclusion.

Again, this was an unfamiliar and laborious process for them. It included listening to and understanding one another's arguments and explanations, analysing them on the touchstone of logic and reason, reviewing one's own observations in the light of new observations and reasoning, modifying one's findings, and then figuring out ways to test and consolidate the conclusions that emerged. There was always the danger of taking short cuts of taking recourse to received wisdom, which even some resource persons tended to fall prey to.

The responsibility of moderating the group discussion was usually given to a resource person. The first step was to list the observations of all the groups on the blackboard, pinpoint out-of-the-ordinary observations, discuss them to find their underlying reasons and, if necessary, repeating the experiment.

Once this process was completed, the explanation seemed obvious. Sometimes there could be more than one explanation. In such cases, each explanation was carefully scrutinised and then applied in another context to see if it answered all the questions. For example, if the explanation is correct, what would happen in such-and-such situation? Very often these would be thought experiments. But they would also often be experiments that one could carry out to confirm what happens. Before doing the experiment the expected observations would be listed, after which the experiment would be performed to confirm the results. In this way the class would move forward, exploring different facets of scientific methodology.

This part of the training was fraught with difficulties. After doing the experiments teachers expected the conclusions to be dictated to them. Or, at the very least, they expected to be told whether their conclusion was right or wrong. None of these happened; the resource group would remain firm in its resolve: the teachers had to decide for themselves whether they were right or wrong. It was never easy to convince them of this process and they always complained about not being given the answers.

The process moved ahead in this stumbling way, one step forward, two steps backward, often unsure, deviating from course without a clear way forward. It appeared a waste of time to those habituated to treading the path fixed by the textbooks. But what was surprising was that most teachers started enjoying it and discovering things for themselves. They would totally immerse themselves in doing seemingly simple experiments that they would otherwise have considered boring.

But a balance had to be established. The resource group had to take a call on how far the teachers could pursue the 'discovery approach'. They had to assess when a dead end was being reached to prevent frustration setting in. This was often not an easy decision to make. It had to be situation specific. But it was a decision the teachers would also have to make in their classrooms, the bottom line being that as much scope as possible be given to unravel every layer of 'discovery'.

Some other processes

The teachers were periodically evaluated during the training. The purpose was not to grade them but to find out where they stood and where they needed more help. Of course, the questions posed during every session did give some indication on a daily basis. But special tests were also periodically conducted in the case of especially difficult concepts. Teachers had to answer 'mini' questions, which often proved to be 'extra long'. These questions were structured in such a way as to assess understanding of basic concepts. After each such assessment, responses were discussed with the teachers and this sometimes led to revision of parts of the chapter.

The training usually ended with a practical examination that had two objectives. One was to assess how far the teachers had developed their experimental skills. The second was to expose them to practical examinations because 40 percent of the marks allotted in the HSTP annual examination were for the practical examination.

The open-ended nature of the discovery approach often led to the teachers asking questions not directly linked to the topic under study. The fear in such cases was that the discussion could go off on a tangent and disrupt the training. Sometimes questions were also asked about the HSTP and its methodology. These were usually postponed to special 'doubt clearing sessions' organised every weekend.

The way in which evaluation was done in the HSTP and its purpose was quite different from the traditional examinations. That's why the training focused on familiarising the teachers with all the aspects of examination. The 'mini' questions and the practical examination gave them a feel of the type of questions asked in an HSTP examination. But special sessions were also conducted for question paper setting. The teachers were expected to prepare questions to test conceptual understanding and assess skill development suited to an open-book examination, not an examination geared to bringing out memorised information. Each group made its set of questions, which were then discussed and assessed by the entire class. The discussions also touched upon the purpose of examinations, achieving balance in a question paper, redistribution of marks and so on (discussed in a later chapter).

One important daily activity in the training was reading and discussing the previous day's report. The teachers would take turns to write and present these reports, the idea being to provide feedback on the activities in each daily five-hour session. This did happen to some extent. Unanswered questions were noted down. So were comments about the way the resource person conducted the sessions, as well as comments about fellow teachers and different aspects of the HSTP.

Unfortunately, the reports seldom went beyond a factual report of the previous day's happenings and saying nice things about the resource teachers. Possibly, that's the way the teachers actually felt, but the more likely explanation is that they saw criticism as being synonymous with condemnation. So they tended to refrain from criticising others. As a result, you had reports written in verse or embellished with similes, but this did not develop into a healthy tradition of providing critical feedback.

Feedback sessions

The resource group would sit every evening during the trainings to collectively review the day's happenings. This was a healthy tradition. The day's class would finish by around 1 pm and the resource group would get a bit of free time till around 2 pm for lunch and some relaxation, after which they would attend the feedback session, usually scheduled for 3 pm. The sessions could be tortuous in a place like Hoshangabad, where afternoon temperatures in May-June cross 40^0 C. But they would take place nevertheless. Trainee teachers were welcome to these sessions.

The feedback from each class would be collected and presented by a person specially appointed for the purpose, usually a volunteer. (S)he was expected to describe and review the day's proceedings, including the role played by the resource person. Important questions raised in class were also noted down. The report would then be discussed collectively. There were times when this reporting turned into feedback reporters vs. resource group duels but these sessions enriched the trainings. They provided a basis for the resource group to tailor the daily sessions according to requirements, to further clarify difficult concepts or try out new ideas that emerged. In a way they were an extension of the daily training, where the resource group was engaged in training itself.

The feedback system was a mixed experience. For example, there were its 'human' aspects. Whenever a feedback reporter raised a question about the role of the resource team, the entire team tended to spring to the defence. At times there were personal insinuations. Many a time, there would be widely different assessments of the same class or process. Such differences also arose because the feedback reporter would have no clue of what the resource group was looking for, and (s)he thought the role played by the resource person was devoid of any purpose. The defensive attitude of the resource persons became more pronounced after the resource teachers took over the responsibility of conducting and leading sessions. This was also related to their confidence levels.

Another problem with the feedback sessions was time over-runs. Having 6-7 to 8-10 classes during training was the norm. If half-an-hour per class is taken as the average, the feedback session required 3 to 5 hours every day, which meant they went on to well past 6 pm. The resource group then had to prepare for the next day. So the resource persons ended up working 11 to 12 hours daily during the 18-day training course. In the early years no one even considered taking a day off on Sundays. That's something the teachers still remember with fondness and pride.

Training the feedback reporters was yet another challenge. Most of them were enthusiastic young volunteers who had to be instructed on what to focus on and what to ignore in the classroom. They were expected to write their reports in the couple of hours of free time before the feedback session began. Many times subjectivity came into play, with assessments of the same class or of various procedures ending up being different. It was heartbreaking for them when much of what they wrote was dismissed as irrelevant.

So an attempt was made to streamline the feedback system. All the reporters would meet before the session and, with the help of a moderator, select the main feedback points to be presented. While this did help, most felt the sessions had become less enjoyable. One more attempt was made. The reporters were included in the resource group. The hope was that the group would help vet the reports first before they presented in the feedback session.

From all these efforts one thing is clear: feedback was considered very important and every effort was made to ensure that it was meaningful, and organised in a positive atmosphere.

Expanding programme, evolving training

When the HSTP was in 16 schools, the resource group attracted lecturers and professors from universities and colleges and scientists from various research establishments. A noteworthy feature of the training sessions in those days was the way in which topics for study and discussion would unravel layer by layer, with questions and counter questions being posed, new experiments being designed on the spot and the links between concepts being established.

The responsibility for teacher training remained with this group at the time of the district-level expansion. But some of the more enthusiastic teachers were welcomed into its fold. These resource teachers played a limited role in the training, mostly helping in the group activities. This included guiding the trainees in doing experiments, answering their questions, and encouraging them to voice their opinions in the group discussions. The responsibility for coordination continued to rest with the resource group.

Further expansion was a given objective for the HSTP, and various aspects of such an expansion were discussed continuously. A new model for expansion was formulated in 1982-83 with the formation of Eklavya.

The model, which again had the School Complex concept at its core, envisaged a phase-wise expansion, the first phase being an entry into all the districts of the Hoshangabad, Ujjain and Indore education divisions. The way this would be done was to seed a School Complex in each district and to use the resources developed in these School Complexes as a foundation for expanding to other schools in each district. So the target was to have the HSTP running in all schools across 14 districts within a few years. Any subsequent expansion would also proceed in a similar manner.

A rough assessment of the practical implications of the model showed that teacher training would be the major requirement in expanding the HSTP. This was a monumental task, given the large numbers involved and the short time span available. One rough estimate put the number at 20,000 teachers to be trained every year over three years in the 14 districts. This was far too big a task for the resource group to handle.

The solution lay in handing over the training to the resource teachers. How successful this transition would have been is anybody's guess, but what is clear is that teacher training is a major challenge for any educational innovation of this scale.

A pilot run was conducted in a teacher training camp organised at Indore in 1987 to judge whether the resource teachers were capable of conducting the training themselves to assess the viability of the transition model. The teachers were given the responsibility of coordinating classroom processes for the first time. Of course, an 'expert resource person' was always on hand to help out. Helping out meant the expert would discuss how to organise the classroom and its activities, think about alternative strategies and take a more active role in case of emergencies.

It is important to analyse the experiences of this and subsequent teacher training camps as this will provide insights into the process of scaling up.

One thing was evident in the performance of the resource teachers. They were well versed in the *Bal Vaigyanik* curriculum and had internalised its philosophy. So they could teach any of its chapters in an organised and structured manner. They also had the expertise to perform every experiment and getting others to do them. They understood the safeguards to be observed while performing experiments, the expected observations to be made, sources of errors, and so on. So training teachers to teach *Bal Vaigyanik* was not a difficult job for them.

But there was one shortcoming. Most of them taught *Bal Vaigyanik* in a mechanical manner. They trod a beaten track: perform experiments, get everyone in the class to respond to the questions asked in the workbook, arrive at the correct answers and then go on to the next experiment. They avoided dilly-dallying, side-tracking or thinking at a tangent. Their argument was that teachers who come for training must perform all the experiments and know the answers to all questions asked in *Bal Vaigyanik* if they are to fulfil their teaching role. So time should not be wasted in useless pursuits. In other words, there should be one-to-one correspondence between teacher training and what teachers are expected to do in the classroom.

They saw 'teaching' *Bal Vaigyanik* (performing all the experiments and getting all the answers) as their main, if not the only, task.

If a question, which they thought was unrelated to the topic, was raised in class, and if the trainees insisted on getting an answer, they would bring in the 'expert'. The trainees were quick to catch on that the resource teachers preferred staying within the ambit of *Bal Vaigyanik,* so they would deliberately ask such questions. Since the trainees knew that the expert was always around to take over, they tended to look to her to solve problems that arose. Many times the resource teacher would also show such an inclination. This usually tended to upset the classroom equation by creating an unhealthy power hierarchy.

The 'staying on course' problem was often discussed in the feedback sessions. The main criticism was that the resource teachers deliberately curtailed a healthy discussion, or declared a teacher wrong even if she was proceeding on the right track, or stopped the discussion as soon as the correct answer was obtained. In a way, the problem could be seen to arise from the limited understanding of 'science' among the resource teachers.

We had earlier pointed out that teacher training was a continuing activity. Three HSTP activities – follow-up, monthly meetings and the *Hoshangabad Vigyan* bulletin – complemented the training to ensure continuity.

Follow up

The system of follow up was established in schools early in the programme. It was important for two reasons. First, teachers often encountered many kinds of problems while teaching and required on-the-spot help. Second, follow up provided feedback on problems in implementing the programme and its materials.

In the beginning resource persons went on regular follow up visits to the schools. Later, higher secondary school teachers, Assistant District Inspectors of Schools and headmasters of middle schools were included in the follow up group, which came to be known as the operational group. Later, some middle school teachers were also included to undertake follow up and gradually they became the major constituent of the operational group.

The operational group, set up in 1977-78, was expected to perform several roles, especially follow up and, later, teacher training. It had no formal structure and no defined criteria for inclusion of teachers. Basically, teachers who had internalised the HSTP spirit, were talented and enthusiastic and could train other teachers qualified for inclusion.

The HSTP had drawn inspiration from the Kothari Commission report in setting up many of its structures, including the *Sangam Kendra* and school complex. The *Sangam Kendra* centres were given the responsibility of chalking out and implementing the follow up plan for their school complex. They were set up in every block of Hoshangabad district (and later Harda district), each linked to around 50-60 schools. In the other districts, each centre took up the responsibility of 7-8 schools.

The *Sangam Kendra* was visualised not just as an administrative unit. It had an academic function as well, with higher secondary school lecturers within the School Complex providing academic support to middle school teachers. Quite naturally, these lecturers were given the follow up responsibility as well.

The *Sangam Kendra* also had to review and analyse the follow up reports and prepare the agenda for the monthly meetings. This was a job that was earlier done by the Science Cell set up at the Divisional Superintendent of Education office. But the arrangement was found to be impractical, so the *Sangam Kendra* got the responsibility by default.

Unfortunately, the high school and higher secondary schools never did accept the follow up idea whole-heartedly. Any of their faculty going twice a month on follow up visits was seen as an extra burden and interruption. As a result follow up was sidelined and became an irregular activity.

There was another – and stranger – problem with follow up. The HSTP saw follow up as an academic activity to help teachers and gain academic feedback. It was distinct from inspection. But many middle school teachers began to complain that the higher secondary school lecturers who came to their schools were mostly ignorant of the needs of the HSTP classroom and curriculum. So they could not really help them out in any way when they faced problems. They also complained that some of the lecturers who came on follow up saw their visit as a kind of school inspection, so they tended to behave officiously rather than being helpful.

These two drawbacks led to the inclusion of more and more middle school teachers in the operational group. But, here again, the experience was not too encouraging. For one, it was difficult for teachers to leave their teaching for two days every month to help out in other schools. The problem was aggravated by the chronic shortage of teachers in most schools.

That's why even though follow up was seen as a necessary and useful activity, it was the first to falter. The system continued to deteriorate, with administrative problems – delays in getting daily and travel allowance – adding to its woes.

Another reason for the decay was lack of understanding. Follow up was a new activity for the educational system, undertaken for the first time in the HSTP. The administration saw it as a useless and superfluous activity. The general attitude was that once teacher training was over and done with, there was no need for continuing support in the form of follow up or monthly meetings. The argument was articulated in the form that need for continuous follow up implies some shortcoming in the initial training. It should be noted that till very recently, a teacher would join the cadre after training and would never look back.

They got no further support even if the curriculum or textbook is changed. (Neglect of this aspect in teacher support is a cause of concern.) More and more information is packed into the textbooks in the name of information explosion. Yet no attention is paid to equipping the teacher adequately for the task. This is an irony. Actually, even if the curriculum remains unchanged, teachers require continuous help and support.

As was pointed out earlier that self-learning deeply affected their enthusiasm and motivation levels. When these are absent, the teaching process is in danger of becoming mechanical.

The follow up persons mostly never had a clear idea of what was expected of them. Attempts were made to train them in *Bal Vaigyanik* curriculum and to familiarise them with every detail of the follow up process. They were given supplementary tasks such as evaluating children and so on to be completed during their visit to the schools. Even proforma for follow up report was developed, but it, too, did not help significantly. Hence, in the final analysis, follow up remained a limited exercise lacking depth.

Monthly meetings

The second platform for continuous teacher training was the monthly meetings. Every month each *Sangam Kendra* would organise a meeting of teachers in its School Complex. After the district-level expansion, 11 meetings were organised every month, their number going up to 23 when the HSTP spread to other districts. Not all the teachers participated in these meetings but around 1-2 teachers from each school attended, depending on the staff situation in their schools.

The main points selected from the follow up reports formed the discussion agenda for these meetings. They were mostly problems that remained unsolved during the follow up visits or problems that had relevance for other schools, although they might have been resolved during the follow up visit. Teachers also got the opportunity to share and try out new ideas and experiments they had devised. Thus, monthly meeting was also a forum to disseminate innovations taking place at the school level.

The purpose of these meetings evolved over time but they always served as a dynamic forum for teachers and resource people to continue an interactive dialogue. In fact they could be looked upon as a strong and vibrant effort to mould the teachers into a professional academic group.

Expectedly, as the follow up process weakened the character of the monthly meetings also changed. This was the period around 1983-84. Fewer academic discussions were taking place and a stage was reached where the only issues discussed were the problems of kit replenishment and payment of travel and daily allowances. There is no denying that these were important issues. But it became a matter of grave concern for the resource group that the problems faced by children, the questions they raised, academic stumbling blocks or other subject related topics were not figuring in the agenda.

The resource group decided to step in. It began selecting topics to include into a common agenda for all the *Sangam Kendras*, over and above the issues emerging from the follow up reports, to stimulate discussion. These were mostly linked to *Bal Vaigyanik* chapters. The idea was to help the teachers get a more in-depth understanding of the content and sometimes just to revisit a chapter. Different aspects of the HSTP curriculum were also shared with teachers. This move did breathe new life into the monthly meetings but it also led to greater centralisation in their planning as a result of which classroom issues tended to get sidelined.

A fresh attempt was made to address this problem. This effort involved organising a preparatory meeting of *Sangam Kendra* in-charges and 1-2 operational group members from each *Sangam Kendra*. Thus a group of around 30-35 teachers used to come together to chalk out an agenda and make necessary preparations for the monthly meeting to be held subsequently at the respective *Sangam Kendras*.

Helping in this preparation now became the main work of the resource group. But some resource persons continued to attend the monthly meetings, playing the same role they were playing in the decentralised teacher training camps. One positive outcome of this new form of monthly meetings was that more discussions of academic issues began taking place while space still remained for discussing local issues.

All in all, the monthly meetings did serve their purpose as a vehicle for continuous training of teachers. They were also helpful in encouraging teacher participation in different aspects of the programme. These meetings also provided a forum for teachers to voice their problems and grievances. However, the main contribution of monthly meetings was as a forum for academic exchange and peer interaction among teachers to voice their problems and grievances. They also helped encourage the teachers to get more involved in other components of the HSTP.

Hoshangabad Vigyan bulletin

The third component of continuous training emerged in the form of a bulletin called *Hoshangabad Vigyan.* The magazine was visualised as an in-house journal of the HSTP for exchange of ideas and information. Its publication began in 1980, three


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years after the district-level expansion, and continued more or less regularly.

The publication served a dual purpose. It became a notice board to carry information and notifications about the HSTP. It also served as a forum for discussions on education and related matters. It also became a forum where the teachers could frankly express their opinions. The HSTP group had to make special efforts to make the latter possible.

Government employees are not usually permitted to express their views (especially critical views) in the media. That's why the Directorate of Public Instruction (DPI) had to publish a special notice permitting teachers to contribute freely without fear of retributive action.

