

PREPARING TEACHERS FOR SCIENCE AND MATHEMATICS TEACHING UNDER THE SARVA SHIKSHA ABHIYAN

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As a part of the pedagogical renewal process in different states under the Sarva Shiksha Abhiyan (MHRD's flagship programme to universalize quality elementary education across India) we have been undertaking a wide range of activities at the national and state levels to promote science and mathematics education at the elementary level. They include development of curriculum and textbooks on EVS/ Science/ Social science, mathematics, establishment of school science clubs, school math clubs & laboratories, development of teaching learning materials related to science and math learning, development of worksheets and workbooks in majority of states for science/math teaching, organization of mobile science exhibitions, science camps, science watching camps, nature study camps, origami for mathematics learning, collaboration with all the resource centres at different levels for effective use of science and math kits, teacher training programmes each year for orientation in science and mathematics, etc. Keeping in view the rich experience and natural resources states to varying extents have managed to promote wide range of innovations in this important field of education.

One of our very popular and influential science and mathematics promotion activities over the years has been the organization of Science Learning Camps for teacher educators and teachers in different states. We have got a resource pool of science and mathematics promoters by drawing the expertise from Manavik (Orissa), AIPSN (different states), etc. for carrying out such camps in different states from time to time. The basic aim of such camps is to create interest among the participants towards science, develop understanding about process of science, develop a sense of appreciation and care towards environment, and project this short-duration camp as an alternative to better science teaching. In this paper we attempt to narrate the activities and overall process of one such environmental science camp undertaken in collaboration with Manavik and some local experts in different fields related to science and mathematics.

This camp was conducted in Assam for about 50 teacher educators and teachers of the state. Following were the major activities undertaken in the camp.

Grouping: After briefing about the philosophy and objectives of the residential camp the participants identified 15 areas as the important components of environment. Accordingly different groups were formed by teaming four children and one teacher. The different groups named themselves as 1. Rhino (for studying animals), 2. Parrot (birds), 3. Grasshopper (insects), 4. Brahmaputra (water), 5. Tilak (soil), 6. Sunny (weather), 7. Star (sky), 8. Thumb (people and society), 9. Plastic (artificial), 10. Fire (energy), 11. Enquiry (environmental problems and remedies), 12. Discovery (folk lores, songs, culture etc.) Three groups were formed for studying the world of plants in detail. The three groups planned to focus on leaves (13), Flowers, fruits and seeds (14), and roots (15). Each group identified its leader/s. They were to be supported by the resource persons and local guides.

Preparation: In the beginning all the groups were guided about their individual and collective responsibility. They were also briefed about the approach and process of the exploratory environment walk they were to begin with. Each group was provided with a 'kit bag' which contained ample number of transparent polythene bags, plastic bottles of various sizes, rubber bands, mosquito net (cloth), water droppers, note pads, scale, pencil, eraser, cutter, graph paper and handy instruments like hand lenses, tripod magnifier, simple microscope, small binocular, etc. They were guided about the effective and proper use of these instruments. Besides these each group carried its specific requirements like the bird watching group carrying special binocular, reference books; the insect group more number of bottles and bags, varieties of insect catching nets, pooter (for smooth and safe collection of insects), reference books etc. Each team planned well before initiating the venture.

Exploration: By the time they started their walk all of them were clear about their responsibilities. Each team had identified its area and plan of research in the nearby areas for an hour and half. Accordingly the groups moved to respective areas and kept on observing, discussing, noting down important observations and collecting as many varieties of samples from different sources. Their collections focused mostly on own areas. The environment related groups had a different approach and collection than the groups focusing on society and culture. The later groups visited houses, met people in different places and tried their best to understand their life, work and status and collected data and samples for further work.

Analysis: After the walk all returned to the campus with heavy carry bags. Each group sat together in different corners in the rooms. They kept all their collections on the floor and started sorting them out basing on minute observation of each sample, through mental measurements and comparisons. They classified them into different units as per their appearances and resemblances.

The group guides and local experts helped them in the identification and nomenclature (naming) of the specimen. Along with the categorization and identification each group kept on recording all the new information through systematic presentations, illustrations, tables, graphs and marks.

