Stepping into Science in Small Schools: Together with Tools, Techniques and Toys

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This intervention action research paper describes the development and implementation of primary level science experiences in the project mode for small schools in the non-governmental organization (NGO) sector located in dispersed small habitations in the desert area of an Indian State called Rajasthan. The project was developed in a participatory manner through a need analysis with the author functioning as designer and mentor. The project includes development, training, implementation and recurrent reviews of science activities in the schools combining the use of hand tools and low-cost science experiments. The components of the science learning at primary level had the following aspects: (a) making improvised measuring instruments; (b) familiarization with elementary hand tools; (c) making models; (d) performing experiments; (e) doing investigations; (f) making toys; (g) science-related drawing skill. The project was meant for grades three, four and five with 20 science-related activities at each grade level. The evaluation of the project was done through quarterly participatory reviews by the teachers and evaluation of children's performance in the annual test. The project after one year resulted in establishing the science activity corner, and annual science exhibition for parents and village community. The innovative features of the programme are the use of readily available material; comprehensive experiences; participatory processes and community linkages. The project resulted in improving the achievement levels in the project schools at grade three as compared to the previous year's achievement scores at 0.01 levels of significance as revealed by the t-test analysis.

Introduction

Ever since science has become a part of the subject of environmental studies at the primary level, its importance is being neglected in the curriculum. Because now science is found in the same book together with social studies, practical aspects of science at the primary level are being ignored and it is being taught like social studies emphasizing rote learning of information.

Besides this, with the emphasis on social studies portion of environmental education at the primary level, detailed pictures have been introduced which have become sterile visuals while science demands line diagrams and recognizable visuals. The making of simple line diagrams is also becoming a matter of the past at the primary level. Also, more abstraction has come at an early age in the form of the concepts of the social studies curriculum. Creating an environment that gives equal opportunities to all is also a serious issue in the environmental studies curriculum since students with varying backgrounds learn better with hands-on experiences. The situation becomes more serious if teachers are not involved in curriculum redesigning, material development and implementation of the methods of science.

Many Indian science educators (Sharma, 1984; Sood, 1989; Kishore, 1991;) feel that science operates through its processes and to learn science is to experience it. In India, primary education is in a state of flux due to emphasis on its universalization over the last decade. Gupta (1995), Kishore (1999), Prajapati (1999) and Verma (2005) hold that it is necessary to develop science curricula and prepare teachers to make science teaching process-based and meaningful through improved low-cost activities and experiments

for primary grades.

In the light of the foregoing, the objectives of the present initiative and study of its effect on achievement scores of children in select remote rural single-teacher small schools in Rajasthan state of India were as follows: (1) To develop the practical science and low-level technological activities for grade three students for multi-grade small rural schools; (2) To implement the developed activities for the academic session to find its effect on the achievement scores of third graders.

Development of the 'Stepping into Science'

In September 2004, the author designed and conducted a nine day workshop on multi-grade teaching for the academic support staff, (N=6) to systematize the learning in single-teacher schools being run by a non-governmental organization (NGO) in the Thar desert of western Rajasthan in India. The workshop resulted in the development of teacher-directed learning, group learning and individual learning work cards so that multi-grade teaching could be implemented with proper time, space and material management. The learning material for three months was developed with the provision of academic support through school visits and fortnightly one-day review-and-sharing workshops of teachers.

During a workshop on multi-grade teaching, it was felt that for the science component of the environmental studies at grade levels three, four and five, it would be desirable to provide laboratory-related or practical experiences to children. Since modest funds were available with the NGO for science education improvement, a desire was expressed by the academic support staff to try out such an idea. A group discussion for two hours was held to crystallize the design of science learning project at the primary level for single-teacher small schools. The following discussion outcomes led to lay the foundation of the project 'Stepping into Science" as summarized in Table 1.

• Grade levels to be covered: Three, four and five
• Number of activities at each grade level: 20
• The Nature of activities at each grade with their numbers under different aspects of science learning :

Improvised measuring instruments	: 2
Hand tools	: 2
Models	: 3
Toys	: 2
Science-related drawing skill	: 1
Experiments	: 6
Investigations	: 4
Total activities	**: 20**

Table 1. Summary of the outcomes of the discussion by academic support staff (N=6)

1. Designing, constructing and using improvised measuring instruments: Beam balance, Distance measuring wheel
2. Use and upkeep of hand tools: Cutter, Screw driver
3. Designing models and manipulating materials: Animal models of polystyrene, Weather cock model, Go-cart model
4. Experiments to learn the concepts and processes of science: Air occupies space Air has mass Wind can do work Air offers resistance to moving things Presence of air in soil and chalk stick Separating the constituents of soil
5. Investigations into the role of a scientist: What is soluble and what is not? What floats and what sinks? Change in the average life of soap bubble froths with concentration of detergent. Relationship between length of the shadow of a stick and time of the day.
6. Science-related visual communication and drawing skill by drawing two-dimensional line diagrams.
7. Relating science to child's life through the science of toys: Pin wheel, Topple-over toy

Table 2. Science activities identified at grade three level

Thereafter, the science syllabus at the primary level was scanned. At the grade three level, there is a prescribed combined syllabus of science and social studies but there are separate text books for science and social studies at grade levels four and five. It was decided to make a beginning at grade three level first and develop science activities and train the academic support staff and teachers to implement the programme.