Training of resource teachers

Orienting the teachers in a radical innovation like the HSTP was a major challenge. As mentioned earlier, in the initial stages they were trained and oriented by the resource persons who came from universities, colleges and research institutions. These 'experts', with an in-depth understanding of their subject and a confidence, were capable of fostering an open environment for discussions during the training camps and monthly meetings. They would come up with new ideas and experiments on the spur of the moment or argue with logic and reason. In fact, the format of training camps in the initial years (1972-77) was somewhat different. These sessions, apart from preparing teachers for the classroom, involved developing syllabus and textbooks, trying to evolve the examination system and so on. So there was always a healthy exchange of ideas on different aspects of the HSTP.

With the rapid expansion of the HSTP, the resource group soon proved to be too small for the task. That was when the idea of creating an operational group comprising school teachers was conceived.

The question often asked is: How were teachers selected for the operational group? It is difficult to give a straightforward answer because there never was any organised method or criteria for selecting them. During the teacher training camps, monthly meetings and follow up, some teachers would be shortlisted, based on their understanding as well as their level of commitment, interest and participation. They would then be included in different forums and programme activities, such as setting and reviewing question papers, teacher training, coordinating monthly meetings, etc. Participation in these activities was the criteria of selection.

A point worth noting in this process is that whether it was teacher training or question paper setting, special attention was paid to creating an environment that encouraged participation and commitment, where the teachers could contribute to the best of their ability and hone their skills and talents. There were so many different roles, and every role given due respect, that everyone got to show her/his best.

We saw earlier the kind of problem which arose when these operational group teachers, who had earlier played a secondary role in teacher training, were asked to take the leading role as resource teachers. The main problem being that they 'completed' *Bal Vaigyanik* in a mechanical way. Such mechanical 'completion' of *Bal Vaigyanik* did not prepare the trainee for their expected role in the classroom. Moreover, further dilution inevitably occurred during classroom teaching.

This was a matter of great concern for the resource group. Training had always been seen as a way of acquainting the teachers with the basic spirit of HSTP and its methodology and the romance and joy of doing science. It was not limited to making them adept in transacting *Bal Vaigyanik* in class. They were also encouraged to think about pedagogical issues like how children learn.

In sum, the training sought to introduce the HSTP innovation to them not as a product but as a process in which they themselves were participants. A mechanical interpretation of *Bal Vaigyanik* could never fulfil this wider objective.

This lack of a wider perspective among the resource teachers had serious ripple effects when the trainees returned to the classroom. They, in turn, often failed to enthuse the students to change their attitude to learning.

The need to broaden the vision of resource teachers was keenly felt. This started the process of resource teachers enrichment training. It was essential to analyse the problems and identify the shortcomings in order to plan and design this training. The main question was why were resource teachers not able to take up their new role in the right perspective?

Some resource teachers felt that one such point was when the trainees began asking all sorts of questions. Very often they did not know the answer. So they would curtail the discussion to ensure that it did not get diffused or go "off track". The end result was that the discussions ceased to be open-ended. According to them, a simple way to resolve the problem was to list out such questions by viewing previous training reports and explain the answers to the resource teachers in advance. But that looked to be an impossible task because one cannot anticipate all such questions.

However, others felt that all such questions cannot be anticipated. In that case, every new question would put us back in the same spot. Therefore, it is better to concentrate on the process of finding answers. It was felt that the major problem the resource teachers faced was that most of them have not formally studied 'science' much and they do not have a rich repository to fall back upon. They needed enrichment in the subject content.

That's how the idea of training the resource teachers by conducting sessions with them on selected science topics gained ground. These special training camps began in 1995 and many were organised during the lifetime of the HSTP. Around 100 resource teachers benefitted from them.

The idea was to develop study packages on fundamental scientific concepts. These included atoms and molecules, ionisation, electricity and electronics, basic life processes and systems, cell structure and heredity, force, pressure and so on.

Another idea mooted was to develop a correspondence course for teachers on such topics but the idea never took off.

Challenges facing innovations

The Ganguly committee found the HSTP teacher training to be very effective, pointing out that the training, follow up and monthly meetings were based on sound educational principles. It interviewed many of the HSTP teachers and found that those who benefited most from the training and were the most enthusiastic were those with little formal science education. It also accepted the need for continuous training and support for teachers.

The committee expressed the view that the future success of the programme depended crucially on maintaining the quality of this professional development of teachers, at its present level.

In the Pipariya meeting referred to earlier, the teachers also commented on how successful the training methods were, although how many of them actually grasped the spirit of the programme is open to debate. Halkevir Patel, a teacher who had been with the HSTP since 1972, felt that the percentage could be between 50 and 60, while another teacher Prem Shankar Bhargava felt it was around 40.

Preparing teachers for an innovation like the HSTP will always be a major challenge. We have already outlined the various efforts made in the HSTP in this context. The important thing is to spread its innovative spirit on a wide scale and that requires creating the proper structures and processes. The HSTP experience shows that the best way of doing this is direct interaction between the teachers and the experts. This dialogue strengthens the belief of teachers in the innovation, and also enriches the programme.

But how far is it possible to adopt such an approach? Traditional teacher training approaches have four mediators between the planners and the teachers. The HSTP began with direct dialogue between the resource group and the teachers in the initial stages and added another link with the formation of the operational group. Even after that the resource persons continued to attend the training camps. So there was always a direct link between the teachers and the programme.

But there was one input in teacher preparation that hasn't been mentioned till now. We have talked about various aspects of innovation related to the content and methodology of science. But innovation is more than just that. Two other aspects are important. First, innovation should also focus on the essential nature of science, and, second, it should focus on education in general. Possibly, both these aspects were woven into the HSTP and its different components, including teacher training. However, no organised effort was made to address them directly.

Another important aspect is about developing strong links between all participants in the HSTP. Good science teaching (or good education in general) demands that these links are based on democratic principles and equality. The HSTP nurtured these principles, so a culture developed (it would be wrong to say 'was developed') in which efforts to reduce inequality between students and teachers, among teachers themselves, between teachers and the resource group, between the resource group and the educational administration and between the teachers and the administration were inbuilt. This culture was so well integrated in the HSTP that it defined its every interaction. The teachers felt it and reacted positively to it. Bharat Poorey describes it in these words:

> "An open environment and a chance for everyone to participate. Participation implies being able to voice one's opinions, being listened to with respect by others, having animated group discussions, and so on."

And what were the outcomes of this massive investment in teacher training and orientation? No organised study has been undertaken to assess the benefits. Whatever one can say can be said only on the basis of feelings, observations and experiences of the participants. The outcomes can be seen from different perspectives.

If seen from the angle of an understanding of science and the syllabus, then some limited studies show that the understanding of basic concepts in science was far superior among the HSTP teachers than other teachers. It also goes without saying that these teachers were better equipped when it came to experimental skills and understanding the elements of the scientific method.

As far as peer relationships were concerned, their spontaneous participation and reasoning abilities were clearly evident in monthly meetings and other forums. Whether with resource persons or administrative officials, the teachers were able to converse without fear or hesitation. Sometimes, they were said to be too outspoken, which became a reason for criticising the

HSTP.

When middle school teachers were first made resource teachers, other teachers reacted negatively. But eventually the ability and expertise of these resource teachers convinced them that their peers can become resource persons.

A similar stand-off existed initially between the middle school teachers and the high school teachers. As one teacher who had been with the HSTP from the beginning put it,

> "The higher secondary school lecturers who were initially members of the operational group could not accept the fact that LDTs [lower division teachers] from middle schools could be their equals. When LDTs were given the responsibility of conducting classes during the training and the lecturers had to assist them in the classroom, they just could not take playing this assistant's role."

The HSTP resource teachers subsequently began training teachers in other states as well.

In fact, the most significant outcome of the intensive teacher training efforts made in the HSTP was the emergence of a group of academically professional teachers. Shashikala Soni expressed this best during the Pipariya meeting (August 2006) when she said,

> "The HSTP created a platform for teachers and gave them recognition. Even today, when the HSTP teachers meet they are linked by a common bond."

Most teachers present in the meeting agreed with her.

The evolution of such a group holds out the promise of newer possibilities in future.

16

CLASSROOM EXPERIENCE

We have discussed the kind of innovative efforts the HSTP made: *Bal Vaigyanik* workbooks, teacher training, the kit, teachers' guides, Sawaliram, follow up, monthly meetings, etc. We also analysed these efforts in detail. But somehow we ignored the children for whom all this intensive work was undertaken. Their absence in the narrative may have struck a discordant note for some of our readers. So we shall try to draw a picture of an HSTP classroom in this section even if the vision of an ideal classroom may have emerged and become evident by now.

Groups

Broadly speaking, all children in the classroom work in groups. The teacher first provides a backdrop for the lesson, or begins with an experiment or experience to introduce the topic. Each group works independently and maintains a record of its own observations. If they face a problem, the teacher helps them out. The problem could be in performing the experiment or recording the observations. It would be better still if the teacher puts up some questions in the groups and gets them thinking. Whenever necessary, children go on field trips with the teacher to collect samples and specimens for study and to observe their natural habitat.

After the experiment is done, the teacher notes the observations of each group on the blackboard. During the group discussions that follow, attention is drawn to wrong observations and, if necessary, the experiment is repeated. Once the teacher is satisfied, a common explanation of the observations is arrived at, with each child being given the opportunity to present her explanation or question the explanations of others. Gradually, the class comes to a collective understanding and conclusion. Children are expected to note not just the final conclusion in their exercise books but a summary of the discussion as well. The teacher makes an attempt to ensure that the conclusion drawn is linked to the daily lives and experiences of children. This would provide a background for the next experiment.

The question is: how far does this ideal process reflect in reality? Comparing what happens in a real classroom with an ideal or typical classroom is a bit of a problem. This is because the HSTP sees the classroom as a living forum that is open-ended and its contours are determined by the local milieu, the textbook, the teacher and the children. So it is natural to ask whether it is necessary to perform all the experiments in *Bal Vaigyanik* or answer all the questions in a logical sequence if the programme is to be successful. Probably not.

So from what perspective should one view the classroom? Is it more useful to see to what extent the different benchmarks in the HSTP learning methodology are being observed and achieved? However, is it easy to recognise and judge elements like development of independent thinking, experimental skills, scientific attitude, a questioning attitude, readiness to consider the opinion of others and abstract thinking, etc.? Don't these elements depend on a wider context? Given such questions, it is difficult to assess an HSTP classroom.

Innovation and resources

Several attempts were made to find out and understand what actually happens in an HSTP classroom, which, to some extent, were quantitative. There are two aspects of the reality. The first is the availability of resources and systems, and the second is how the class was conducted. For example, a major problem in the first few years after the district level expansion was the availability of kit material. This problem became acute after 1982 but the situation saw some improvement subsequently. Storing the kit material in schools was also a serious problem because, for many years, the government did not provide almirahs for the purpose.

Another resource problem was the availability of trained teachers. Many of them were routinely transferred or promoted, so this led to a shortage of trained teachers in many schools every year. That made training of new teachers an annual necessity.

There was one more problem: lack of adequate space in classrooms. This is a problem common to all subjects, but it was more serious for the HSTP because the methodology required children to work in groups performing experiments. Teachers often raised the problem of numbers in the classroom, with some schools having as many as 80-90 children in a class while some others had barely 7-8 children.

One special arrangement made for the HSTP was that instead of having a period every day, two periods were clubbed together thrice a week for teaching science. This was done because it was difficult to distribute the kit, perform experiments and conduct discussions in a 30-35 minute period. Clubbing two periods together gave more time. So the headmaster was requested to allot the two periods, preferably just before or after the break so that a little more time would be available for distributing the kit etc.

If we look at what really happened in schools, this arrangement was in place in a little more than a third of the schools, despite sincere attempts to implement it well. The headmasters pointed out that if two periods were combined every alternate day for science, then two periods would have to be combined for some other subject on the other days and most teachers did not want such an arrangement for any other subject. The HSTP teaching suffered wherever this arrangement could not be implemented.

Classroom management

We now come to the second aspect – classroom management. A couple of surveys showed that children in around a third of the schools did all the experiments themselves. Even fewer schools were able to conduct classroom discussions effectively to arrive at common conclusions. And even fewer were the number of schools where children were able to write down their own answers.

For obvious reasons, the HSTP classrooms were fairly diverse. Teachers adopted their individual ways to manage these classrooms, which were quite different from the traditional classroom. The standard method used in a traditional classroom is to read the textbook aloud. At most, the teacher would pause at a few places to explain or clarify things.

The best record we have of the HSTP classroom is the follow up reports. Written by the resource persons and follow up teachers, they do not contain detailed descriptions of classroom proceedings but a broad picture does emerge. One of the basic drawbacks of these reports is that they focus more on administrative and implementation aspects of the HSTP and less on drawing an overall picture of the classroom or describing the dialogues taking place therein.

Apart from the follow up reports, many teachers were also requested to jot down their classroom experiences. Some of them wrote their experiences in considerable detail and sent them to us and these reports proved especially useful in identifying the status of various elements in the classroom and coming up with an overall picture.

A meeting was also organised with teachers in Piparia to get their views, while some teachers were interviewed individually.

After the HSTP was shut down, a study was planned with teachers, students, past students and parents but it was never carried out. However, a pilot study undertaken in 2003 to prepare for the bigger study provided many significant insights, which put together useful quantitative data on different aspects of the HSTP such as teacher training, *Bal Vaigyanik*, the teaching methodology, etc. In addition, many in-depth interviews were also conducted.

The picture that emerges from all this data is mixed. Although it isn't appropriate to break up the HSTP methodology into discrete fragments, this is what happened. Are experiments being conducted or not? Are children working in groups? Are discussions taking place or not? Do children write answers to questions themselves or not? Are correct concepts derived or not? Are field trips undertaken or not? Are long-duration experiments conducted or not? It should be clear that it is a combination of these elements that constitute the HSTP methodology. There is no compulsion that all these elements should be in evidence in every 70-minute period. What is demanded is that children interact with their environment and discover things by doing experiments. Hence classroom assessment should be done keeping in mind this overall perspective and not on the basis of what proportion of each element is present or not.

For example, many follow up reports point out that experiments are not performed in groups, or children don't do experiments themselves but watch the teacher demonstrating them. It is not necessary that this is something negative. What should be assessed is whether this is happenning constantly and whether children are being deprived of a key element of the scientific method (doing experiments).

There was considerable discussion on this aspect in the Pipariya meeting. Most of the teachers observed that over a period of time there sets in a lassitude in doing experiments. There was no agreement on the reason for the loss of interest or since when did it begin to occur but most teachers felt that the deterioration was especially marked in the decade of the '90s. There was also disagreement on how bad things were. One teacher (M. L. Patel) pointed out that he taught in both ways because of pressures of completing the course. In some chapters he would bypass the experiments and get children to directly write answers to the questions posed. Another teacher (Halkevir Patel) went to the extent of saying that he adopted this approach from as far back as 1973. One view was that the situation was especially deplorable in private schools.

Probably, teachers refrained from doing difficult experiments, or experiments in chapters they thought were difficult. For example, one teacher Shobha Vajpayee writes, "In the beginning I could not conduct the test for protein in food substances either because the required material was not available or because there were problems in making a 2 percent or 10 percent solution."

A survey conducted by Eklavya (2000) revealed that the ideal of all children performing all experiments and drawing conclusions after discussing their observations was to be seen in very few schools.

But wherever the system worked well, it had many important impacts. For example, Shobha Vajpayee relates: "The chapters were done completely experiment-based and different kinds of material was used in them. Groups sat separately to perform experiments and recorded their observations. Normally, I used to prefer scheduling science as the last period since it gave a bit of extra time for study, sometimes after the school was over. Even after the other classes would be dismissed for the day, children continued to work in the science class with a lot of interest and enjoyment. One child would be in charge of distributing and returning the kit material and the children in every group took turns to organise and collect material from the kit almirah for their group. If some material had to be brought from home, each group brought what it required. Or else one or two children would bring what was needed and distribute it among the groups. Children became so expert in doing experiments that everything was carried out without a hitch. Learning in such an environment helped make my ties with the children stronger and relaxed. We often felt this enthusiasm and experience reflecting in other subjects and activities. Children enjoyed learning. All this helped them in their future. The methodology made them so adept that in many other instances as well I saw them doing things in an organised way – making preparations for work, taking responsibility during and after completion of work."

A follow up report of a school in Sohagpur (February 1983) reveals that not only were children doing experiments in an organised manner, but were understanding things through mutual discussions. "The teacher had begun the 'Measuring Distance' chapter. She proceeded through questions 1 to 7 (discussions and some experiments). She got the children to play *gilli-danda* and measure the distance with the *danda* and also got them to measure the depth of a well with a rope. The girls enjoyed doing these activities. They copied the figures the teacher was writing on the board without being told to do so. The learning process seemed so natural…

"In Class 8, a discussion was going on about 'Time and the Pendulum'. It was obvious that this chapter had been done in great detail. There was some confusion about how changes in the length of the string affected the period of oscillation. One girl very confidently repeated the experiment and confirmed her results."

We see another example of such organised functioning in a school in Dhar (February 1988): "The teacher was doing the 'Separation' chapter. The students were sitting in groups. Each group was given a beaker, filter paper strip and wire. A girl in each group put a drop of ink on the filter paper. One girl filled the beakers of all groups with water. The experiment then began (with the strip being suspended in the beaker of water). Madam told the children to remove the strip from the water once it was soaked up to the wire and let it dry."

Or take a glance at an urban school in Dhar (September 1988):

"The chapter was 'Acids, Bases and Salts'. All the required solutions were on the teacher's desk. The table for the observations was drawn on the blackboard and children were told to copy it in their exercise books. Then a child from each group was called up in serial order to do the experiment and the observations were shared with all the students...

"For the chapter 'Making Maps' the teacher directed the children to draw a figure on the floor. A sheet of paper was pinned in the centre of the figure and its outline was drawn with chalk. A point of origin was chosen and marked with a pin. A series of points numbered 1 to 8 was then marked on the perimeter of the figure. Children used a string to measure the distance to each of these points from the point of origin and then marked their direction on the paper."

When experiments are done in an organised way, children are enthusiastic, which is a precondition for learning. Speaking at the Pipariya meeting, Shashikala Soni pointed out: "I would get children to do the fly lifecycle experiment in the chapter 'Life Cycle of Animals'. They would shriek with joy when they observed the fly emerging."

Or take the experience of Umesh Chauhan, a teacher from Timarni: "Children filled pots with water and put frog's eggs and some aquatic plants in them to observe how tadpoles developed. Seeing tadpoles forming from eggs and developing into frogs over 23-24 days was an experience full of curiosity for the children. The day frogs with tails jumped out of the pots onto the floor children also jumped in unison. They drew diagrams in the serial order of the developmental stages they had observed. Even I saw the development sequence from egg to tadpole to frog for the first time."