Exhibition: The plant group had occupied a big area displaying their items in different units, e.g., trees, shrubs, herbs, creepers, aquatic plants, moulds, mushrooms, orchids, insectivorous plants, crotons etc. They had collected 102 types of leaves, 67 types of flowers, 47 types of fruits and vegetables, 56 types of seeds and 96 types of roots. They had placed them separately with small labels indicating their names, place of collection and name of the collector. The area was colourful and well organized. The animal group had made sketches of all animals (big and small) that they came across on different pieces of paper and had displayed them under heads such as terrestrial, aquatic, amphibians, etc. They had further classified them as pet and domestic animals also. They had caught and bottled several colourful lizards, snails, fishes and had displayed them. Along with these they had exhibited a small puppy and sheep beside their exhibition corner! whom they had carried from the field. A long snake-skin also stretched across below their banner titled 'our world of animals.' The bird group had drawn the sketch of 22 birds and had displayed them along with a caged parrot from somebody's house.

The insect corner was very lively with varieties of colourful butterflies, grasshoppers, ants, beetles, mosquitoes, cockroaches, flies etc. North-east India was full of these varieties. The team in

collaboration with the subject experts had caught them carefully and had put them in separate bottles closing the mouths of the bottles by mosquito nets for proper ventilation. The caterpillars were busy eating their respective fresh tenure leaves inside the bottles. The team had succeeded in identifying all of them except two butterflies.

The soil group had displayed 24 types of soil (!) which included soil from the ant house from above the tree and soil from 35 feet below the earth from a freshly dug well. Similarly water group had bottled and exhibited 12 types of water. They also had collected various aquatic animals and plants to form an aquarium there. The weather group had observed the sun through the safe solar goggles and had conducted several interesting experiments like measurement of temperature at different places, changes in length of shadow of trees, buildings, rods etc. with apparent motion of sun, rate of transpiration in different plants, observation of sun spots through projection method, rate of evaporation from wet clothes etc. They had designed several charts to study the changing pattern of clouds, types of clouds, wind direction, place of sunrise, apparent path of sun in the sky, etc.

The groups working with society had compiled enormous data by discussing with various types of people and visiting different colonies. They had made tables on types of houses, home resources, economic status, educational status, sanitation, health, occupation etc. They had also drawn an attractive resource map of the village. The other group had displayed a good number of charts highlighting the freshly collected folklores, stories, songs, riddles, paintings and historical information about the people.

On the whole the 15 exhibition corners looked like attractively colourful pages of the book called 'our environment'. The creators of the pages were all busy in embellishing their respective pages by discussing, planning and applying their creative skills continuously.

Sharing experience: After the complete layout all the participants sat together to listen to the experience of each group and about their world of exploration. Each group came to the front together and reported its experience. This was a good chance for all the groups to listen about the different themes minutely, ask question and get an holistic idea about the environment. The members of each group were highly enthusiastic to express own personal and collective excitements before all. They were all very forceful and lively as it was based on their own experience.

Preservation: Now it was the time for preserving all the materials the proper way. The resource persons guided them about the preservation techniques. All the leaves and small plants were preserved inside the newspaper pads. Each leaf, flower small plant and root was carefully laid flat on the sheets independently so that there was no wrinkle or superimposition on any specimen. The thick newspaper pads were kept on the flat concrete floor and were pressed from the top by putting bricks on wooden plates on these pads. The participants were guided about the process of preservation by demonstration of samples of preserved specimen like queen termite, snakes, scorpion, honeybee, mosquito, toad, etc. in formaline solution. The Manavik team had prepared these exhibits long before. These specimens were demonstrated but none of the living organisms collected during the walk were killed for the purpose. The participants learnt how to prepare the 10% formaline solution and preserve rare specimens for study for many years undecomposed.

Exploring plants: The next day the participants went for ‘fun with the plants’. In the morning each group was allotted a limited area to do ‘tree mapping’. They marked the position of each type of plant in their area on paper. They calculated their number and categorised them as per their specialisation. The fifteen maps made this way were put together on the wall. That was not only colourful and attractive but showed a clear picture of the world of plants in the nearby campus. The resource persons themselves were surprised on discovering the large biodiversity in Assam. After this holistic picture all the groups were guided about the environment of each plant in detail. They drew the canopy of each plant and discovered how plants of same category resemble each other significantly. They were able to realise how plant scientists (botanists) look at the world of plants and research. Besides these they measured the heights of the plants and observed their foliage and branching patterns.