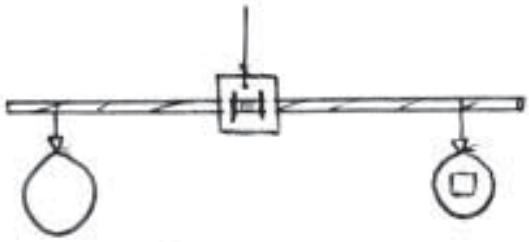
The activities for grade three level were identified which became the basis of the four-day training workshop organized for the academic support staff in the last week of October 2004. Twenty science activities for grade level three

Experiment: To prove that air has weight.

Material : Two soda straws, cello-tape, balloons thread, pin

Procedure :

1. Take two soda straws and join them with tape to make a long beam.
2. Inflate two balloons and tie their mouths with thread.
3. Take a piece of paper 2 cm × 2 cm and put two blade cuts on it separated by 1 cm. Make a small hole on the top of the paper piece pass a thread piece through it. Tie and knot to the thread.
4. Pass the taped beam through the cuts and tie at its two ends a balloon each as shown.



5. Put a cello-tape piece on one of the balloons and balance the beam by sliding the paper along the straw.
6. Now puncture the balloon with cello-tape piece by pricking it on the cello-tape.

Observation and conclusion

What happens?

Fig. 1. Example of a science activity at grade three level translated into English

have been summarized in Table 2.

It was thought appropriate that the project should be developed in year-wise phased manner so that teachers and the schools could be equipped for it keeping in view the budgetary provisions and time available for the teacher training.

Figure 1 shows an example of a science activity at Grade three level. This version of the experiment required less number of balloons to be bought for the whole class. Moreover, with puncturing the balloon at the cello-tape piece stuck to it, the balloon did not burst and air escaped slowly. By sticking another cello-tape piece at the hole, the balloon could be used again. Some instances of making the experiments further cost-effective occurred during the first year of the project. Furthermore, the straw makes a very light beam and hence a sensitive lever balance which can detect small changes in the weight of an object.

Making the diagrams, and illustrating the experimental setups and the phenomena are important skills for children to communicate the concepts of science. Often, no deliberate effort is made to sharpen this skill in schools. As a part of the present innovation, this aspect was taken up in a graded fashion starting from two-dimensional line drawing to oblique drawing to isometric drawing. These aspects of making diagrams have been included in the programme. Each student has to draw twenty diagrams for each grade level. These diagrams also became helpful in building students' vocabulary with mental images of visuals. See Figure 2 for some selected examples.

Implementation of the Project

A four-day training framework was prepared for the teachers (N=30) and training was imparted in the workshop made so that the activities to be done could be finalized and hands-on experience be given to thirty classroom teachers and educational support workers (N=4).

Every day, six hours were spent for training and it was also linked with a follow-up system consisting of fortnightly review and sharing meetings. In a week, a two-period block (1.5 hours) was spent by students to perform an activity and write about it. A weightage of 40% was given to the science activities as a complementary programme to normal learning of environmental studies prescribed by the state government.

For the first year of the project, science activities were integrated in the curriculum of grade three. A list of investigations was prepared by the author and shared in the second fortnightly review and sharing workshop so that some hands-on work could be initiated in grades four and five also.

The use of simple mini hand-tools inculcated among children a systematic habit of skillful utilization and proper upkeep of the tools. For making improvised apparatus and models, the application of simple tools became evident. Also, children were asked to make labeled charts of the tools to give practice for making diagrams and exercising drawing skills. This also helped children acquire a vocabulary associated with tools and workmanship.

Outcomes

One of the outcomes of this project was the extension of 'stepping into science' activities to grade levels four and five by the teachers and the academic support staff, thereby, providing a sense of ownership of the programme. At the end of the academic session, a two-day review workshop