That children made every possible attempt to ensure that they did the experiments correctly can be seen in this example from an urban school in Dhar (January 1987): "The chapter being taught was 'Sound'. The teacher asked one child to read the chapter aloud. Children were then asked questions about experiment 1. Their answers were based on what they had seen — that the bell vibrates when struck with a hammer and the vibrations stop when you touch the bell with your palm. The same experiment was repeated, using a scale to beat a brass pan (*patilee*). Students touched the edge of the pan with their fingers and said they experienced a tingling feeling. For experiment 2, some water was filled in the pan and the students were made to stand in a circle around it. The teacher tapped the edge of the pot with a finger and asked children to observe what happened on the surface of water. Tiny waves were being generated on the surface, but not clearly enough for the children to see. Even the teacher was not too satisfied. So she asked a child living near the school to get a brass *thali* from home and the experiment was repeated. Now the waves were clearly visible."

Children quickly learn to be patient and persistent, as Shobha Vajpayee observes: "In the chapter 'Why Do Things Float?' it is important to weigh the objects and water several times. Children used the balance and weights they had made in the 'Principle of the Balance' chapter to weigh. One can't help but appreciate that even after using equipment they had made themselves, their final results were more or less correct. They learned to wait patiently for the last drop of water to drain from the overflow vessel to find out the volume. They also taught me to be patient, saying, 'Wait madam, another drop of water is about to fall.'"

But read what she has to say about what happens after children perform these experiments with such care and attention: "When doing the experiment I had told children to do the relative density calculations later at home. Watching them do the experiment and note down the data, I felt the chances of going wrong in calculating the relative density were few. They had made their weighing balances so skillfully and were so patient while doing the experiment. But when I saw their calculations my head spun. Their answers were in tens and hundreds. These children who were so capable in science were weak when it came to maths. Whether calculating the average from a graph or the average period of oscillation, they were defeated by numbers."

Compare this with the description of an urban school in Itarsi (January 1983). Here the children were not doing the experiments themselves yet they participated in a big way. "In class 6 the experiment was about good and bad conductors of electricity. The table was drawn on the blackboard. The teacher himself conducted the experiment. Student groups were not doing it. About three-fourths of the class stood around the teacher. After testing each substance children would run back to their seats to note their observations. Even though the teacher was doing the experiment, there was a lot of life in the classroom. Children kept picking up different kinds of things to test, waited for the bulb to light up, and then noted their observations in their tables."

But in one rural school in Bankhedi block (February 1983), neither were the children doing the experiments nor were most of them (especially girls) aware of what was going on. It was a small school. All three classes combined had just 35 students. "The teacher was doing the 'Electricity-3' chapter (class 8). There were only 3-4 textbooks in the classroom. The experiment was to observe effect of electric current on a compass needle. There was only one compass, so the experiment was not being done in groups. The boys clustered around to see what was happening while the girls stood watching at a distance. One or two of the brighter boys would do the experiment themselves while the rest observed from afar. So they could not get any idea about the direction in which the needle was deflected or guess the direction of the current. I suggested that they do the experiment themselves. Most of the boys then came forward to do it. They also figured out for themselves the direction in which electricity was flowing in the wire. The teacher was noting the observations in the table on the blackboard. The students began noting the observations in their exercise books only after I insisted. Somehow they arrived at the right hand rule."

The situation in an urban school in Itarsi (January 1983) was a bit strange. The teacher was doing the experiment. Some children could see what was happening, others couldn't. Two classes had been combined. "In class 8 the teacher was doing the experiment to prepare indicator strips with turmeric (*haldi*) ('Acids, Bases and Salts' chapter). The class was being held outdoors in the sun. Around 50 students were seated in rows. A test tube stand with a couple of test tubes was on a table to the front. There was some paper and a bit of turmeric as well. The teacher sent two children to get soap to make a soap solution. I wandered around the classroom to observe what the students were doing. The desk with the material was too far for children in the back rows to see anything clearly. Their books were not open either. Those who had their books open told me that all the previous experiments in the chapter had been done.

"There were many solutions to be tested with the turmeric indicator paper. The teacher asked one boy to read aloud the method for making turmeric paper. His voice couldn't be heard clearly except by the 3-4 children seated nearest to him. Another child stood by the desk, applying the turmeric paste on a piece of paper as per the instructions of the teacher. The 35-minute period came to an end while doing just this. The class continued perhaps because I was present, but by then another section of class 8 came in. So there were 80-90 children sitting in rows. Apart from the 20-25 children sitting in front, no one else seemed to know what was happening. Anyway, after the paste was made the teacher picked up a sheet of smooth paper, saying, 'We don't have any filter paper, so I'm using this smooth paper.' He put the soap solution on the turmeric paper and showed it to the children sitting at the back, saying it had turned red. Children were asked to note this in their books. Then he took another solution which he said was an acid solution and poured some on the paper, showing children that there was no effect on the turmeric paper. He then more or less announced that acidic solutions have no effect on the turmeric paper while basic solutions turn the paper red."

Looking at a rural school in Piparia tehsil (1983) one gets the impression that many teachers don't understand the purpose of the experiments they do. In this case the teacher was apparently doing the experiment only because the follow-up person had come but in the confusion a comic situation was created.

"The teacher was doing the 'Acids, Bases and Salts' chapter in class 8. He had made no prior preparations. After the class began children were running about getting test tube stands and test tubes. On the table were a test tube stand, 2-3 test tubes, a conical flask containing some stale lime water, a bottle with [phenolphthalein] indicator solution and red and blue litmus papers.

"There were no groups in the class. Children sat with their books open but showed little activeness or enthusiasm, as if they were surprised, wondering what had happened to the teacher today that he has come to the class with some kit material. He put indicator solution on the litmus paper and showed the result to children. He moved energetically around the classroom but I couldn't figure out what he was looking for [because] the children were not performing experiments, nor were they reading their textbooks or writing anything in their exercise books... [When the teacher who had come with me] pointed out a mistake there was more furious activity, with children running to get acids or bases."

But teachers who understood the purpose of the experiments put in considerable effort to help children also understand. Take the example of Umesh Chauhan trying to explain how valves work. In his words: "I was teaching the 'Air' chapter in class 7 that day. I had to explain how a water pump worked. I drew a diagram of the pump on the blackboard and labelled its various parts. I also drew diagrams of different stages to illustrate how the pump worked, including diagrams to show the opening and closing of valves.

"I used these diagrams and tried to show them that valve 1 [top valve] closes when the pump handle is pressed down while valve 2 opens because an area of lower pressure builds up between them. In this way I showed them how and why each valve opens and closes and how water fills the pump and then begins flowing out.

"I explained this process twice and then asked the children: when does valve 1 close, when does valve 2 open, and so on. But their faces told me they had not understood the process.

"I asked one child whether he had understood. Quite courageously he asked, 'Sir, you won't beat me?' I promised I wouldn't. Only then did he admit that he hadn't understood. 'When you say 'va' your mouth opens and when you say 'lva' your mouth closes, that's all I understood,' he added. That's when I realised that using diagrams to explain something wasn't easy. What you need is a model. The next day was Sunday but I spent the whole day in school trying to figure out how to build the model. These attempts led me to the idea of making a working model of a water pump from a broken boiling tube. This model became quite popular and was widely used in many teacher training camps."

Chauhan's boiling tube water pump was later included in *Bal Vaigyanik*.

Some teachers adopted a new practice: doing the experiments and the 'teaching' separately. Some would first 'complete the lesson' and then do the experiments. Others did all the experiments, after which they held a question-answer session on another day. These teachers did not see experiments as an integral part of the learning process but only from the point of view of the practical examinations. Or may be many teachers saw the *Bal Vaigyanik* experiments in the same way they saw experiments in the higher classes – as something to be done in the 'practicals' period. Some schools even had a separate room for doing experiments. On the day a class had to do an experiment, it was convened in this 'practical classroom'. These teachers felt this was a good arrangement because the kit material did not have to be carried around.

Take the example of an urban school in Dhar (September 1986): "The teacher was answering the questions for the students to write. When I asked him about the discussion, he said the children had done the experiment the previous day and were writing answers to the questions today."

A follow up report of an urban school in Hoshangabad block (January 1974) reveals that this practice had taken root early in the programme: "The 'Area' chapter was being done in class 6. A girl had written all the questions in her exercise book. When asked what the answers to the questions were, she said the teacher hadn't yet dictated the answers."

This observation is strengthened by a follow up report of a rural school in Piparia block (1983): "We examined children's books in classes 6, 7 and 8. All the class 6 books had the questions and answers clearly written out but it was evident that the answers were dictated because the language was the same. There was apparently some attempt at discussing the experiments also but it was obvious that the answers were all 'fictitious'."

The situation in a school in Kesla block (1983) appears to be even more deplorable. No experiments had been done, the teachers had dictated no answers nor were the children's notebooks corrected. "We asked to see a few notebooks. There was something written, mostly meaningless. The teacher had blindly put a tick mark on the answers."

Many teachers reported that their experience with children writing answers to questions was mixed. In the Piparia meeting they said that most children did note down their observations and participated in discussions. But they faced problems when dealing with topics that required logical thinking. Mahadev Prasad Tiwari pointed out the way he dealt with such situations:

ask each child for their reason, then combine all the reasons and proceed. When done properly, everything goes well, otherwise it could be disastrous. The time factor also played a role because if a discussion was begun and didn't reach a conclusion before the end of the period, all efforts would be in vain. Another teacher H.P. Mandhata pointed out that all these things happen in only around 50 percent of the schools.

This problem is illustrated in an urban school in Dhar (September 1987). In many chapters, the logical arguments needed to reach a conclusion could not all be taken up in a day. This was affecting the learning process. Some teachers demanded that the experiments and discussions should be such that they can be completed within the day, otherwise there would be problems. "The 'Balance' ('Principle of Balance') chapter was going on in class 7. Students had made their balances and brought them along. They were told to make weights out of tile pieces and pebbles, using their balances. In this class the only activity that took place that day was making weights."

Halkevir Patel firmly says he never dictated answers. Children wrote their own answers based on their observations. But he acknowledged that he dictated the final conclusion in many chapters. For example, after observing the motions of the sun, moon and stars a question was asked whether these heavenly bodies were moving or whether it was the earth that was moving. He would explain that it is not possible for four people to move with the same speed because each one is different. So if all four appear to be moving with the same speed it's probably because we are moving and they are all still. He felt that there was always a need to give this explanation. Supporting him, Mahadev Prasad Tiwari adds that children cannot express themselves properly because their language skills are weak. He used to club all the answers of the children into a single answer which he would make them note down. A similar situation prevailed in the Agar School Complex of Shajapur district. “After the experiment, the conclusions reached by the different groups in the discussion were consolidated into one conclusion and this was the final answer noted down by the children. We never gave any definitions or dictated any answers.”

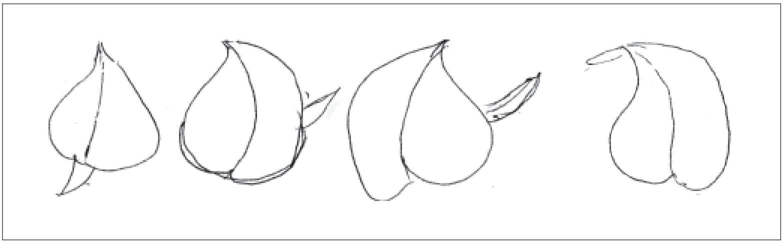
M.L. Patel points out that all observations used to be written on the blackboard and analysed. Then the children were told to write answers based on what they had discussed. They would then write their answers, although some answers in some chapters were dictated.

Prem Shankar Bhargava held a contrary view. He felt that children could do as many experiments as possible and discuss their observations, but they could never write answers to the questions asked. That’s why the teacher had to dictate answers. Pradip Sharma, a Higher Secondary School Lecturer, felt that discussions were not conducted properly in many schools and children wrote down wrong things. So it was better to dictate answers in such cases.

Sulabha Zaki from the Dhar School Complex points out that answers may be dictated but the rest of the process did go on along expected lines. “Observations, conclusions, discussions all used to be successful but getting children to write answers, especially in their own words, was like facing a sheer cliff because they did not know how to write in even Hindi. I was forced to dictate answers to them,” she says.

Another point that emerged in the Piparia meeting was that the *Bal Vaigyanik* guides available in the market were being used to dictate or copy answers to questions.

See the following example of a school in Sohagpur block (February 1983) where no experiments were done but children were nevertheless involved in serious, logical discussion. "A discussion was going on in class 7 on germination of seeds. The teacher was telling the children that he had come across three germinating gram seeds and drew three diagrams on the board. He asked them: 'Have you ever come across these types of germination?' Two children got up and made the following diagrams, saying you could never get the kind of gram seeds shown in the teacher's diagrams:



"The discussion then went into the question of why germination cannot occur in the way shown by the teacher. They all pointed out that there should be a hole; there should be a radical.

"The same teacher then taught the chapter 'Living and Non-living' to class 8. He wrote a long list of things on the blackboard, suggested by children: animals, plants, seeds (wheat, gram), chalk, stones, hair, nails, etc. One entry was "shadows". Then started the process of dividing the items into living and non-living. He made children do this task. They would ask questions on the basis of characteristics of living things. For example, do stones walk, do seeds breathe, etc. The teacher discussed seeds in detail, using the example of wheat stored in a godown to show that seeds breathe. Worm eaten seeds, boiled seeds, leaves on trees, fallen leaves were all discussed. Finally he took the discussion to shadows. Shadows move, they become bigger or smaller, so are they living things? Children enjoyed the discussion, especially when told that shadows move and change shape. They persisted that shadows were non-living. Asked why, they said, it does not breathe. The teacher took the discussion to another level, asking: if we are not around, if things are not around, will there be shadows? There cannot be shadows in darkness either. The existence of shadows then began to make sense to the children. The teacher then explained that shadows have no substance since they do not occupy space, do not have mass, etc."

Many classrooms saw such interesting discussions on living and non-living things. The open-endedness seemed to prompt children to express their own thoughts. Take the example of one such discussion in an urban school in Dhar (August 1985): "The teacher asked: What are the properties of living things? The children proposed the following properties: 1. They have life. 2. They grow. 3. They move. 4. They talk. 5. They do things themselves. 6. They eat. 7. They breathe. 8. They think. The teacher added one more property: they reproduce."

There's no further information on how the discussion proceeded. But what is clear is that the properties listed were not bookish. That was exactly the thrust in the *Bal Vaigyanik* chapter.

The example from a rural school in Mandleshwar (September 1989) tells us what kind of innovation is possible in the classroom if the teacher is willing and the curriculum permits. "The teacher was doing the chapter on internal organs of the body...The children observed the legs of polio-stricken Narendra Jaiswal, one of their classmates, and the teacher asked questions about his leg muscles. The answer they arrived at was that there were fewer muscles and they were all weak."

We hope that the discussion was held with sensitivity so as not to offend the polio-stricken child.

A similar situation is seen in a rural school in Hoshangabad block (August 1973). The children were caught up in some new questions emerging from their activities. "Class 6 was doing the first chapter and there was an interesting discussion going on about transparent things (Is wire netting transparent?). Class 7 was working on coordinates. The children were engrossed in marking the correct location of the cities in the map they had made. Some children had noted that the polar coordinates are independent of the scale chosen for making the map. They will try and check this idea and let us know, very interesting."

The ingenuity of the teacher is evident in a follow up report of an urban school in Mandleshwar (January 1988). "The 'Measuring Distance' chapter was going on. Madam asked a girl sitting in the last row to stand up and said: Distance *(doori)* is how far apart I am from this girl. What do you usually call it?' Group 2 said they called it *phaasla*. She then asked how they would measure it. The children said, by our strides. She asked a small girl to measure the distance. The girl measured 10 steps. She then asked a tall girl to measure the distance. The girl measured 6 steps."

More on the enthusiasm of teachers is seen in a follow up report of an urban school in Dhar (January 1986) where an experiment with pinhole cameras was going on. Such an in-depth quantitative experiment is perhaps possible only in an HSTP classroom. "The teacher used two boxes to do experiment 4. He put one box inside the other and placed a burning candle before them. The outer box had a square hole on the side facing the candle while the inner one had a screen of square-lined paper. The children changed the distance between these two faces from 2 to 6 to 10 cm and then calculated the area covered by the image of the candle formed in each case. The areas were 1, 4 and 6 squares respectively. They then kept the distance between the two faces constant but now moved the candle back and forth – 0, 10, 20, 30, 40 and 50 cm – until the image equalled 1 square. The third time they again kept the boxes fixed and again moved the candle forwards and backwards, but this time to get images equalling 6, 4, 2 and 1 squares. They then drew a graph, using the data they had collected."

A slightly different picture emerges in a follow-up report of a girl's school in Sohagpur tehsil (February 1983). It shows that even though the classroom was being managed in an organised way nothing 'new' was happening. This was a class that had done some of the 'difficult' experiments from *Bal Vaigyanik*, such as the shadow cast by a stick in "Looking at the Sky" and the embryonic development of a hen's egg. This was also the school in which class 8 students helped class 7 students. "The chapter on development was in progress in class 7. The teacher began the discussion with the first few questions in the lesson. The girls were a bit withdrawn, that was obvious. But they kept answering the questions mechanically one after another, so the teacher couldn't bring anything new into the discussion. The sun dial graph [chapter: "Looking at the Sky"] and the bar diagram of the weighing balance principle were dutifully pasted.

"Another day the experiment for the day was studying the day 1 and day 5 fertilised eggs [fertilised eggs at different development stages]. The girls had already observed day 3 fertilised eggs. The teacher hadn't come to school that day, so the class 8 girls were showing the eggs to them."

The teacher, Sunila Masih, later explained that this was how the embryonic development stages of the egg were taught. "We do this experiment once in three years to see how chicks are born from eggs. All the three classes – 6, 7 and 8 – do the experiment together and monitor the development stages. It's particularly exhilarating for them when they first register the heartbeat of the chick."

The long-term experiments were among the so-called 'difficult' experiments in *Bal Vaigyanik*. We get very few descriptions of them in follow up reports. One such rare report from an urban school in Dhar tells us that the teachers do try to do these experiments even if doing them is difficult. "The 'Growth' and 'Making graphs' chapters were in progress in class 7. All the students used a string to measure the length of plants in their pots and noted the readings in the table."

Malati Mahodaya, a teacher from a girls' school in Dhar, gives the following description of the "Life Cycle of Animals" chapter: "I got the girls to first read the chapter aloud in the class. A girl then asked me, 'Madam, how can we answer the questions when we don't have any eggs?' I told her, 'We'll go on a field trip tomorrow, but you must prepare for it. Each group must be given four injection bottles from the kit.' I had appointed a class monitor for getting items from the kit almirah. 'Each group should label their bottles. First, look at the diagrams of the larva and pupa. Now label the bottles 'water from a ditch', 'mosquito larva', 'pupa' and 'tap water''. Then two empty Pan Parag tins were given to each group and I told the girls to label them 'a' and 'b'. I also told each group to keep a wide-mouth plastic bottle, hand lens, transparent plastic sheet, pins and glass slides.