Then they worked on different parts of the plants. They rubbed crayon on papers by pressing them against the bark of different plants. The difference between bark marks from the different plants were distinctly visible. Similarly they pressed leaves below white paper and rubbed crayons to collect beautiful ‘leaf marks’ of each leaf. Couple of groups filled up their note pads with leaf marks alone. The marks carried distinct prints of the leaf outline, rib and veins. They enjoyed comparing the pattern of venation of different leaves. The monocot plant leaves showed all the veins converging at the tip of the leaves whereas the dicot leaves showed high branching. They also drew the positions of spikes, and thorns of different trees to see how they play important role in protecting the plant from extinction. Several plants were found to be the abode of hundreds of insects, animals and birds. At this stage they calculated how a plant contributes lot of resources like oxygen, food, fuel, fodder, shade, protection, shelter, medicine, etc. directly to the society and catalyzes the process of rain, winds etc. indirectly.

They found that a plant like mahua or mango contributes to a great extent to the society in the field of economy, medicine, literature, culture, education, development etc. They realised that the society owes a lot to these plants. They were guided to conduct several simple experiments related to seed germination (in transparent plastic bottle), study of root and shoot (by dipping cuttings in bio-fertilizer in bottles and observing regularly the roots and shoots), role of light, water and sunlight (by putting small plants in different conditions), osmosis (by putting saturated sugary solution in potato cups in water), capillary action (by dipping some plants in coloured solution), food preparation in plants (by testing with iodine for starch on leaves), presence of chlorophyll and other pigments (testing by rubbing against white paper and against KOH), sensitivity towards light (by putting small plants in closed boxes with single window), respiration in plants (by inverting a glass funnel on aquatic plants and collect oxygen), structure of plant cells (by observing stem sections, and onion skins) preparation of handmade indicators (by dipping paper strips in solutions of turmeric, beat root etc.) All these simple experiments were demonstrated basically to introduce the participants to the wonderful processes in plant world.

Some discussions: Many questions were put up by the participants during the experiments. Some of the interesting ones were as follows:

Why do roots move down and shoots grow up?

How does a seed give birth to a plant?

Why are the leaves green? Why some leaves differ in colour?

Do the plants respire like us?

How do plants live under water?

How do plants make their food?

Which appeared first on earth-trees or seeds?

These points were debated upon and sometimes tried out through supportive simple experiments to help the participants construct some knowledge on them.

Educational values: The teachers started saying that such organized walks and analyses can be quite useful to their classroom teaching. They were more thrilled to discover that the whole learning process of children can be better facilitated through this approach and children can learn language, mathematics and science the better way. To guide them more about this the resource persons started with the leaves. On discussion it was found that children could derive enormous knowledge from their shape, size, length, number, position, direction, shade colour (contrasts and harmonies), area, volumes, angles, symmetry, odours, arrangements, order, etc. These are all related to the basics of science and mathematics.

The names, places, developmental processes and use of the plants were enough for the children to develop ample vocabulary and language knowledge as well. Besides these they were learning the approach of looking at this world and the ways of using them also. The development of herbarium, leaf zoo, leaf mark etc. involved their aesthetic and creative applications to a good extent. On the whole they were also learning the ways of appreciating and caring for the environment. The children enjoyed the process very much and teachers said that this approach can make the overall teaching learning process enjoyable, lively, creative and meaningful.

Like the leaves they had also learnt the ways to explore and benefit from the world of flowers, fruits, seeds, twigs and roots. They were all guided to make a 'green house' in front of the building by using transparent polythene sheets and bamboo sticks. Many types of small plants, newly germinated plants, sprouting carrot, onion etc. were planted inside this warm area. Within a day all the plants had turned fresh and healthy. The participants, especially children were fascinated by the dramatic impact of temperature on the 'child plants'.

Exploring Soil: All the soil samples were observed through the naked eye and magnifier to know the size, type and quality of particles in each type. Then each sample was mixed in limited proportion with water in different transparent glasses and stirred well so that the particles mixed well with water. After some time of standing the particles in each glass sedimented to the bottom in a definite order - the big particles on the lowest layer followed by smaller ones above it in order of size. The sandy soil samples settled fast and the water remained clear to a good extent but the soil collected from the cultivation fields took lot of time to settle as it contained lots of small particles and other organic particles like cow dung, compost, humus and plant parts like decomposed leaves, wooden, roots etc. This showed that the samples containing more of such organic materials provided food to the plants and were more fertile whereas samples containing more of sand were less fertile and the water holding capacity of these samples was less. Similarly

other tests were also conducted to test the acidity, hardness and fertility of the different samples of soils. Children went on to make models with the clay to exhibit beside their soil tests.