"Then I explained what had to be done in each experiment. I got them to draw a table in their exercise books in which they could note down their daily observations.

“We went on the field trip the next day (28.07.01). Seema saw some cow dung that was 2-3 days old. She asked, ‘Madam, are these dung worms?’ I replied, ‘No, they are not dung worms. Put them in one of your tins. We’ll find out what worms they are later.’ A bit further on we saw cows and buffaloes grazing. I told the girls, ‘Let’s go see if we can find some eggs. Flies always lay eggs in fresh dung.’

“We found a clump of 20-25 eggs. I told Shweta to put the eggs in tin ‘b’, cover the mouth with the plastic sheet, tie the sheet firmly in place and use a pin to poke a few holes in it. Tin ‘a’ had only dung with no eggs in it.

“Further ahead, we came upon a tank containing water with algae growing in it. I saw mosquito larvae and pupae in the stagnant water. I called the girls, showed them how to identify mosquito larva and pupa and asked them to collect samples in the injection bottles. I reminded them to cover the mouths of the bottles with the plastic sheet, tie it firmly in place and poke small holes for air to pass. Once the larvae and pupae were collected I told them to fill another bottle with tank water. One bottle was also filled with drinking water.

“We had the material for two experiments, so we now went looking for frogs’ eggs. We found a fairly big pond filled with water and saw frogs’ eggs stuck like sago in a substance that looked like soap lather. The girls were excited. We had a problem filling the plastic jar with the eggs but we managed. After this we returned to school.

“We filled water in a broken *matka* (earthen pot) and put the frogs’ eggs in the water. I told the girls to take out one egg every day and measure its length. On the second day a baby came out of the egg. The girls exclaimed, ‘But madam, this is a fish.’ I told them, 'We'll wait and see whether they are fish babies or frog babies.'

"During the discussion about our findings, the following questions came up:

1. Where did the frogs' eggs come from?
2. Why do flies lay eggs in dung?
3. Why don't we see mosquito eggs?
4. Flies develop in 10 days while mosquitoes grow in 4-5 days and frogs develop in 40 days. Why?

"I explained to the girls that different living creatures have different life cycles. Later, they collected silkworm eggs and wall lizard eggs. They even brought bed bug eggs. We kept these too in bottles and observed them."

Studying the lifecycle of frogs was never easy, as we can see from what Kishorilal Soni, a teacher from Agar, has to say: "Children would bring clusters of frogs' eggs to the class and keep them in a *matka* filled with water. They would also put in some grass and other acquatic plants. Tadpoles always formed, their front limbs emerged, but most of them died before their rear limbs developed and their tails withered. From 1985 to 2002, only twice did we succeed in getting adult frogs from tadpoles. We wanted to know what was lacking in our experiments and even talked to the Eklavya resource persons. They told us this must be happening because some element (perhaps, iodine) was probably missing."

Umesh Chauhan gives details of a similar long-duration experiment. The interesting part in his narration is that the experiment opened the door for a dialogue on social beliefs and he took full advantage of the opportunity. "I was teaching the chapter on 'Reproduction in Plants' to class 8 that year. To prepare for the pollination experiment I asked children, 'Are there *gilki* (a kind of gourd) creepers growing in the backyard of any home in the village? Before coming to school tomorrow, ask the owner if he will permit us to do an experiment in which we have to tie bags around a few *gilki* flowers.' One student immediately replied, 'Sir my house is close to the school and there are *gilki* creepers in our backyard. I'm sure my father will let us do the experiment.' The next day we made our preparations and went to the boy's home to do the pollination experiment.

"We tied strings as markers on the male and female *gilki* flowers, then covered pollinated and unpollinated buds in polythene bags with tags giving the pollination date, group name, etc., for each bud. Just then the gardener came with a question, 'Guruji, most of the pumpkin flowers are just falling off. Do flowers drop if people point fingers at them?'

"Here was a good chance of doing our experiment and tackle a superstitious belief at the same time. The children looked for female pumpkin flowers without damaging them or the creepers. Observing the flowers I noticed that they were bell shaped and many were filled with rain water and their pistils were rotting. When we dissected them we saw that their ovaries and styles were also rotting. One more thing was noticeable. They were filled with a sticky substance inside (probably nectar) in which insects coming to pollinate the flowers were being trapped. This could be the reason for less pollination activity in these flowers.

"Anyway, thankfully the skies cleared and the weather was fine on the days we did the experiment. We chose nine female buds, pollinated them and covered them with large polythene bags with tiny holes to allow air circulation. We tied strings to these flowers to identify them. I told the children to wiggle their index fingers at these flowers. They enjoyed doing this with both hands. When we came back to the house a few days later the gardener and the children were astonished to find pumpkins forming in the place of the nine pollinated flowers.

"The gardener and his grandson (my student) were very happy. We even taught them how to pollinate the flowers. That also put an end to the superstition. The gardener and the entire class now knew that pointing fingers at the pumpkin flowers didn't cause them to fall off. They fell either because water had filled in them or they had rotted, so pollination did not take place."

Another example of the social impact of an environment-based curriculum can be seen in the following example from the Dhar School Complex. The teacher Malati Mahodaya relates: "Some people had noticed winding snake-like patterns on the leaves of different plants and the news soon spread like wildfire. People stopped eating leafy vegetables and a question was also raised in the Vidhan Sabha, asking what our scientists were doing about this problem. One of my students decided to investigate. She found a tiny yellow-coloured insect in the snake-like pattern on the leaf of a tomato plant. The insect was eating the chlorophyll as it moved forward inside the leaf. It was the insect called leaf miner."

But there were also schools where experiments were done but they appeared to be without any purpose because nothing came out of them. Take the example of a girls' school in Seoni Malwa tehsil (1983): "The school had a teacher who took her job very seriously. I talked to the girls. They told me they had just done the experiment to find out the period of oscillation (of a pendulum). I asked them: What is oscillation? They just looked at each other. After a lot of coaxing it all came out that they did make a pendulum, swung it to and fro and even calculated how many oscillations there were in a minute.

"I then asked: What other chapter have you done? They said 'Soil'. What did you do in this chapter? We weighed soil and did an experiment. We measured water with a measuring jar. Which soil absorbs the most water? Again silence.

"They had done only the water absorption [by soil] experiment in the chapter but they had no clue about the conclusion reached."

A follow up report of a school in Harda tehsil brings this point out even more sharply: "I observed the class 8 from a distance. The children were doing the experiment to calculate the period of oscillation and the teacher was helping them. There were just eight students in the class. I talked to them later. The class had only one girl who was sitting far back, watching the experiment being done. During the discussion it was clear the class was totally lost. Only one student was talking. I found out he was a failure from the previous year. None of the others could even articulate what they saw or what happened in the experiment. It didn't make sense because all of them said they had performed the experiment and a class of eight would have seen the experiment clearly even if it was a demonstration. Teaching is done in school, experiments are performed, the teacher puts in a lot of effort, yet the children remain clueless. It just doesn't make sense."

The same situation is seen in a rural school in Meghnagar (August 1988). The experiment had been done meticulously, going into every detail. But the end result was a big zero. "The teacher herself demonstrated the experiment to find out the relative density of a substance. She asked a student to weigh an empty bottle, using a weighing balance. The girl said the weight was 17gm. The teacher then called up another student to fill the bottle with the liquid and weigh it. The bottle with the liquid weighed 25 gm.

"The teacher then began filling [another] bottle with the second liquid, asking [the children] how much more she should fill. The question would have made more sense if she had placed the bottle next to the earlier filled bottle.

"The teacher was active but the students sat passively.

"The teacher assumed that the weight of all the [empty] bottles was 17gm because they were all the same shape and size.

"After the experiment, the following table was drawn on the blackboard:

Name of liquid	Weight of empty bottle (a)	Weight of filled bottle (b)	Weight of liquid (b-a)	Relative density
Water	17	25	25-17	8
Mustard oil	17	25	25-17	8
Kerosene oil	17	23	23-17	6
Cooking oil	l7	24	24-17	7

"The teacher also asked whether ghee was soluble in water. The students said it does not dissolve. The teacher then explained that substances lighter than water would not dissolve in water."

But hope springs from the experience of a school in Kesla block (January 1983) that many teachers did, indeed, internalise the basic objective of science education: “The science teacher had never studied science. I observed his class 7. He was teaching the lesson about the cycle pump and water pump. A cycle pump had been brought to the class but there was no experiment about it in the lesson. He first showed the pump to the students, alternately asking and telling them about its various parts. He explained how air passed through it. Then he drew a diagram of the water pump and began explaining how it works. He kept asking the children many questions all the while to bring out how much they understood. It wasn’t a one-way lecture-explanation... After this I questioned the children about roots and leaves. They explained the relationship between venation, type of seeds and roots. I asked them: Is it possible for a young shrub with fibrous roots to grow into a plant with a tap root? I said this was what a student in another school had written and asked where he had gone wrong. The children had an answer. They said it wasn’t easy to distinguish the main root of a shrub, so this could be the reason for the mistake.”

If a class is not organised properly – if children are not working in groups or the teacher is demonstrating an experiment – then it is the girl students (in co-educational schools) who are the worst sufferers. This is clearly seen in 2-3 follow up reports of an urban school in Hoshangabad block (March 1982): “The teacher does teach and the children do some experiments but most of the experiments are demonstrated by the teacher or the children take turns with one set of the kit material. I was sitting in the class during the ‘Air’ chapter. The girls were sitting separately.”

One comes across this situation in several schools, such as the Harda school referred to earlier.

In one urban school in Hoshangabad (January 1983) children’s participation was limited because there wasn't enough kit material. But children tended to come up with make-do arrangements if given the chance and, in fact, the lack of equipment in this class came as an opportunity for them. The follow up report brings out the importance of not forcing them to toe a particular line. "The 'Electricity-3' chapter was being done in class 8. There were around 40-50 students but there were only two compasses. So the class was divided into two groups (around 20-22 students in each group) and the experiment got underway. It's natural that in such a large group 7-8 children take the lead while the rest sit chatting with their books open. The experiment was to see what effect a current flowing through a wire placed above the compass has on the compass needle. Children were engrossed in what they were doing but were having a problem using the switch. After trying a couple of times, they removed the switch and connected the wires directly. The other students sitting idle did the experiment after a lot of coaxing. A 4-6 metre long enamelled wire was used in the experiment, so children had problems figuring out the direction of current flow. They were also not writing anything in their note books. I sat with one group for a fairly long time, trying to figure out why the compass needle wasn't deflecting even when a current flowed through the wire. The boys checked the cells, bulb and everything else. They were all okay. Finally one boy managed to figure out the problem. The enamelled wire had snapped in one place, so the boys had joined the strands together but they had not scraped off the enamel coating at the ends. So they opened the joint, scraped the enamel off, joined the wires again and did the experiment again. The compass needle was now deflecting. By then the period was long over but around 5-6 of the most interested students had stayed on to search for the flaw and were more than happy after rectifying it themselves."

This 'making do' with whatever is available can be seen in another rural school in Hoshangabad block (January 1974). It was the openness of the HSTP that provided both the students and the teachers the opportunity to innovate. "The 'Air' chapter was being taught. The children made some improvements in the equipment used to measure air as they went along. Basically, they blow air and collect the displaced water. Everything was going fine. But the bottle emptied while they were doing the experiment. One girl suggested using a three-holed cork, the third hole being used to refill the bottle with water. I suggested using the two-holed cork itself but with a Y-shaped glass tube.

"The experiment was done using both methods – the one given in the card as well as the modified version. The volume is larger in the card method (around 3-3.5 times larger) and less in the modified method probably because you work against a pressure."

(The follow up person gave only these brief details. He also drew a diagram showing a bottle filled with water and two rubber tubes fitted into the cork. The diagram showed both the rubber tube ends submerged in water. When you blow in one, water flows out through the other. This can be collected and measured. Function of the thrid tube is not clear.)

The descriptions given by some teachers show that children make an attempt to understand the design of the experiment while doing it. As Sulabha Zaki points out: "While doing the ink separation experiment in chromatography one girl student asked why we used only this special strip of paper [blotting paper] and why ordinary note book paper cannot be used."

Or as Kishorilal Soni writes about a class in the Agar School Complex: "A student once asked the following question about the lifecycle of flies experiment: 'Sir, you used cow dung to perform the experiment but can it be done on some other base material (medium)?'"

These may appear to be trivial examples but they show that children think about the experiments they are performing and even come up with alternative approaches wherever needed.

Sulabha Zaki points out that children observe the interactions between things very carefully during the experiments. "A group of girls found that some particles of sand were attracted to the magnet when they used it to separate a pin from a mixture of substances. I told them that sand often contains iron particles. There was a mound of sand near the school. The girls collected a bottle full of iron particles from the mound with the magnet. They enjoyed doing the activity, saying it reminded them of the story of the cowherd who discovered the magnet."

But what happens when experiments are not done? Take the example of a rural school in Hoshangabad block (November 1973). "Class 7 was in session. The teacher was trying to start a discussion on the experiment with springs joined in series and parallel. All the readings of the students were the same: the teacher had written them on the board and they had copied them. So more than half the children could not figure out whether springs joined in series stretch more or less than a single spring... The children were rarely encouraged to speak or find out for themselves."

A similar situation prevailed in a rural school in Meghnagar (October 1989) where the process was completed with a mere description of the experiment. "Today's lesson was 'Nutrition 1'. The teacher was telling the children that if some foodstuff is rubbed on a piece of paper and if the paper becomes translucent, it contains fat... After this he explained how the protein test for foodstuff is done. In the same way he then told them that if foodstuff turns blue or black when iodine is poured on it, it contains starch."

Field trips

We have said earlier that field trips were a problem area for the HSTP. There was one thing remarkable about field trips. A growing number of teachers were showing their reluctance – and even antipathy – to field trips. Among them were teachers from urban schools. They said it was difficult to organise field trips for their students because there was no place they could be taken to where they could find and collect the samples they needed to study. Many teachers (especially male teachers in girls' schools) said taking girls on field trips was not practical. Some from rural schools also said that taking children to fields, rivers or streams could be dangerous (what if they are bitten by snakes?). Some teachers pointed out that field trips require a lot of time, so their headmasters often refused permission. One other argument was that it was difficult to maintain discipline during a field trip.

Many teachers however kept coming up with innovations to deal with these problems. For example, some teachers would take all the three classes together on field trips. This made it possible for more than one teacher to accompany the students. Some teachers even gave up the idea of going out into the field. Instead they would tell the children to collect flowers, plants, rocks, etc., on their way to school assuming that the sole purpose of the field trips was to collect material for study. Very often, some students were sent out while the class was in session to collect this material. As a result children seldom asked the kind of questions they tend to ask when they see something in its natural setting. They could also not make crucial observations about the natural surroundings – for example, the arrangement of leaves on trees, or the natural habitat of animals.

Some enthusiastic teachers came up with a complicated alternative that later proved to be a bit of a problem. They got children to make herbariums and use them for demonstration year after year.

But there were teachers who made sincere efforts to take children on field trips so that they could make first-hand observation of their environment. They made their own arrangements and many of them were able to convince their fellow teachers to help. A follow up report cites the example of a teacher in an urban school in Dhar (August 1987): "The girl students went on a field trip with their teacher to the nursery near Udayvilas palace. They collected innumerable flowers. The nursery gardener also explained grafting to the girls. The science class was usually held in the 5th and 6th periods but the headmistress gave the subject teacher the first and second periods to ensure that the flower samples didn't wilt.

"The class 6 girls also went on a field trip. They collected leaves, noting down their names. The teacher told them to fill out the table. They had collected so many leaves that all their time was spent in filling out the table."

A similar description is found in a follow up report of an urban school in Dhar (September 1986): "When I reached the school at 8 am the girls were standing in line in the courtyard. When I went to the office I saw the teacher coming out of the office. She said all the classes were going on a field trip today. You come along too. We took the students to a field near Jhiranya. Each class was allotted a task. So some students collected flowers, others collected insects, while some collected branches laden with disease-causing insects. The class 6 students talked to the owner of the field to find out its area and the crops sown."

Similarly, class 7 students of a small town school in Sohagpur tehsil had just completed a field trip (September 1989). "There was general agreement on the number of legs ants have but the children didn't seem to agree on the number of body segments."

Class 7 children not agreeing about something would be heresy in our textbook-centred education system.

Shobha Vajpayee writes about her experience of making the arrangements and the impact of field trips. "Before discussing the chapters that require field trips, one thing needs to be made clear. These chapters were always adapted depending on the situation. For example, for the class 6 'Grouping of Leaves' field trip, the students went out if the weather was clear, but if it was raining, each student would bring 3-4 different types of leaves on their way to school. But there was always a variety of leaves available. Anyway, we usually organised field trips to collect materials related to 'Leaves and Roots'. Field trips and surveys related to crops always included children talking to their parents and neighbours as almost all the students in our schools were from agricultural families.

"Impact of field trips was long-lasting. Whenever children brought new flowers, leaves, animals or insects, even catching baby snakes and lizards, they asked countless questions about whatever they collected. I got to see many types of insects because of them. They even introduced me to the flower of the *ber* (jujube) tree and its fragrance.

"For the chapter on crop protection in class 8, we usually studied wheat and gram fields because these were the crops sown by farmers. The children once collected so many different kinds of weeds from a gram field that even the owner didn't know the names of many of them. They stopped farmers passing by the school to find out the names but even they didn't know.

"I would first explain to children how a field trip is conducted – what they should do, or not do. They would then take over and organise everything. They often spent the entire time after their midday break – meaning an extra period – to carry out the field trip or hold discussions after it. Often two classes went on the field trips together (with their teachers) and returned after lunch. Sometimes we got the headmaster to permit us to tweak the time table and allot the first two periods instead of the last two for the field trip."

The field trip took on a festival-like atmosphere in the Friends Girls School in Sohagpur. As Sunila Masih relates: "Field trips were important for the HSTP but we couldn't always undertake them. In my school, the teachers and students of all three classes went on field trips to nearby places once every month (usually from 8 am to 2 pm on Saturdays). The three classes would decide which chapters they would take up for the field trip. They would collect and analyse material class-wise. They also made notes. Everyone sat down for a common lunch, followed by a cultural programme of songs, poetry, dance, jokes, etc."

The above descriptions are inspiring and highlight the importance and possibilities of field trips and going outside the school to study the countryside. However, what emerged in the Piparia meeting was a deteriorating situation as far as the field trips were concerned. The teachers pointed out that the practice and the purpose of going on field trips we progressively diluted in the HSTP until they ended up only as sample collecting exercises, with all the other associated activities being given the go by. M.L. Patel goes to the extent of saying, "Instead of wasting time on field trips it was felt that the time could be better devoted to teaching."

It seems that some teachers skipped field trips and initiated discussions based on the experiences and observations of children. Their approach fostered the impression that field trips were not an integral part of the curriculum but only a teaching aid.

Many teachers considered them to be an obstacle in the way of teaching. After the HSTP was shut down, a study showed that most schools conducted only one or two field trips a year even though the teachers accepted that going out to study science in a real situation was an important element in science education. Some teachers even felt that studying life sciences should only be done in the field because you cannot get an entire tree or all its leaves into a classroom. Most field trips had to be carried out in July-August when nature was at its most glorius. But this wasn't always possible.

Former students of the HSTP remember the many opportunities they got to learn on field trips.

There were many reasons why field trips were increasingly neglected. The most important was lack of time. As it is, the total teaching time was insufficient. Added to this was the problem of scheduling field trips in the time table. It was not easy completing them within two periods. The shortage of teachers also meant there were not enough teachers to take children out. However, the main reason seems to be that field trips were not considered educational activity.

Although, field trips were not undertaken, the material collected from outside was used very often. Take the example of a rural school in Meghnagar (September 1989): "Each group had fruits like brinjal, *gilki*, bottle-gourd, tomato, chillies, plantain, bitter gourd, lady's-fingers, ridge-gourd, custard apple and onions as well as brinjal and lady's-fingers flowers. The students were comparing flowers and fruit in the chapter 'Flowers and Fruits – part 3'."

Or an urban school in Dhar (September 1985): "Flowers of banyan tree and fig tree were distributed among the students. They were told to dissect them horizontally and vertically. The teacher then asked them: 'Did you find seeds or something else?' The students answered 'seeds', with some also saying 'flowers'. They then examined the parts of fig flower with a hand lens. 'Can you see petals and sepals?' Some students answered 'yes', some 'no'. 'Now look for the androecium and pistil. The students used the hand lens to look. Some said they could see the stamens, others said they could see the pistil. The answer to question 42 was unisexual flower. They were then told to observe the parts of the flower near the aperture and near the stalk. 'Where are the male and female flowers located?' The students said the female flowers were near the stalk and the male flowers near the aperture."

Sunila Masih relates her experience: "Our school has lots of bougainvillea. Children thought its colourful leaves were its flowers. But when I showed them the small bell-like flowers attached to the leaves and dissected one with a blade to reveal the stamens, pistil and other parts, their faces would light up with wonder and joy."

Or take this narrative from an urban school in Dhar (October 1985): "The subject: 'The living world through a microscope'. A drop of water from the bottle was placed on the slide and the teacher examined it under the microscope. He showed children, one by one, the living creatures in the water. I too saw them. One student brought algae growing on bricks and walls, not the water algae. They also examined an onion peel."

We have many such narratives of what happened in the classrooms. What they show is that the HSTP classroom depends heavily on the activities of children and the efforts of the teacher. This is to be expected when the textbook is no longer the focus of learning. But there is a problem. In the textbook-centred learning, there is assurance that the children always arrive at the 'correct' answer. In child-centred education, children and teachers are autonomous learners, so there is always the 'danger' that they may end up accepting a 'wrong' answer. The question that arises then is: Should more importance be attached to know the 'right' answer in the educational methodology rather than to the process by which children arrive at an answer? Another related question is: Does the 'right' answer in a textbook give rise to a dialogue or engagement with children's (and teachers') previous beliefs or is it just thrust upon them? It seems that children repeat the so-called right answer in the classroom and in examinations even if, deep down, they do not believe in it. On the other hand we have the HSTP which believes in the autonomy of children and gives them space to talk about and analyse their past experiences and beliefs. But there is a danger here, as we pointed out earlier. Sometimes the limited understanding of teachers could lead to an erroneous belief being established as true.

In other words, what is the best method of transferring 'accumulated knowledge' to children? Anyone seeking to make a serious intervention in education needs to confront this question.

There are many aspects of the learning process that emerge from these classroom experiences but there is a lot that still remains hidden. For example, these narratives don't elaborate on the kind of interactions that took place between children themselves and between teachers and children. It is also not clear what the teachers did to keep all children involved and interested, although, as Kishorilal Soni points out, many schools tried to make mixed groups of 'weak' and 'clever' students.

This much is clear. Children in the HSTP classroom were fairly free and they had an agency in the classroom. There is a CD available of some classes of the Government Middle School in Oodan (Harda district). Seeing it gives one an idea about the kind of autonomy children enjoy and the way in which the walls of the classroom dissolve. By showing how dynamic and fluid the HSTP classroom is, the narrative presents a completely new picture of what a classroom should be like.

17

EXAMINATIONS

One reason why the innovative science education programme running in Bombay's municipal schools was closed down was that the municipality refused to permit any changes in the Board examinations. It was clear to the teachers that their students would not be evaluated for the kind of things they were learning in science: the Board examinations would only ask questions about formulae and memorised information. So their students would be at a disadvantage and would suffer.

This was an important lesson from the Bombay experience. That's why when B. G. Pitre met Sudarshan Kapur and Anil Sadgopal in Rasulia regarding the proposal to start a science education programme in Hoshangabad, he told them that they should get permission from the government to change the examination system before implementing the innovation. This point was mentioned in the 1972 proposal although it was not emphasised strongly enough. Anil Sadgopal puts it succinctly: "Examinations throw all innovations back because they are a powerful weapon to maintain status quo."

Changing the examination system was a major concern of the

HSTP from the very beginning. The basic approach was that an examination should evaluate what children are taught or what they are expected to learn.

Like the HSTP's other components, the examination system gradually evolved on the basis of field experience. So examination practice kept evolving over the innovation's 30-year lifespan, although the basic thrust remained the same.

One thing needs to be mentioned, however, right at the outset. The HSTP group was clear that the best examination would be one the teacher herself conducts. That is, every teacher should have the freedom to assess her students. The purpose of this examination would not be to pass or fail students, or to place them in first, second or third class. It would be to assess how much and what the students had learned till then, which topics they were now equipped to learn, where they needed more time and support, and what more they needed to experience. This topic was discussed threadbare by the resource group and the teachers during the early phase, with the resource group constantly insisting that internal assessments should have relatively more weightage.

Board examinations during those days of the HSTP were held at different stages of the school cycle in Madhya Pradesh. The first examination was held in class 5 and was conducted at the district level. Next came the upper middle school Board examination (class 8) that was held at the divisional level, followed by the class 10 and 12 Board examinations that were conducted by the state-level Board of Secondary Education.

The first batch of the HSTP students reached class 8 in 1974-75. At that time, Friends Rural Centre and Kishore Bharati once again broached the subject of examinations with the state government. Taking an important – and bold – decision, the government permitted the two organisations to organise and conduct the class 8 examination in the 16 HSTP schools, recognising this examination as equivalent to a Board examination. In other words, the government had accorded two non-governmental organisations the status of an examination Board. This was an unprecedented step for any state government to take and its importance cannot be lost on anyone working in the field of school education.

So the class 8 Board examination in the 16 schools was conducted by Friends Rural Centre and Kishore Bharati from 1975 to 1980.

After the district-level expansion of the innovation, the HSTP group came out with a paper in 1977 describing the kind of examination system it had developed. This paper is reproduced below. I have added a few points in parentheses to clarify some aspects. The paper goes into the thinking and logic behind each element in the examination system, which we shall discuss later. The paper is by and large based on the learnings from the field experiences until 1977. During these five years many things were tried and it will be pertinent to have a look at them. The third point is that the examination system was not adopted exactly in the form developed during the pilot 16-school phase. Several changes were made in the details. We shall discuss these as well. Finally, we shall go into the field experiences of implementing this examination system and the impact it had on the teaching-learning process.

THE HSTP EVALUATION – A FRAMEWORK (1977)

We have, over the last five years, gradually evolved a system of evaluation in the HSTP, which we felt was best suited to our objectives. Now that the programme has been extended and others will be taking over the responsibility of evaluating these students, it is necessary that whatever till now has been in our minds, and has been applied almost intuitively, be written down.

Class 8

We shall consider first the procedure of evaluation of class 8 students and then comment on the class 6 and 7 evaluation. The major difference in these two categories [is] that the class 8 examination is done through an external board whereas the 6 and 7 class examinations are promotional, hence local in nature.

The board examination at the end of class 8 consists of three parts: internal assessment (15 percent), a written paper (45 percent) and a practical test (40 percent). To pass, a student must have a minimum 33 percent in the aggregate and 25 percent in each of the three parts.

[This division of marks was arrived at after intensive consultation with teachers. The resource group was always in favour of giving more weightage to internal assessment.]

Internal Assessment: The teacher is expected to assess his students on the basis of regularity of attendance, daily performance in the classroom, record work, and performance in the monthly and bi-annual examinations.

Written Paper: This is an unlimited-time, open-book examination. The paper usually consists of ten questions designed in such a way that it would take the average student roughly two and a half hours to complete. Students are advised to bring their record books and *Bal Vaigyaniks* with them and they can consult them whenever desired. They are of course not free to consult among themselves or with anyone else.

[A look at 1975-80 question papers reveals that for many years children were allowed to bring any book, not just *Bal Vaigyanik*, although this might not have had any practical significance in the seventies, especially in rural India. Moreover, they were allowed to solve the question paper in two sittings with an interval in between, and consult each other during the interval. Evidently, they were not allowed to talk to teachers. It was, in all probability, the first example of an open-book examination, and to be allowed to talk to classmates would sound unimaginable even today.]

The question paper is usually framed by a group of persons who try and set questions extending over the whole range of the curriculum. One question is usually totally unrelated to the actual course work and designed to test the students' IQ and natural ability. The remaining are a mixture of questions of the objective type, open-ended questions, short descriptive type questions, questions requiring students to draw diagrams, questions requiring simple calculations and, sometimes, questions of straight recall. The objective in framing such questions is to test various attributes of a student, namely, comprehension of concepts, logical ability, power of expression, imagination and to test him in situations close to what he has encountered in the classroom, as well as situations which are far removed.

Once the paper has been set, a preliminary allocation of marks to each question is done, keeping in mind how difficult a question is, how long a student would take to answer it, how much written material a student has to comprehend to answer the question, how difficult and important the concept involved is, how much logical and computational ability is involved, how much imagination is required, whether the test-situation is a familiar one or whether a student is being required to apply processes that he has already learnt in situations that are totally new to him.

[However, these pre-allocated marks were not printed on the question paper.]

Amongst this set of questions, a few are singled out (two or three) as those that form the core of the programme, i.e., the students must have achieved a certain minimum amount of comprehension in their underlying concepts in order that they be promoted to the next class. Quite obviously, such questions would not be of a trivial nature. Some of the areas from which such questions would be set are measurement, units, handling of data, graphic representation and its interpretation, classification, idea of sets and sub-sets and similar basic concepts from other subjects. In the preliminary allocation of marks, such questions would be given a higher weightage.

[The ideas of fundamental elements, minimum expectation, etc., fossilised in the course of time. Later, these were strictly defined and included in the examination manual.]

The written test is then administered to all students. Before evaluating them, a random sample consisting of roughly 20 percent of the total number of answer books is drawn. The examiners, after having decided upon the expected answers to various questions, study this sample and grade the given answers into various categories, ranging from excellent to poor. The distribution of such grades to each question is then noted and based on it changes are made in the pre-allocated marks to various questions along the following guidelines:

(1) No or very marginal change is made to pre-allocated marks of questions singled out as forming the core curriculum, no

matter what the sample distribution is like, unless strong evidence of a badly-framed question is encountered.

(2) Amongst the rest of the questions, the weightage of questions which are done very well or very badly by a majority of students is reduced and added to the weightage of questions whose answers are well-distributed in the categories excellent to poor.

The rationale for doing so is that if our objective in evaluating the student is (a) to differentiate, as well as possible, between bright, good, fair and poor students, and (b) to ensure that they have learnt a basic minimum in order to proceed to the next higher class, then (1) above takes care of the latter and to achieve the former, questions in response to which the student's answers span the largest spectrum should be given greater weightage, i.e., they in effect become better questions in comparison to those whose answers are uniformly good or bad and which therefore have a low power of differentiation.

[This redistribution of marks is a statistical procedure and was the cause of suspicion about the HSTP examination. This will be discussed in detail later.]

An added advantage of such a procedure is to point out questions which are ambiguously or sometimes wrongly set. (Our experience shows that every question paper contains one or two such questions). If on the basis of answers of the random sample, the examiners are convinced that a particular question is badly or ambiguously framed and the performance of the students in the sample has been affected as a result of this, it's weightage is drastically reduced, and in exceptional circumstances the question may be totally deleted. Only under such situations are the pre-allocated marks of questions of key importance, which have been singled out beforehand and drastically changed.

Having thus finally allocated marks to various questions, all the answer books are marked, including those belonging to the sample. While marking, one examiner marks a particular question of all papers instead of marking all questions of each paper.

[The idea behind one examiner marking one question in all the answer books is to do with uniformity. However, after district-level expansion, it had to be given up due to practical reasons.]

Super Marks: Since many of the questions in the paper are open-ended, there is usually more than one correct answer to each question. On the basis of their experience and the general abilities that would normally be associated with a student of class 6, 7 or 8, the examiners usually decide what kind of an answer to a particular question would deserve full marks. In the event that a student provides an exceptionally better answer than what the examiners think is the best, or shows exceptional skill or imagination far above the level of expectation, he is given super marks, over and above the full marks for that question. During our five year experience, there has been only one instance when a student, because of this provision, got more marks than the maximum possible marks; in fact it was 104 out of 100. It is very rare that a student will display extraordinary ability in all questions since different questions test diverse attributes and faculties. In any case, this provision is meant to be used in very exceptional circumstances only, and also in questions of higher conceptual or skill value.

Practical Test: Unlike the written paper, the practical test is of fixed duration. An unlimited time test would require an impossibly large number of trained people and laboratory facilities. Such tests, therefore, normally consist of four different experiments or activities that every student has to perform in a fixed time, about fifteen minutes each. The experiments are so chosen as to test the capacity of observation, experimental finesse, ability to draw diagrams and make tables and to interpret observations and derive conclusions.

[Later on, five experiments from well-defined categories were given.]

Classes 6 and 7

The procedure outlined above, and as mentioned at the outset, is for an evaluation done by an external board of examiners. In the school tests, taken by the teacher himself at monthly, bi-annual or annual level, it is not necessary to determine the weightage through this procedure, since the class teacher is aware of the relative importance of various chapters and hence can pre-allocate marks on his own. The other fact is that since random sample is required for final allocation, this would not be an appropriate method in case the actual number of answer books is small, as would be the case in many school tests.

However, if the annual examination for classes 6 and 7 is envisaged at the block level, then the procedure described above should be used.

Summary

Briefly, the HSTP examination system had many elements that were different from the traditional examinations. These were:

- Freedom to refer to note books and textbooks (open-book examination).
- Unlimited time for the written examination.
- Provision for holding a practical examination (at middle school stage).

- Group setting of question papers.
- Consciously incorporating questions outside the curriculum.
- Review and analysis of answer sheets.
- Not specifying marks allotted for each answer in the question paper.
- Redistribution of marks after the examination.
- Division of the curriculum as per examination requirements.
- Super marks.
- Two sessions to solve question papers and freedom to talk in the interval (in the initial phase).

After the district-level expansion

Many of these provisions were retained even after the district-level expansion and were integrated into the HSTP divisional Board examination. The Divisional Superintendent of Education published an examination manual. The manual had the distinction of providing logic and reason behind the structure and processes adopted in the HSTP examination, so that it is implemented on the basis of proper understanding rather than as a dictum.

Barring super marks, unlimited time and the freedom to discuss during the written examination, the other provisions were retained. Question paper setters were given the following instruction: "The time specified for the written examination is 2.5 hours. The paper should be such that an average student can answer all the questions in about 2 hours in a relaxed manner bereft of fear."

According to the manual, the written and practical examinations were for 60 and 40 marks respectively. To pass, a student needed to score a minimum of 25 percent in each, with a combined percentage of 33 percent. The manual also stated that "the majority of questions in the two examinations should be such that the student would have to do some written and practical activities. The only difference between the two is that the written examination focuses more on theory and concepts while the practical examination tests more for experimental skills."

Practical examination

The practical examination was retained at the district level although internal evaluation was discontinued. Actually, like in other subjects, internal evaluation (so called continuous evaluation) continued to be done but since it did not affect the result of the final examination, it was taken less seriously. The practical examination tested the student's ability to perform experiments, observe what is happening and explain her observations.

The initial arrangement for conducting the practical examination after the district-level expansion was as follows: a team of two examiners would go to each school, set the question paper and try to complete correcting the answer papers there itself. Each student had to do five experiments, each carrying seven marks. The remaining five marks were for the *viva-voce*.

But there were some practical and human problems in conducting examinations in this way. One problem was that many examiners often found it difficult to think up good experiments to judge the students' abilities. Then, there was 'problems' of standardisation of the practical examination across schools.

One human problem was that the examiners could not do their duty with objectivity; how could you fail the students sitting right in front of you? Another problem was the pressure put on the examiner by the local school teacher. As a result, teachers themselves began questioning the objectivity of the practical examinations.

This was pointed out in a letter written by Dr. Arvind Gupte to the Divisional Education Commissioner on December 15, 1982: "Around 9,000 students sat for the 1982 divisional middle school examination... Of them, around 2,400 failed in the written examination while only 19 of the regular students failed in the practical examination. Among private students, 148 failed in the written examination and 20 in the practical examination." He concluded that "proper evaluation yardsticks were not used for the practical examination, turning it into a meaningless exercise. This laxity in conducting the examination will definitely have a negative impact on academic standards."

Analysing the human and academic factors behind this deterioration, the letter offered some recommendations. The main recommendations were that evaluation of the answer sheets should be done at the *Sangam Kendra* level and the teachers should be trained to conduct practical examinations.

When these problems began to surface, the resource group, in the typical HSTP spirit, began a dialogue with the teachers, seeking their participation, guidance and advice. The issue was discussed at the monthly meetings held in January 1983, where the teachers made their suggestions. But these suggestions were too diverse and often contradictory. For example, one suggestion was to leave the practical examination entirely to the local teachers while another was that the examiners should come from as far away as possible. Some teachers felt that the experiments should be selected in consultation with the teachers but others felt that the paper should be set at the district level. Some teachers wanted a readymade list of experiments from which examiners could choose (as is done at the college level). Then again, while some teachers wanted answer papers to be corrected in the presence of the teachers, others wanted this to be done later at the *Sangam Kendra*.

Most teachers accepted that the nature and the purpose of the practical examination were different from those of the written examination but felt that it was difficult to keep track of a child's overall performance in the practical examination. That's why they felt that valuation should be done on the spot. All of them concurred that it was the laxity in setting the question papers which was the main cause for the falling standards of practical examination.