Water: The Brahmaputra group had collected twelve samples of water from different sources and had developed an attractive aquarium on the collection-day. Today they discussed with others how water is found everywhere on earth. Then they experimented with different characteristics of water like it has no shape of its own, maintains regularity, participates in the water cycle, evaporation, condensation, flows downwards, different forms of water, water for growth of plants, process of osmosis, skin of water, climbing water, waves in water, hard and soft water, study of aquatic lives etc. This way they not only explored the water samples in the area but also could be clear about the environment and characteristics of water.

Air: The participants tested the flow of wind by tying a big polythene bag at the top of the house and observed the changing direction of wind over the days. Besides this they played with bubbles, tested the strength of air by designing simple air-jack, observed the respiration in animals, birds and plants etc. They were also demonstrated the different characteristics of air by the Manavik team for a short duration.

Weather: The sunny group had devised several record tables to study the daily weather of the area through regular observation and try to understand the causes and effects of heat, air and water on the local climate.

Energy: In the morning they designed the model of the solar system in the playground by putting balls of relative size at relative distance from a large sun (made out of a two dimensional cardboard) at the centre of the field. By forming this Solar model the participants were surprised to know that the Sun is so big and provides large amount of energy in all directions. The other activities were related to measuring time through a handmade sun dial, using solar energy by a solar cooker, a green house, a solar oven etc. They also conducted simple experiments related to plants as solar collectors, energy change, food change etc.

Sky watching: The participants were guided about the night sky and its different coordinates like directions, apparent path of the sun, zodiac signs, constellations, stars, planets etc. The clear night sky in Assam had several attractive constellations like Saptarshi (the great bear), Cygnus, Bootes, Aquila, Serpent, Opheucus, Cepheus etc. and several zodiac signs as Leo, Virgo, Libra, Scorpius, Sagitarius and Capricornus to enthuse the participants. Familiarisation with the planets like Venus, Jupiter and Saturn were also of great joy for them. It also led to good discussion about the history and development of astronomy and stories in different lands behind different constellations. On the next night the participants were guided to enjoy the rings of Saturn, the moons of Jupiter, phases of Venus and the craters on the Moon.

Out of the eggs: To study how life begins and changes in different organisms the resource persons had collected different specimens before the camp began. The different items included eggs of frog, snake, lizard, butterfly, chicken etc. The frog eggs had hatched into active tadpoles on the first day itself giving opportunity to all to observe their steady changes over the week. Children kept the record of their changing sizes, food habits, movement and different body mechanisms. The snake egg did not hatch in the camp days and disheartened all. The wet butterfly from the cocoon thrilled tremendously in early morning as it dried up before all into a multi-

coloured large one. After a detailed observation it was released into the open air. The cute little lizard came out of the egg exactly like a crocodile on a layer of cotton in the plastic bottle. None of the participants had observed this before. An incubator was made in advance to warm chicken eggs artificially. Semi incubated eggs of different days were cracked open to exhibit the sequential changes in the developmental stages of embryo. The 'crying egg' was finally opened carefully before all to discover a wet, weak chick. After about an hour under the artificial warmth of the bulb the chick stood up enabling itself to enjoy the world.

Observation houses: All the participants were guided to construct different types of structures for studying the habits of different plants, animals and insects comfortably. The 'mini pond in the big plastic tub (dipped in ground) and the big transparent plastic jar as 'aquarium' were the temporary houses for all the collected aquatic plants, animals and insects. The sand, water and organisms were properly maintained so that all the living creatures could be observed from top and side distinctly. The handmade 'aqua-observer' (a plastic tube with its one end closed by transparent polythene sheet and cello tape) was found much useful for observing the down-water insects, fishes etc. very closely.

A 'terrarium' was constructed out of a big TV carton by covering two of its sides by transparent polythene sheets with ventilation facility. This observation box contained the terrestrial small plants, insects and small animals. 4-5 'formicaria' (ant houses) were constructed by using plaster of Paris, dough and glass sheets. They all resembled the ant houses that lie underground. Food particles inside these artificial houses attracted ant families to go inside and settle there comfortably. The glass covers enabled all to observe the disciplined working culture in these 'social insects'. Similarly 'vermicaria' (earthworm houses) were also made in the camp to culture earthworms and observe their behaviour. Different types of seeds were kept in the campus to invite types of birds to the campus for observation. Participants also learnt several techniques to invite various birds, animals and insects and let them settle in the handmade simple open houses.