To summarise, the teachers' suggestions were of two kinds. There were those who felt that the practical examinations should be more decentralised to make them more effective. This would ensure proper assessment of experimental skills of students taking into consideration the prevailing conditions in schools. On the other hand were the teachers who wanted a standard examination of uniform quality for all students.

There were cases where examiners wanted to set an experiment only to find that the chapter had not been done in the school or that the required kit material was not available. Many times they set very simple or very difficult experiments. So the problem was to ensure that the practical examination maintained a high standard while taking into consideration the conditions in schools.

Keeping this dual requirement in mind, the system was modified in 1983. Under the new system, the question paper was to be set by a group of teachers at the *Sangam Kendra* level. This is how it worked. A meeting of teachers would be convened on a certain day and teachers would work in groups of 2 or 3 to formulate questions. The *Sangam Kendra* coordinator would then make sets of five questions for each school and seal them in an envelope. The envelope would be taken to the school by the examiner, who would open the envelope and conduct the examination in the concerned school. The examiner had the authority to change one question depending on the circumstances.

A Good Question for a Practical Examination (from the Examination Manual)

"Make an accurate weighing balance with the wooden strip, string and leaf-cups given to you. Don't forget to label your balance with your name and roll number."

This question helps to evaluate conceptual understanding as well as experimental skills using simple and easily available materials. Only those students who understand the principle of balance will be able to make an accurate weighing balance. This means they must know that it isn't enough to merely balance the weight in the two pans; the distance of the pans from the fulcrum must also be equal. If the examiner wishes, she can probe this understanding further. For this each examinee could be called separately and asked to prove with the help of weights that the balance weighs correctly.

Another problem with practical examination was that the examiner would often reach a school only to find that the kit needed for an experiment was not available. One way of solving this problem was to attach a common kit list for all the question papers and send it beforehand to all schools in the *Sangam Kendra* to ensure that proper kit arrangements were made. One fear was that this would increase the chances of leakage of the question paper. But the experience over the years showed that this fear was more or less baseless.

The answer papers of the students used to be assessed later at the *Sangam Kendra*. Oral evaluation was discontinued and in its place 5 marks were allotted to one of the questions. These marks were for skill and neatness and the examiner would allot them during the examination itself, noting them in the answer sheet.

This new system changed the nature of the practical examination. The main impact was that at the time of making the question paper attention had to be paid that the experiments should be such that some evidence could be attached to the answer sheets or somehow it could be ascertained that the child actually did the experiment.

The teachers were concerned about the variety of experimental skills to be evaluated. Keeping this in mind, the curriculum was divided into six parts for the purpose of practical examination:

1. **Measurement**: Measuring distance, area and volume. Weighing things. Measuring temperature. Units of measurement. Least count. Approximation. Variation. Precautions and errors in measurement, etc.

2. **Environmental awareness**: Diversity in parts of plants. Crops and diseases affecting plants. General knowledge of insects and other animals. Diversity in the living world. Soil, etc.

3. **Chemistry**: Separation. Acids, bases, salts and their neutralisation. Gases. Chemical skills, etc.

4. **Scientific processes**: Observational skills. Asking meaningful questions. Making graphs. Making groups. Making Maps, etc.
5. **General concepts**: Magnetic effects of electricity. Volume. Reproduction. Heat. Light. Internal structure of the body. Chance and probability. Why do things float? etc.
6. **Special**: Making equipment with local materials. Performing experiments according to given instructions, etc.

The question paper had to have one question each for the first three areas (1, 2, 3) and one question each for at least two of the three remaining areas (4, 5, 6). Since the examiner was free to change any one question, the change had to be for the same area.

Written examinations

Group question paper setting: Setting question papers in a group was a practice that was retained after the district-level expansion of the HSTP. At the 16-school stage, the resource group used to set the question paper. The task was given to the teachers after the district-level expansion. This was clearly stated in the examination manual: "As far as possible, scope for group discussions among teachers should be ensured for formulating questions and setting question papers. Experience shows that no matter how knowledgeable a person is, peer group interaction enhances her/his ability to set better questions or a more balanced question paper. So the responsibility for setting question papers for the written and practical examinations should be given to groups of at least three (if not four) teachers."

Such a collective process raised the question of maintaining secrecy. But the teachers saw it as a progressive step and participated enthusiastically. This had a positive impact on the type of questions set and the overall quality of the question paper.

Open-book examinations

Students were allowed to take *Bal Vaigyanik* and their note books to the examination hall. The HSTP didn't expect children to memorise information in the textbook and notebook. So they were free to refer to their textbooks and notebooks (in which they noted down their observations, summarised classroom discussions and recorded laws, definitions, etc.) during the examination. This meant that they didn't have to memorise facts, terminology, experimental methods or other information for the examination. Moreover, any additional information required to answer a question was usually given along with the question.

Apart from curbing the tendency to memorise information, the idea of allowing children to search for information required to answer a question in their textbooks or notebooks was basically to take the fear and tension out of examinations.

The open-book system proved to be a worthy challenge for teachers as well. The examination manual stipulates that "the questions should be such that their answers cannot be directly obtained or copied from the textbook or notebooks." That meant that the question paper setter could not ask definitions, laws, etc. in a question. The manual also made it clear that the "examination would evaluate the development of scientific skills and perspective in students and their ability to use the scientific method and logical analysis to acquire knowledge. It would also evaluate how well they have understood basic scientific concepts and how aware they are of their environment." That's why the hope was that "the questions would be such that they judge the children's observational and analytical abilities, experimental skills, curiosity, creativity and conceptual clarity."

But many questions were raised about the open-book examinations, mainly by parents. Their fear was that allowing children to consult their books would encourage them to copy. It reflects an understanding that this is the only use of a book, especially a textbook. After all, examinations are mainly to test mental retention and memorised answers. So if the textbook was in front of the child, then what was the purpose of the examination?

When parents were told that no questions from the textbook would be asked (so there would be no scope for copying answers), they were only confused further. What was the purpose of allowing textbooks for examinations if the answers could not be found in them, they asked. Shouldn't the textbooks have all the answers? It is not a part of popular psyche that the textbooks can be referred to in order to construct proper answers.

There were other misgivings which reflect the same perceptions of the textbook. The teachers often mentioned that the children kept sifting through the book in the hope of getting the answers and wasted valuable time in the process. Thus even children have inherited the idea that the book should supply all the answers Not much attention had been paid during the HSTP teacher training camps to inform teachers about what purpose a textbook serves and how it is to be used.

It wasn't as if examination-related issues were not discussed during the teacher training. They were given adequate space but using textbooks during examination was never discussed in any depth. Therefore, even teachers did not have any clear idea of the role of textbook in the examination (apart from memorising it or getting readymade answers from it). Thus, full potential of such an important dimension of the innovation could not be realised.

The open-book examination led to another problem. 'Preparing for exams normally meant going through the textbook and revising the answers to the questions it contained. If children were allowed to refer to their books during the examination, then what did 'preparing for the examination' mean? Parents were not too happy with the situation, although children liked the change.

The reactions suggest that the open-book approach forced people to look with new eyes at the concept of examination. It also reduced pre-examination jitters and tension levels, which made children happy. They remember the practical examination as a kind of holiday, a fact highlighted by the pilot study conducted after the HSTP was shut down.

Examinations in all three classes

The examination manual stated that topics from classes 6 and 7 could also be asked in the class 8 Board examination. This tended to upset both the teachers and the parents. The general attitude was that once a topic figures in an examination, it should not be taken up again (because you have the right to forget everything once the examination is over). People also felt that allowing questions on the content of all three classes in the class 8 examination would be too much of a burden on children. The examination manual provided the following justification:

> This fear has no basis [because] the examination tests only those qualities that should develop and be internalised if a student performs experiments or goes to a field trip in the

> proper manner. For example, if a student is taught to make detailed observations, (s)he will be able to use this ability in any situation, even if it is outside the syllabus. If a question seeks to test the observational powers of a student, it doesn't matter which class content the question is taken from. In the same way if a student has learnt how to plot graphs, (s)he should face no problem whether the data for plotting the graph is taken from class 6 or class 7, or even from outside the syllabus. Questions can be asked in the class 8 Board examination on fundamental concepts covered in class 6 and class 7. For example, if a student has learnt to group things on the basis of common properties, then (s)he can be asked to group any random items to assess whether (s)he has grasped the concept of grouping. There are some scientific concepts such as grouping, measurement, variation, least count, etc., that are relevant in all scientific processes and at all levels of the science curriculum and without understanding them a student cannot claim to have learnt science. So the rule is that in the class 8 Board examination questions will be asked only about fundamental concepts from class 6 and class7 and not on every topic covered in these classes.

A list of fundamental concepts of the HSTP curriculum was circulated as part of the examination manual. This list can be seen in chapter 4 (Curriculum and Syllabus, page 43).

Some of these concepts are sweeping in their range and complexity. Among these are the last two concepts (in the list – Diversity in the Living World and Chance and Probability). The students were not expected to understand such concepts in their totality; the only expectation is that they begin to understand and use them. The question paper setters are sensitised to this fact. We have already discussed this aspect from the point of view of examination in the chapter on curriculum.

An example of a Good Question for the Written Examination from the Examination Manual

"Class 6 has a chapter on 'Separation', in which children learn different ways to separate substances contained in a mixture. Many kinds of questions are asked on this topic in the examinations. See some examples below:

1. Describe at least three methods of separating substances.
2. Explain the following terms: sublimation, chromatography, distillation.
3. How would you separate a mixture of camphor and ammonium chloride?

These three questions can only be answered by students who have previous knowledge about the topic. They do not assess the experimental skills or scientific attitude of a student or her/his understanding of the theoretical aspects of separation. A student who remembers some facts about the topic (regardless of whether (s)he understands them or not) will be able to score well in answering these questions. Such questions will not be asked in the HSTP examination.

Now have a look at a question on separation that complies with the HSTP objectives:

Some information about four substances is given in the table below:

Substance	**Soluble in water?**	**Sublimation occurs or not?**
Ammonium chloride	Yes	Yes
Camphor	No	No
Salt	Yes	No
Sand	No	No

a) How will you separate a mixture of camphor and ammonium chloride?

b) How will you separate a mixture of camphor, ammonium chloride, salt and sand?

The question contains information about solubility in water and sublimation of the four substances. Students are expected to use this information to think of ways to separate these substances from the mixture. The question tests the student's ability to analyse logically and only indirectly tests her understanding of separation. If the student has more or less forgotten the separation methods, she can still answer the question on the basis of logic, reasoning and analysis if she has performed the experiment.

Minimum expectations

The minimum expectation to pass the examination was that students understood the following basic concepts:

1. Forming groups and sub-groups.
2. Measuring distance, area, volume and mass. Measuring units, expressing them in decimals. Least count, errors in measurement, variation, approximation, average and mode.
3. Coordinates and drawing maps.
4. Making tables, bar diagrams and graphs, understanding them and drawing conclusions from them.
5. Making provisions for control in experiments.
6. Skill to conduct general and chemical experiments.
7. Ability to make equipment from locally available materials.

A third of the question paper was devoted to evaluating these minimum expectations, with a third of the total marks allotted to them (that is, 20 marks).

The Nature of questions

Two points about the nature of questions have already been made – that they are not based on memorised information, and that their answers cannot be copied straight from the textbook or notebook.

Apart from this, question paper setters were expected to keep in mind the linkages and continuity of the content across all the three classes. They were also expected to include some questions that had no direct link to the topics covered in the syllabus but tested students' understanding of some basic scientific concepts. The only caution was that they should bear in mind that whatever they asked wasn't beyond the grasp and experience of an average student.

They were also expected to formulate questions that may have more than one possible 'correct' answer to assess the creativity and special talents of students.

Question paper setting process

A meeting of 30-40 teachers was convened every December-January. A few new teachers were added to the group every year. The teachers would first review the previous year's question paper. Each question was discussed to see if it complied with the HSTP objectives. The overall balance in the paper was also assessed. The aim of the exercise was to pick out the positive as well as the negative aspects of the question paper and move one step ahead. It was also to familiarise new teachers joining the process with the overall objectives of the HSTP examination and the nature of questions to be asked. Sometimes the performance of students in different questions was also analysed.

Next, the group would study and discuss the examination manual to familiarise everyone with the purpose and methods of evaluation. The issues discussed included 'fundamental concepts', 'minimum expectations' and what constitutes a balanced question paper. Resource persons from Kishore Bharati/Eklavya and others were present to assist in this process.

After this, the teachers were divided into groups of 4-5 and each group was expected to formulate a question paper. It normally took around two days to finalise the question papers. The marks for each question were specified, along with instructions for evaluating the answers. The marks were not printed on the question paper. (these were tentative marks that used to be reviewed and redistributed after the examination using a statistical method). The question papers and the evaluation criteria would be sealed in separate envelopes and handed over to the Divisional Superintendent of Education (DSE) office.

After this, the DSE would call a moderator – normally a teacher or lecturer from a high or higher secondary school who was part of the resource or operational group. The moderator would be given 5-6 question papers. Her/his job was to prepare a set of three question papers. (S)he could choose any three of the submitted question papers, or combine questions from different question papers to make new question papers. Her/his major responsibility was to ensure that the question papers covered the fundamental concepts, minimum expectations and a major portion of the curriculum in a balanced manner.

The three question papers made by the moderator, along with the memorandum for evaluation, would then be sealed in three envelopes and again handed over to the DSE who would, without looking at them, allot one for the main Board examination and one for the supplementary examination. The third question paper was kept secure for emergency situations.

The next step was printing the question paper. The demand for secrecy meant that the question paper should not fall into the hands of anyone who could misuse it before the examination. Hence proof-reading and other jobs had to be done by the printers themselves. As a result some mistakes were inevitably committed at this stage. For example, the printer once reduced the size of a diagram in a question linked to area measurement, leading to changes in all the answers. But there was a system to address such problems. We shall now discuss this procedure.

Redistribution of marks

There are two aspects to the process of redistributing marks. The first is reviewing the question paper on the basis of the answers given by students and then preparing fresh evaluation criteria on the basis of this review. In a way this process acknowledged the fact that no matter how carefully or with how much effort one formulated questions and prepared a question paper, there would always be shortcomings and scope for improvement. The way children answered the questions could be seen as a comment on the question paper.

If this review process is conducted well and with care, it can become a valid basis for curricular and pedagogical reform.

There may be two kinds of problems with question papers. First is the way a question is posed. Possibly, because of the language or diagrams used the child is unable to understand the question the way the question setter intended. Or there can be more than one possible answer to the question. Children's answers will then be different from the expected answer. In a mainstream examination, these 'different' answers will be marked 'wrong', without considering the possibility that they may be just as logical, given the way the question is posed. If this is the case, these answers should also qualify as right. The advantage with this approach (of reviewing the answer sheets) is that one can ask open-ended questions or questions with more than one possible answer.

The second kind of problem is that the question paper setter may have misjudged the difficulty level of the question, it turning out to be either too difficult or too easy. Both situations are problematic. As mentioned earlier, the objective of the HSTP examination was twofold: first was to evaluate the minimum level of understanding of the stipulated curriculum, and second was to assess the relative abilities of children. A question that was too difficult or too simple would not serve this purpose. That's why it was necessary to reallocate the marks allotted to the question.

When setting the question paper, marks were allotted for each answer but they were not indicated in the question paper. Therefore, so far as marks were concerned, children had no clue of the relative importance of each question while taking the examination. There were two reasons for not indicating the marks. First, this information was of no use to students, although some teachers felt that children should know the marks allotted for each question; they could then decide which answer should be how long. This was a wrong assumption because the effort required to answer a question was not linked merely to how long the answer was.

The second reason was that children had to answer all the questions in the HSTP examination. So, eventually, it didn't make a difference which question carries more marks.

Another reason for not indicating the marks for answers was the possibility of redistributing the marks after reviewing the answer papers, so allotting marks beforehand was unnecessary.

A brief description of the process of redistribution of marks follows:

Before the examination was held, around 500 roll numbers of students appearing for the examination were randomly selected and sent to the examination centres. This was about 5 percent of the total number of students sitting for the examination (around 10,000). Each centre picked out the answer sheets of all the randomly selected students appearing at that centre, sealed them in an envelope and dispatched them to the DSE Office.

Groups of 2-3 teachers would then evaluate each of the randomly selected answer sheets at a 'marks redistribution' workshop, first giving marks as per the predetermined allocations. These marks were noted down on a sheet of paper and not on the answer sheets because they were not the final but temporary marks.

The evaluating groups would also note down all the answers given by children that were not the 'correct' answers. These 'wrong' answers were reviewed to see whether children may have understood the questions differently because of lack of clarity in the language or presentation or any other aspect pertaining to the question.

This analysis provided feedback on the curriculum and the textbook as well as the teaching methodology. So the process can be looked at as an attempt to add a new dimension – feedback collection – to examinations.

The marks obtained by each student were totalled and the mark-sheets were arranged in descending order of the total marks obtained.

Now came the statistical calculation using certain formulae developed for the purpose. The mark-sheets were divided into three equal lots, with lot 1 being the highest scoring students, lot 2 the lowest scoring students and lot 3 the in-between students. Lot 3 was set aside during the next step.

The total marks obtained for each question in lots 1 and 2 were compared and two indices were calculated: the facility index and the discrimination index.

The facility index (F_x) indicated the average marks scored per student for the question: if 1 mark is allotted to a question, how much each student scored on an average. Clearly, the facility index would fall between 0 and 1. If no student answered the question the index would be 0 and if all the students answered it the index would be 1. In a way the index judged the difficulty level of the question: the higher the index, the easier it was.

The discrimination index (D_x) showed the average difference between two groups of students. This indicator would also range from 0 to 1. If 1 mark was allotted to a question and if one group of students scored 1 and a second group scored 0, then the discrimination index would be 1. If both groups scored the same marks the index would be 0. The index showed how good the question was in differentiating between children: the higher the index, the greater the differentiation. (Theoretically this indicator could also be negative but it never was so in the many years it was used.)

What we required was that, firstly, a question was neither too easy nor too difficult, and, secondly, the question can differentiate better between better and weaker students. For this, a balance had to be achieved between the facility index and the discrimination index. To achieve this balance, a combined indicator called the quality coefficient was calculated:

$$\text{Quality coefficient } (\alpha_x) = F_x D_x (1 - F_x)$$

The quality coefficient shows where the question stands in relation to the facility index and the discrimination index. The redistribution coefficient of the question was then obtained by the following method:

$$\text{Redistribution coefficient } W_x = \alpha_x \times \text{marks allotted for question no. } X$$

The weightage of all the questions was calculated in this way. However, all questions with minimum expectations were excluded from the calculation. Once the weightage was determined, the marks for each question were redistributed using the following formula:

$$M_x = W_x \times Mt/\sum W$$

Here M_x is the redistributed marks of Question X, W_x is the redistribution coefficient, Mt is the total allotted marks for all the questions (excluding the questions related to the minimum expectations), and $\sum W$ is the total of the redistribution coefficient of all the questions.

This process may appear a bit complicated but most teachers learned to do the task with a fair degree of competence.

But the process did give rise to many misconceptions about the HSTP examination system. Critics accused the HSTP examiners of discarding difficult questions to improve the overall examination result. They also felt that the brighter students who could answer the more difficult questions were placed at a disadvantage. Many people felt that it was undesirable to carry out such exercises once the examination was over because that would tend to dilute its seriousness. Many people, ignorant of the exact process, felt that all this was done to improve the result. However, most of the teachers who participated in the process saw it as highly useful and transparent.

Actual questions

It would be useful to look at the questions actually asked given the theoretical framework. Were they suited to the objectives of the HSTP? Is the spirit of innovation evident in designing questions?

Question paper setting was one of the most difficult challenges in the HSTP, so whatever was attempted should be seen in this light.

We had pointed out earlier that resource persons associated with Kishore Bharati and Friends Rural Centre conducted the examinations during the 16-school phase. Most of them were university teachers or research scientists. They were knowledgeable in their subject areas and understood the links between different concepts. After the district-level expansion, middle school teachers took over the process of setting question papers. Inevitably there were qualitative differences between the questions formulated during the first phase (1975-78) and the post district-level expansion phase.

There is no denying that the teachers did make sincere efforts to set questions that complied with the HSTP objectives.

Between 1981 and 2002, 22 main annual examinations (and as many supplementary examinations) were conducted in Hoshangabad district alone. Apart from this, annual examinations were also conducted in Indore and Ujjain divisions (1986-2002) and Harda district (following its bifurcation from Hoshangabad district). If the questions set during this period are analysed, one astonishing fact emerges: barring a couple of exceptions, no question was ever repeated. The teachers maintained the pressure to formulate new questions year after year.

It is also evident that they made every effort to judge conceptual understanding and skill development among children. In fact, it would be useful to publish the HSTP question papers. Some examples are given below.

Some questions asked in the examinations

The HSTP took great care to ensure that the questions were not memory-based and did not seek to extract information. But carrying this out in practice was a difficult challenge that tested the creativity of the question paper setters. Yet, many commendable efforts were made. We shall discuss some examples here to see the basic differences between the HSTP examination and the mainstream Board examination:

1. April 1976 (class 6)

   What are the properties you would look for if you wanted to find the differences between two wheat plants? And why? (Some plants are displayed in the examination hall. You may look at them if you wish.)

2. April 1976 (class 8)

   a) You have done copper plating experiments using electric current. How would you coat an iron vessel with copper? Draw a diagram to explain the process.

b) Can this method be used to copper plate an earthen vessel? Yes/No.

Give reasons for your answer.

3. April 1976 (class 8)

Read experiment 1 in the chapter "Looking at the Sky". In this experiment, a stick is planted vertically in the ground and pegs are fixed at half-hour intervals on the tip of its moving shadow. A boy from Hoshangabad performed this experiment and drew a line to join all the pegs. The line looked like the one drawn below. In this diagram, the timings of only two pegs are specified: 1 pm and 2 pm. Now answer the following questions:

i) Where was the stick planted? Indicate its position in the diagram.

ii) The line has three points a, b and c marked on it. At which of the three points would the 3 pm peg be?

iii) Indicate the east and west directions in the diagram.

iv) Indicate the north and south directions in the diagram.

v) Can you tell by looking at the diagram in which season the experiment was done?

4. 1975

Design an experiment to find out whether sunlight is needed/ not needed for seeds to germinate.

5. 1974

Suggest an experiment to prove that the air you breathe out and the gas produced by a burning candle both contain carbon dioxide. Draw a diagram of the experimental set-up.

6. Two groups are given four substances each. The properties of these substances are listed in the table below.

Substance	Dissolves in water?	Magnetic or not?	Melts easily?
Iron filings	No	Yes	No
Wax	No	No	Yes
Sugar	Yes	No	No
Lac	No	No	Yes

One group chose a substance and the other asked the following questions to find out what the substance was:

1. Is the substance soluble? Answer: No
2. Is it magnetic? Answer: No
3. Is it white? Answer: No

a) What is the substance?

b) Can you formulate better questions so that you can get the correct answer by asking fewer questions? Write the questions in the blanks below.

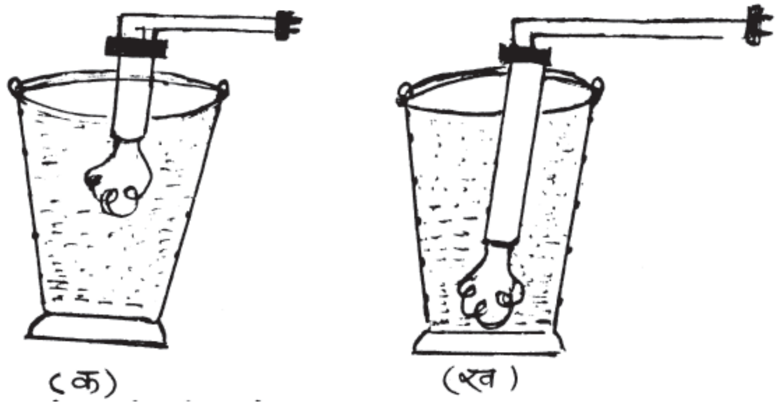
7. Hoshangabad annual examination, 1996.

Mahesh heated water in two buckets by placing some apparatus in the buckets in the way shown in the diagrams below. Answer the following questions:

i) In which bucket will the water be heated quicker?

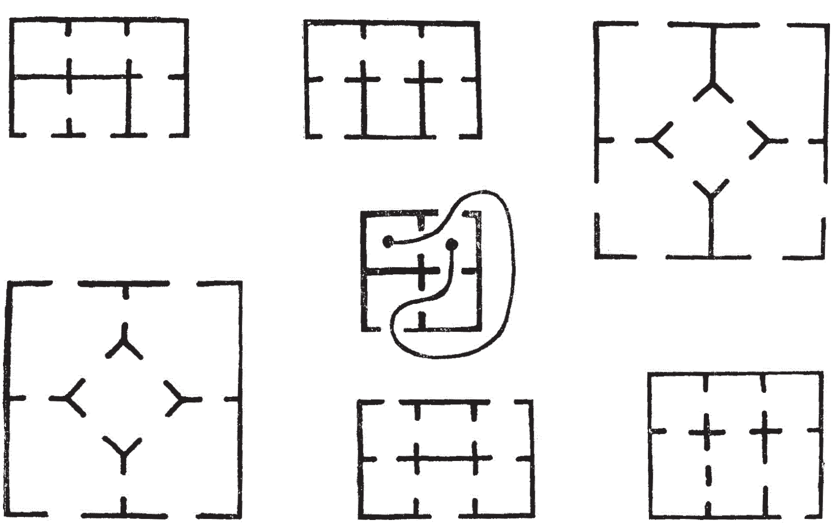
ii) Why does the water in that bucket heat faster?

iii) How is heat transferred in this case?



[This question was discarded because a review of the question showed that most children were unfamiliar with the 'apparatus' and so could not answer correctly.]

8. Diagrams of several houses are given below. In each diagram draw a line passing through all the doors of the house without going through any door twice (as shown in the diagram in the centre). Mark those diagrams with an x where it is not possible to draw the line. Make a new door in these cases to make it possible.



9. Hoshangabad 1985.

   Satta is a game played with money. The players choose one among 10 numbers – 0, 1, 2, 3, 4, 5, 6, 7, 8, and 9 – and bet money on it. If that number opens, they win.

   What are the chances of a player winning?

   If the bet is played with two numbers then the numbers would be 00, 01, 02.....98, 99. A player can bet on any pair of numbers and wins if that pair opens.

   What are the chances of a player winning with a pair of numbers?

   On the basis of your observations, is playing *Satta* gainful or harmful?

This last question, linked to the children's social environment, reverberated in the state assembly (*Vidhan Sabha*) where it was alleged that the HSTP was teaching students to play *satta*. This was a rare instance of such a debate on an educational issue taking place in the state assembly.

But, it must be added that class 6 and 7 examinations were conducted at the school level and efforts to include such innovative questions are not evident there. This could be because, except for a small percentage, many of the teachers had not participated in question paper setting for the Board examinations, so they could not benefit from the discussions that took place during these exercises. These teachers usually stuck to formulating the more traditional type of questions for the school examinations.

But why didn't the questions asked in the Board examinations influence or put pressure on these teachers? This is something that needs looking into. One reason could be lack of resources.

There is little scope for using diagrams and other materials for local examinations because the question papers are not printed. Another reason could be that large number of teachers did not get adequate exposure to enable them to make question papers with new objectives.

Teachers from many *Sangam Kendras* did try to address this problem and came up with a new initiative. They got together and decided to prepare a single question paper for all the 50-60 schools of their school complex. This provided the opportunity for the teachers to work with the resource teachers to prepare 'good' questions. A second advantage was that the question paper could be printed, because it served a larger number of schools. Once this system was implemented some improvement could be seen, yet a problem remained.

The education administration played no part in this process of preparing collective question papers at the *Sangam Kendra* level. So it was an effort coordinated solely by the teachers. A school could opt to join it or not. But wherever the attempt was made, all the schools in the *Sangam Kendra* did join in. The only difficulty was that teachers had to find time and spend extra hours to do this work in the absence of official permission.

Impact on teaching/learning

One aspect of the question papers is that teachers favoured questions which coud be valuated 'objectively'. In other words, a question should be such that instruction for their valuation can be clearly and unambiguously framed. As a result there was less space for open-ended questions or questions with more than one correct answer, and their number went down. The proportion of questions requiring children to write explanations also decreased because in assessing such answers there was always the risk of 'subjectivity' creeping in. Such changes were perhaps inevitable when a system is scaled up to the macro level.

One other related consequence was that more questions began to be asked from chapters where it was easy to frame questions whose assessment had less scope for ambiguity.

The skewed representation of chapters can be seen in a review of question papers set between 1982 and 2002. Some chapters featured regularly every year, while some others were almost totally overlooked. It wasn't just the chapters. Even different concepts, elements of the scientific method and experimental skills began to get uneven attention in question paper setting. It is clear from an analysis of question papers that certain chapters appeared every year while some others were ignored.

Chapters from which questions were asked almost every year were:

1. Measurement
2. Coordinates
3. Graphs
4. Decimals
5. Electricity
6. Bar diagrams/Probability
7. Time and Pendulum
8. Acids, Bases and Salts
9. Relative Density
10. Structure of Human Body (after 1987)

Four of these chapters were part of the minimum expectations.

Among the chapters that tended to be neglected were the following:

1. Living World through a Microscope
2. Sound
3. Heat
4. Reproduction
5. Gases
6. Living and Non-living

7. Looking at the Sky
8. Light
9. Soil

It is not as if no questions were asked from these chapters, but their proportion fell. If seen in terms of marks, more than half the questions were from the following chapters:

Chapter	Marks Allocated
1. Measurement	98 (minimum expectations)
2. Coordinates	68 (minimum expectations)
3. Graphs	88 (minimum expectations)
4. Bar diagrams	89
5. Acids, Bases and Salts	55
6. Relative Density	69

This distribution is seen in a survey of question papers covering 15 years (for which the question papers and the final allocated marks are available). The total marks for the 15 years were 900 (60 x 15) and the above six topics accounted for 467 marks (51 percent).

Other chapters that have more or less adequate representation include:

Chapter	Marks Allocated
1. Decimals	36 (minimum expectations)
2. Classification, Grouping	33 (minimum expectations)
3. Electricity	48
4. Pendulum	32
5. True/False	35
6. Life Cycle of Animals	45
7. Structure of the Human Body	33

Among these, the last two ("Life Cycle of Animals" and "Structure of the Human Body") began to find a place after 1987.

The question paper review exercise carried out in 1986 showed that almost no questions were being asked from some chapters. So, many teachers had stopped teaching these chapters. Among these were the biology chapters, whose representation in the survey cited above was as follows:

Chapter	Marks Allocated
1. Environment/General Observations	11
2. Crops	22
3. Flowers, Reproduction in Plants	8
4. Life Cycle of Animals	33
5. Structure of the Human Body	45
6. Growth/Development	12
7. Living and Non-living	22

These chapters accounted for 153 (17 percent) of the 900 marks. This was the situation even after questions began to be asked almost every year after 1987 from the two chapters "Life Cycle of Animals" and "Structure of the Human Body".

The situation until 1986 was as follows:

Chapter	Marks Allocated
1. Graphs	29
2. Measurement	27
3. Relative Density	22
4. Bar Diagrams	21
5. Acids, Bases and Salts	20
6. Coordinates	19

7.	Environment/Observations	11
8.	Pendulum	9
9.	Flowers/Reproduction	7
10.	Crops	5
11.	Soil	2
12.	Life Cycle of Animals	0
13.	Structure of the Human Body	0
14.	Growth/Development	0
15.	Living and Non-living	0

This imbalance in assessing learning outcomes through examinations raises many questions. The first question is: What effect it would have had on teaching/learning? There is no systematic information available on this aspect but if we accept what the teachers have often said, they had guessed it and modified their teaching strategies accordingly.

For example, when teachers at the Piparia meeting were asked whether the examinations had any impact on teaching in schools, they replied in the affirmative, saying the impact was significant. The chapters not included in the examination were seldom taught. The chapters considered important from the examination point of view included "Motion in Graphs", "Grouping", "Acids, Bases and Salts", "Why Do Things Float?", "Time and the Pendulum", "Chance and Probability", etc. The chapters that were neglected or overlooked because they seldom figured in the examinations included "Looking at the Sky", "Machines", "The Living World through a Microscope", "Classification", "Electricity", "Growth", and "Development".

The second question is: Why did this happen? Was it a consequence of the limited creative abilities of the question paper setters? Or we have to admit that an examination of this kind cannot assess understanding of some concepts or judge skills and abilities? In other words, did this mean that the HSTP written and practical examinations were inadequate and there was a need to add another dimension to them?

Take the example of biology chapters. They encouraged children to study animals and plants, fruits and flowers, insects, crops and crop diseases in their immediate environment. In the process they developed skills and methods which not only sensitised them to their environment, but also equipped them to continue learning on their own. How would a written examination test these aspects?

Similarly, the chapter "Structure of the Human Body" taught children how to recognise the different bones in their body, understand how the joints work, and build up a mental picture of the body and its different organs. The same was the case with chapters like "Life Cycle of Animals", "Growth", "Development", "Reproduction", etc. How was sensitivity towards the environment to be assessed?

The attempt in all these chapters was to develop in children's minds an understanding of their milieu and to familiarise them with methods to study the environment. Such an understanding cannot be universal, nor can the methods. Looked at from a conceptual point of view, the HSTP examinations, despite all the innovative efforts, remained behaviourist. Children were generally asked questions to which there could be only one correct answer, so that an evaluation could be made. Therefore even if the HSTP examination provided greater scope for open-ended questions – and such questions were set from time to time – compared to the mainstream examinations, somehow conceptual understanding or mental images are not amenable to assessment through such examinations. It demanded more creativity to find a fitting answer to this problem.

This problem had an interesting outcome. When pressure on the teachers increased to set questions from as many chapters as possible, they began setting questions from two particular chapters – "Life Cycle of Animals" and "Structure of the Human Body". All the question papers set after 1987 contain questions from these chapters, but most of them were formulated by merely tinkering a bit with the questions in the 1987 paper.

We have noted above that some chapters predominated in question paper setting. A closer look at the questions reveals that most of them were basically numerical in nature. This wasn't a problem in the case of mathematical concepts like measurement, coordinates and graphs. But even in the case of concepts like chance and probability, acids, bases and salts and relative density, the focus of the questions was on the numerical aspects rather than conceptual understanding.

It seems that these chapters were favoured because they were more amenable to formulation of questions that made assessment 'objective', straightforward and unambiguous. For example, in "Acids, Bases and Salts" the question would usually have a table giving the effect of indicators on different substances and asking the children to identify acids or bases. Or it would be questions involving calculations, which were more popular. Similarly, the "Chance and Probability" chapter is based on an abstract concept that the children were not expected to grasp in its totality. But very few questions were set on this abstract concept. Instead, there was an abundance of questions on drawing bar diagrams of given data, finding the mode, finding the average, etc.

Another interesting observation is that whenever a conceptual question was asked, it would usually be structured in sequential manner. Some marks were allotted for each step. Finally, when it came to applying the concept, some more marks were allotted like any other step.

In sum, it can be said that the HSTP did develop a totally new examination method. Ideally, the HSTP group would have preferred to leave the task of assessment entirely on the teachers themselves, but mainstreaming necessitated a Board examination. Efforts were made to free children from the tension of examinations by introducing open book examinations and giving them unlimited time to answer (at least in the initial phase). To keep the examination sensitive to school, the HSTP introduced systems for question paper setting by groups of teachers, for reviewing question papers after the examination and for redistributing the allotted marks for each question. In addition, the HSTP gave greater emphasis to testing experimental skills in children with its provision for conducting practical examinations.

The teachers were instructed not to formulate questions that tested children for memorised information or whose answers could be copied directly from the textbook. Setting an HSTP question paper thus became a challenge for them and most of them responded in a concrete way, making every attempt to set questions that evaluated the conceptual understanding of children. Most important, the teachers tried to ensure that questions were not repeated over the years and this is reflected in the question papers set during the 25 or so years following the district-level expansion.

One positive outcome was that the fear of examinations was considerably reduced. This was mainly because children were free to consult their textbooks and notebooks during examinations. In actual practice, children did not make much use of this option but the fact that they had the textbook with them had a striking psychological impact.

Teachers also changed in the way they looked at examinations. Setting question papers in groups and reviewing them after the examinations were processes that gave them a new platform for educational dialogues and discussion. The transparency of the process dealt a blow to the hyped-up secrecy and mystery surrounding examinations.

However, the HSTP examination could not breach all the well-entrenched barriers. Even though it gave more scope for open-ended questions, the teachers continued to hesitate to formulate questions the answers to which were more difficult to evaluate. As a result many important concepts got less space in examinations. Similarly, although the HSTP examination manual stated that evaluation should assess whether children have developed the ability to ask meaningful questions, were sensitive to alternative explanations, or were more open to accept dissenting opinions, etc., such concerns found no place in the examinations.

An analysis of question papers shows a tendency to favour quantitative concepts. Qualitative concepts got relatively less space, while open-ended questions which test the ability to ask meaningful questions or understanding of linkages between experiments and concepts were almost totally neglected. Making such questions for 10,000 children was perhaps not possible. It appears that most of these things could be properly assessed by the teachers at the school level. And may be evaluation would not be possible with a single one-off question, perhaps there should be provision for asking supplementary/

counter questions. In other words, there should be provision for an oral examination.