For looking at the small animals and insects the participants looked at different areas they live in. They included areas beneath rocks, under the soil, in tree barks, in decomposed wood, in garbage, straw heaps, decomposed cow dung in tree branches, compost and moist locations. The little animals were collected carefully by using nets and pooter. Then they were observed minutely by keeping them in wormery, terrarium and aquarium. Equipments like view tube, ordinary hand lens, magnifiers, simple microscope etc. were much useful for the finer observation of these collections. Besides these the study of micro organisms like aquatic micro organisms, and others in compost soil etc. were very fascinating for all the participants. They drew the sketches of the animals observed this way and exhibited them on the final day.

Environment, society and science: On each night the participants were shown set of slides on the different aspects of environment, society and science and their inter relationships. The different themes of this series were as follows:

a) Our place in the universe: This set of slides started with the human beings and moved outwards in an order of the family, village, block, district, state, country, continent, earth, solar system, galaxy, cluster of galaxies till the grand universe. Then it reversed back beyond the human beings

in the order of dogs, cats, rats, cockroaches, ants, bacteria, virus, molecules, atoms, sub-atomic particles till the quarks.

b) How we began: This set of slides talked about the story of evolution in animal and plant kingdom – beginning with the early hot days of earth through single celled protozoans, multi-cellular organisms, invertebrates, amphibians, reptiles, mammals, birds, etc. to monkeys and human beings in a systematic way.

c) How apes became humans: Lot of enthusiasm was found in the discussions which followed from this slide show on the history of changes in human body (skull size, brain, tail, thumb, postures etc.), work, life and civilizations since the days in jungles.

d) From yesterday to today: Human beings, ‘the tool-making animals’ since their appearance on earth explored around, tried to understand everything and use it for own benefits. This approach for generations till today has contributed to the incredible developmental changes on earth. Overall it was the story of science and scientists since the primitive days.

e) Our tomorrow: Science and technology on one hand have given hopes of creating paradise on earth (through ample comfort, security and productivity). On the other hand their misutilisation on various issues has threatened the existence of life on earth in the name of wars, diseases, pollution, terrorism, capitalism and exploitation. Now we the innovator of science and technology are at the crossroads! Which road we should take now? – the way to paradise (through peaceful humanitarian use of Science) or the way to hell (through destructive use of science)? We will have to ‘act now’ for a future.

These slides developed by People’s science movement in India were explained in simple language with an intention to aware the participants of the history and development of environment, life, science and society in a holistic way so that they learn the true spirit of science.

Green educational games: Everyday the participants enjoyed the late afternoon games very much. Besides the ‘web of life’ game some other games which were well appreciated by all were as follows: Who am I, seasonal signs, tree conversation, earth, the zoo game and environment craft game. All these games were not only mentally and physically challenging, but were much educative as well.

A visit to the zoo: On the last day all visited the Assam state zoo with a plan to study the history and aims of the zoo, science of animal/bird preservation, biodiversity in the zoo, possibilities and problems and the history and behaviour of each life in the zoo. They all went around consulting respective authorities for clarification in own areas. After the visit they all sat together to synthesize their data in the form of a small research document. The zoo authorities were highly pleased on receiving a copy of this organized observation and presentation.

Problems in Environment: Since the beginning each participant was keeping a record of all problems related to the local environment in all its components. On analysis it was realized that only human beings especially their planning and careless attitude were responsible for the problems in local environment in the form of forest degradation, pollution, social inequalities, poverty, diseases etc. It was also felt that the land can be made a better home if the local people at own levels realize this and act together as per their plan.

Alternative thoughts: To look for possible alternatives examples were thought of by all from life and work of Gandhi, Buddha, Holt, letter of Chief Seattle, Jean Geono's 'The man who planted trees,' The tree, etc. Besides these the social movements like Chipko movement and cleaning operations in different countries were also discussed. Finally all planned to begin environment care clubs in own area (school and colony) and culture a caring attitude towards environment as a whole for a better future.

The open exhibition at the end of the camp was visited by a good number of people. There were altogether about 1800 exhibits in the six rooms which were mostly developed by the young participants and teachers touching upon all aspects of their environment. The direct experience and information gathered in the process were much more lively, exciting and enriching than their typical textbooks and school environment education. Similar camps were organized in different parts of Assam after this independently.

Additional Information

MANAVIK: A resource centre in Orissa for research and innovations on science, mathematics and health education.

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