Another shortcoming was that despite so much effort and investment being put into the Board examinations, the local examinations continued to be dominated by conventional questions. This was a matter of concern for the resource teachers who tried to organise local examinations at the *Sangam Kendra* level in the 1990s in order to improve the standard of question paper setting. Several *Sangam Kendras* did take up the task, duplicating the process introduced for the Board examinations, minus the review of question papers and redistribution of marks. It was teachers themselves who spearheaded the initiative at the *Sangam Kendras*, without any order from the education administration.

In this way, the HSTP sought to affect concrete changes in many administrative aspects of conducting examinations and put in a lot of work into breaking down obstacles that inhibited the creativity of teachers. But a lot more remained to be done and there was a lot of scope to do more. So even though far-reaching innovations were made in examinations by the HSTP, several questions still remain to be answered.

The most important question is whether the HSTP examination succeeded in fulfilling a new role or whether it continued to play the role of traditional examinations. The question also arises whether fundamental changes are at all possible in a highly centralised examination. In the beginning there was strong emphasis on internal evaluation of children by the teacher. Perhaps the HSTP group would have happily conferred the entire responsibility of evaluation on teachers. But experience shows that teachers themselves were against such an idea. As we have seen, the centralisation of the practical examination was the result of their demands. In such a situation, to what extent is innovation in examinations possible?

If we accept the need for a centralised examination, the questions is: What kind of questions can be asked in such an examination? What type of questions could serve to evaluate what children have learned? The HSTP experience with examinations shows that there are several obstacles in formulating such questions in a centralised examination. The reason is: you can only ask the kind of questions that provide written answers that can be unambiguously evaluated.

18

EVALUATING HSTP

When preparing this book, one point kept nagging: there were very few narratives about children's learning outcomes. There is ample information on implementing the HSTP and its different processes and components, but practically nothing on the 'product' of this mammoth effort. Very few documents were available that tell us what impact the innovation had on children who studied science the HSTP way.

Even if there was little statistical data available on this aspect, there could have been qualitative accounts, formal or informal.

The overriding concern of the HSTP group seems to have been to develop a 'good' programme, make available all the required inputs, and implement its different processes and components.

No comprehensive systematic assessment of HSTP from the point of view of children's learning is available. Of course, there are several research studies which analyse one or the other of specific aspects of the programme. We present here a summary of these studies, although these cannot replace a comprehensive evaluation. There have been six to seven such studies.

M. S. Mohan Rao conducted a study in 1980 (M.Ed. dissertation

"Evaluation of Hoshangabad Science Teaching Programme", Regional Institute of Education, Bhopal, 1980) in which he found that the HSTP teachers gave more importance to experiments and children had a significantly better understanding of science.

A study done around the same time by U. K. Dewan (M.Ed. dissertation, Barkatullah University, 1979-80) used the Test on Understanding of Science (TOUS) and Test of Ethics and Process of Science (TOEPS) to compare the performance in science of class 8 students in Hoshangabad and Raisen districts. (Raisen is a neighbouring district of Hoshangabad.) The study found that Hoshangabad students were significantly better.

In contrast to these two studies, Rajnikant Dube (M.Ed. dissertation, Regional Institute of Education, Bhopal, 1982-83) found no significant difference in the understanding of science and scientific abilities in a comparative study of the HSTP and non-HSTP children.

Another study (Rajiv Bhavsar, Ph.D. thesis, Rani Durgawati University, Jabalpur, 1997) found that the non-HSTP students were more aware of their environment and had better scientific understanding than the HSTP students.

Pradip Kumar Sharma (M.Ed. dissertation, Devi Ahilya University, Indore, 1997-98) found that the HSTP students were significantly better than the non-HSTP students in a comparative study when judged on the following criteria: interest in science, involvement in the classroom, reasoning ability, experimental skills, ability to derive conclusions, environmental awareness and observational skills, etc.

A similar study was conducted by Kajal Kumar Nandi (M.Ed. dissertation, Vikram University, Ujjain, 1997) in Jhabua district, an adivasi area where the HSTP was implemented in one School Complex. In this study, a question paper based on selected portions of the HSTP and the mainstream textbooks was prepared. The performance of the HSTP students was significantly better and the researcher recommended that other schools should get the benefits of the innovation.

Of particular interest was a Ph.D. study conducted by Rajnikant Dube, who had earlier chosen the HSTP as a topic for his M.Ed. dissertation ("A comparative study of the HSTP and the non-HSTP strategies of teaching science at middle school level with respect to scientific creativity, problem solving ability and achievement in science", Barkatullah University, Bhopal, 1994). The study had 28 elements for scientific creativity, three for achievement in science and six for problem solving ability and included 451 HSTP and 427 non-HSTP students from class 8.

This time, Dube found that the HSTP students were significantly better than the non-HSTP students on all three counts. He also found that the HSTP students used their previous knowledge in the form of rules to solve problems while the other students were unable to do so. Apart from this, the HSTP students were able to improve their answer as they progressed in their search. They could choose appropriate activities and use unorthodox methods to solve problems. They were better in knowledge, understanding and application of science.

One noteworthy study was conducted by Ejaz Masih in 1998 (*New Trends in Science Education*, Manak Publications Pvt. Ltd., 1998). It compared 564 HSTP students and 583 students studying the NCERT curriculum, using the Test on Understanding Science (TOUS), Test of Science Related Attitudes (TOSRA) and Test of Concept Attainment in Science (TOCAIS). Although this study, too, showed that the HSTP students were significantly better when judged on these three criteria, the most worrisome finding was that the understanding of science and scientific concepts of both the HSTP and the non-HSTP students left a lot to be desired.

Apart from these, the HSTP group conducted studies from time to time to assess children's understanding of specific concepts. One such study found that the HSTP students had a significantly better understanding of measurement and decimals.

A different kind of studies were also conducted by the HSTP group from time to time. Here the aim was to find out whether the HSTP students faced problems when they went to higher classes and whether their performance in science suffered as a result. Here again the performance of the students in classes 9 and 10 coming from the HSTP stream and the mainstream were compared on the basis of the marks scored in class 9 and 10 science examinations. They showed that the performance of the HSTP students was in no way affected.

But this kind of studies did not really satisfy the HSTP group. For one, there were serious doubts whether performance in an examination could really reflect a child's learning. Especially because the mainstream examinations basically tested for memorised information, with the questions asked mostly being variations of questions given at the end of each chapter of the textbook. That's why the only thing that could be said was that the students from the HSTP stream were able to quickly adjust to mainstream methods of learning science. This is not at all surprising because, even in middle school, they learned other subjects by traditional methods.

There is one more aspect to performance in examinations. The objective of the HSTP was to develop qualities like curiosity and experimental skills, the ability to ask questions, investigate and read given information critically, and being open-minded to other people's opinions. There was no scope for expressing or testing these qualities in the classes 9 and 10 examinations.

So the idea was mooted to carry out a comparative study to assess such qualities. The proposed study was widely discussed within the HSTP group and among educationists as well. The first question that came up for consideration was which aspect of the HSTP needed to be evaluated.

This point needs to be explained more clearly. The HSTP tried to provide many different inputs – *Bal Vaigyanik*, experiment kit, teacher training, new examination system, new type of classroom, etc. So one kind of evaluation could be to see how successful the government structure was in providing these inputs. In other words, the subject of evaluation would be: what is the capacity of the government system to provide so many inputs?

For example, Kishore Bharati and later Eklavya had to put in a lot of effort to create a system to make available experiment kits to schools. No less daunting was creating a system to have trained teachers in all the schools. Many of these teachers were routinely transferred to primary schools or other districts even though the government had a policy not to transfer trained HSTP teachers to schools where the programme was not running (except in cases where the teachers themselves wanted the transfer or were being promoted).

That's why the first question that was raised about evaluation was whether it would at all be meaningful to evaluate children's attainments when the implementation of the programme was incomplete in many ways.

Another problem with evaluation was that so many inputs were provided that any observable differences emerging from a study could be seen as a consequence of these inputs rather than the basic objectives of the programme. In other words, if systems for intensive teacher training, follow-up, monthly meetings and Sawaliram could be provided in the traditional curriculum, would it not be likely that such changes would be observed even there? So the question was how to keep this aspect in mind during an evaluation.

One could also evaluate how effectively the available inputs had been put to use. For this, the teachers are the most important link. Whatever the inputs, the classroom transactions finally depend on them. But the HSTP had at no time specially selected teachers for the programme. So it had to put in every effort to train them for the task. Despite these efforts one couldn't confidently assert that they were capable of making the ideal HSTP classroom a reality.

With so many factors coming into play, it was natural for the HSTP group to feel that evaluating the method would be a meaningless exercise because it was obvious that children were not getting full benefits of 'learning by doing'.

There were many in the group who also felt that since it was axiomatic that science could only be taught by this method, there was no need to look for proof. So the question of proving the efficacy of the HSTP should never arise. All one could do was evaluate the consequences of introducing this method into the government system. But it would be wrong to judge the HSTP and its method on the basis of such an evaluation, which at best would bring out the deficiencies and gaps in implementation and show the way for taking corrective action.

This doesn't mean that students' learning should not be evaluated. What is being said is that on the basis of such an evaluation one needs to think about how to streamline the programme. Here it would be pertinent to reflect on a serious problem faced by programmes that are put forward as an alternative to the mainstream. These innovations have to constantly prove their legitimacy. No programme of this nature runs in a political or social vacuum. The mainstream has the power of status quo and an inertia. Any attempt to change the status quo is seen by mainstream actors as a challenge. In such a situation it is not possible to take up any evaluation process in an objective manner.

Anyway, the HSTP group always felt that an educational evaluation of the programme needs to be undertaken. The matter was also discussed with some educationists. It would be relevant to outline the most far-reaching discussions. In 1982, Dr. S. K. Dani, an educationist, seriously applied his mind to the problem when told about it and came up with a proposal for conducting a comparative study of the HSTP.

He highlighted some of the problems in this regard. The biggest problem, he pointed out, was that such a study had never before been attempted in India. So the tools to conduct the study were not available. Such tools were available in the west but they had been developed in accordance with the western milieu. So if they had to be used, they needed first to be acclimatised to suit the Indian milieu. Only then could the tests be finalised. After this a pilot study would have to be undertaken to standardise them. Finally, the tests would have to be conducted in a sample of HSTP schools and some non-HSTP schools in another district and only then could a report be prepared.

In this way the proposal was formulated as a seven-year effort.

Dr. Dani was of the opinion that identifying comparable schools for such a comparative study would not be an easy task. It would need further study to identify such schools.

This proposal was submitted to the State Council of Educational Research and Training (SCERT) but the government failed to take a decision on it.

At the time of the district-level expansion and even later, the programme was evaluated by different committees set up by the state and central governments. Before the decision for state-level expansion was finalised, the state government satisfied itself that the HSTP students entering the higher classes (the Board classes) would not be at a disadvantage.

In the same way, keeping in mind the possibility of expanding the programme to the state level, the Government of India set up a committee under the chairmanship of Prof. B. Ganguly of the National Council for Educational Research and Training (NCERT). Totally agreeing with all the educational principles underpinning the programme, the Ganguly committee recommended that the programme make good the neglect of the product of science in its curriculum. The committee, however, did not carry out any evaluation of the students.

After the Ganguly committee report was submitted, the state government set up an HSTP review committee under the chairmanship of Dr. G. S. Mishra, the director of the State Institute of Science Education. But the report of this committee was never made public. However, it does seem from details of the preliminary sittings of the committee that student evaluation was part of its agenda.

Different from all these studies was a survey conducted by a group of teachers to understand the implementation of the programme. The teachers from Itarsi sought to understand the different aspects of the problems coming in the way of implementation and suggest some possible ways in which they could be resolved. A detailed questionnaire was prepared for the survey and a pilot study was undertaken. A report of the pilot study was also prepared but for some unknown reasons the matter did not proceed further.

After the programme was shut down there was again talk of conducting a comparative study. It was felt that such an assessment involving past HSTP students and teachers would be useful. But this proposal too remained stillborn.

There is one more aspect that requires attention. Generally, evaluation has been seen as a quantitative study. The format usually involved collecting macro-level data and then carrying out a statistical analysis. Perhaps, at that time the techniques to carry out a qualitative study were not adequately developed. It now seems that looking at evaluation through a limited statistical lens could have been one reason for the obstacles in the way of evaluating the HSTP.

19

EPILOGUE

It goes without saying that more has been left out of this book than has been included. We have focused more on discussing how the HSTP curriculum and its teaching learning materials were developed, including teacher's training and participation, classroom experiences and the different facets of examination. At places we have gone into details because innovations tend to acquire labels and all subsequent explanations of their content are viewed within the confines of these labels. This book tries to look beyond the labels. The HSTP is usually seen as synonymous with 'learning by doing'. But although 'doing' is important and integral to the innovation, it is still just one part of it. There are many more dimensions that explanations by labels tend to smother. We have touched upon many of these aspects but many more have probably been overlooked or neglected.

Some people may feel that what has been left out is important, so the book may leave them dissatisfied by its incompleteness.

One thing is evident: nowhere does the book attempt to define HSTP within a theoretical framework. This may rankle with some people but two things can be said in this regard. First, at no time during its 30-year history did the HSTP group attempt to see the programme through the lens of existing educational theories. All decisions were based on the group's broad understanding of science and the scientific method, and the situation prevailing in schools. Each decision was taken after analysing the pros and cons. At one time the deciding criterion for including any topic in *Bal Vaigyanik* was that it could be investigated through activities and experiments. If people say the approach puts too much emphasis on inductive logic, or label it empiricism, the HSTP group is not likely to be too perturbed. But with time, this approach, too, loosened around the edges and became more flexible. In any case, the HSTP group was never a monolith committed to a particular school.

The other thing that can be said is that I undertook the responsibility of writing this book because I was keen to tell what we did. I have been part of the programme for many years and its different processes both thrilled and educated me. I have little knowledge of educational theory and no experience of formal educational discourse. That's why this book sticks to narrating what was done. My (and may be most of the HSTP group's) situation is somewhat like the Hindi poet Dushyant Kumar's, when he says:

> With burning coals on my palm I wondered
> Will someone tell me the nature of fire?

An innovation cannot be explained solely by its educational content. There is a sociology involved in giving practical shape to educational ideas and implementing them. This is especially pertinent in explaining how the HSTP evolved.

Right from the beginning, the HSTP group was clear in its mind that it would not create 'an island of excellence'. That quite naturally meant intervening in the government school system, which is the mass education system in the country. This decision shaped what was to be done and took the HSTP group into totally un-navigated territory – working with a state government, the school education department, educational administration, educational research and training institutions, and so on. And the experience has been mixed.

From the time the decision was taken to launch the innovation to the time it was unceremoniously shut down, the HSTP saw many ups and downs – some educational, others political. This dimension has not been included in the book, even though many people have written and commented on it – for example, Anil Sadgopal in his book *Shiksha Mein Badlav Ka Savaal*, referred to earlier. Reviewing Indian education in depth, he has even raised questions about the character of institutions that seek to intervene in the education system.

One of Eklavya's annual reports, *New Beginnings*, has also thrown light on the political dimension (particularly the sequence of events leading up to the closure). In addition, several other reports published by Kishore Bharati and Eklavya have said a lot on the subject. Nevertheless, the HSTP experience still remains a good case study to understand the possibilities and limitations of working with the government. In this context, it would have been useful to review the role of the educational administration in implementing an innovative programme, its possibilities and limitations, but that's something this book has not attempted.

The HSTP experience gives one very important insight into the limitations of working with the government. Even after officially handing over the programme to the government at the time of the district-level expansion, Kishore Bharati and (later) Eklavya continued to be closely associated with its implementation. They had to constantly be on hand to ensure that even the most minor tasks were performed. The question this raises is: Why can a government bureaucracy not internalise an innovation and the culture it brings?

Similarly, we have not gone into the status of the kind of material and human resources that are needed to keep such an innovative programme running and expanding. The standard joke in the early years of implementation was that Kishore Bharati shouldered the academic responsibility of the programme with just two-and-a-half staff workers. If we overlook Eklavya's initial years, the situation was no better.

If a programme is to be expanded to a macro level or is to be seeded in new places, where would the human resources come from? This is another problem that needs looking into and the HSTP experience could give useful pointers.

One more point for discussion is: what is implied when we talk about expanding the programme? Does expansion mean introducing *Bal Vaigyanik* as the course of study in different places? Or does it mean helping to form groups in different places that can develop their own local innovations based on their understanding of local conditions with the help of local teachers and other resource persons? The HSTP group discussed this problem threadbare. It adopted and tested both approaches. First, Kishore Bharati and Friends Rural Centre took up the work of district-level expansion. Later, Eklavya seeded the *Bal Vaigyanik* package in many districts and also helped groups in Gujarat and Rajasthan to develop their own innovative packages. Reviewing both types of experiences could help in preparing a road map for expansion of innovations, or rather the spirit of innovation.

Community participation is another aspect to be considered. Such participation has been given a formal platform with the *Panchayati Raj* system. Although there were no systematic or planned efforts to enlist this participation in the HSTP , this is an issue worth deliberating upon.

Another aspect that is almost totally neglected in the narrative is: what did children actually learn? The stage for undertaking such a study has long passed. Many times plans were formulated for a large-scale study but nothing came of them. A pilot study did take place after the HSTP was shut down, but for some reason it did not pave the way for a larger study. This is a huge and irreparable loss for the HSTP.

SUSHIL JOSHI

Sushil Joshi was born in Ujjain in 1955. After obtaining a Ph.D. in chemistry from the Indian Institute of Technology, Bombay, he joined Kishore Bharati, an organisation working in the field of education and development in Madhya Pradesh, in 1982, and stayed with it until 1985. Since then he has been doing freelance editing and writing. During this time, for around 20 years he contributed in a concrete way to the Hoshangabad Science Teaching Programme. He has written innumerable articles on science, education, environment and science-society linkages and has translated many important books into Hindi. For the past several years, he has been editing *Srote*, a science and technology feature service published by Eklavya.

The Hoshangabad Science Teaching Programme (HSTP), which began in 1972, was a unique innovation in school education. It was a 'celebration' in which countless people got together to develop a meaningful and joyful experience for children. It helped open the floodgates to creative energies in the field of education across the country and provided a platform for such efforts. Instead of focusing on the 'knowledge explosion', HSTP sought to make 'science by doing' the basis for developing scientific concepts, using methods that encouraged children to search for answers to new questions and problems. This was the adhesive that bound together the different components of the special curriculum it evolved. The purpose of this book is to give the reader a clear picture of the educational components of this innovative programme.

The book focuses on three areas: the development of educational materials and how they were structured; teachers' participation and the methods used to orient them to internalise the spirit of HSTP; and examinations and evaluating what children had learned. Sushil Joshi, the author, was actively involved in HSTP for over 20 years. In his words: "I just wanted to tell people what we did."

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