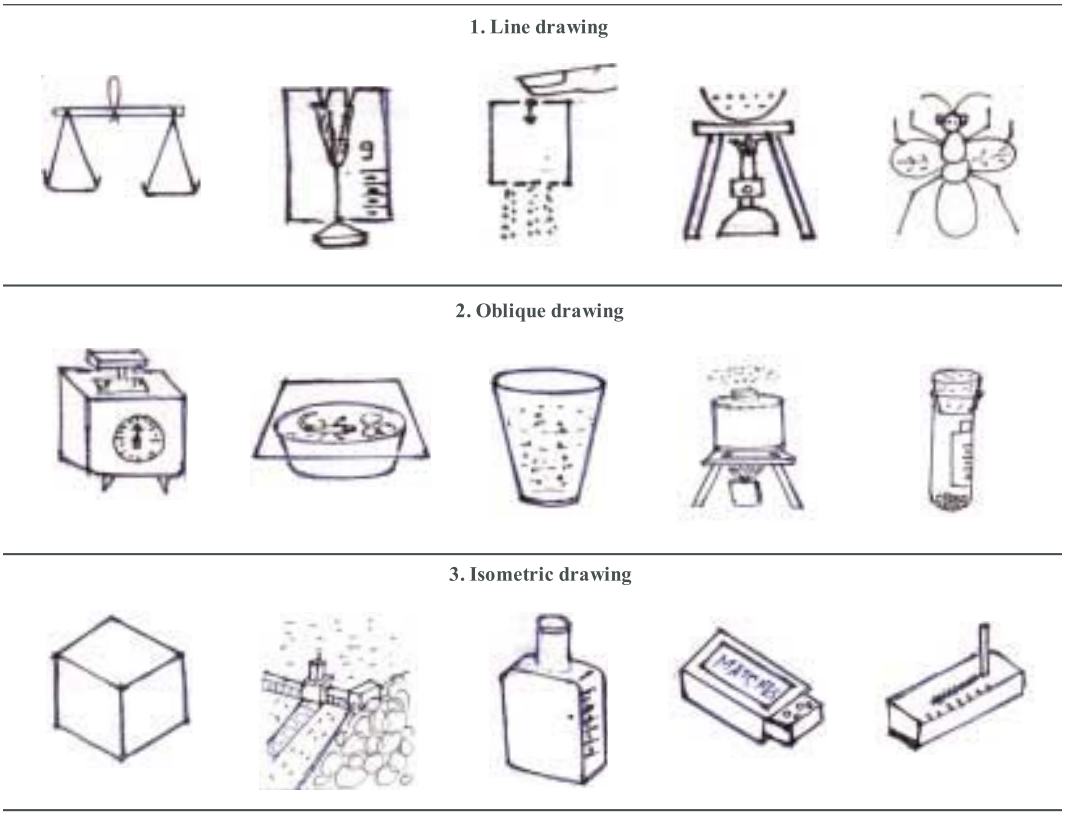


Fig. 2. Selected examples of drawings skills for primary level science

was held to get the reactions of the teachers and prepare a curriculum for science experiences at grade levels four and five.

The typical reactions of the teachers to the project were as follows.

- I, myself as a teacher, have understood the importance of the processes of science and acquired the skill of drawing diagrams in three ways. It has also improved my skills in the use of blackboard for illustrations.
- The children have started enjoying science and look forward to the two-period block for doing activities and learning from them.
- Annual science exhibition and interaction with the community has brought the school and local community closer.
- The project, the way it was implemented and periodically reviewed, has built my professional competence to an extent to teach science to other grades.
- By giving weightage to the science practical for the annual test, the value of practical aspects has been established and it has given children a sense of better performance.
- It was quite interesting to learn science with toys and relate to design and technology along with the use of hand tools.
- The interest of both girls and boys has heightened due to the systematic introduction of a variety of science activities.
- The inclusion of riddles and poetry has made the learning and remembering of science concepts interesting for children.

The comparison of student's achievement levels in environment studies of grade three before and after the implementation of the project shows a significant gain in achievement scores at 0.01 level as revealed by the t-test analysis (see Table 3) of the teacher-made tests.

The annual cost of running the 'stepping into science' project per school comes out be about Rs. 2,400 (£ 30 approximately). Thus, the running cost of the project is quite af-

Situation	Number of students	Mean	Standard deviation	t-value
Before	215	50.34	5.86	62.12*
After	210#	65.54	4.33	

* Significant at 0.01 level

5 Students dropped out of schools by the end of the session

Table 3. The t-test analysis of achievement scores of grade three students

fordable even in the resource deprived rural situation.

The project has been deemed quite interesting and effective by teachers since it provided the children feel for the diverse aspects of practical science in a systematic way. And, involving teachers as a collective in the programme fostered a sense of ownership for the programme among them. Furthermore, a conscious effort to integrate the 'doing' aspects of science and technology along with bringing the school and community together through science exhibition made this project efficacious.

Another outcome of the project was the development of the curriculum outline of science practical for grades four and five (see Table 4) as an in-house extension activity with the author as an occasional adviser for the years 2005 and 2006.

Thus, by including the innovative features like the use of locally available materials, mini-toolkit, processes of science, designing, drawing, material manipulative activities with hand tools, riddles, poetry, ownership of participating teachers and community linkages, the programme could succeed in the deprived conditions of small dispersed habitations of the Thar desert. The project illustrates how for any innovation in science education to be mainstreamed, making it relevant to the local needs and context is essential along with involving teachers as a collective to develop and implement the project.

Aspect of practical science	Grade 4	Grade 5
1. Improvised measuring instrument	1. Measuring cylinder 2. Lever balance	1. Rain gauge 2. Rubber band balance
2. Hand-tools	1. Pliers 2. Wood saw	1. Spanner 2. Hand-drill 3. Hacksaw
3. Models (Using polystyrene)	1. Model of digestive system 2. Model of excretive system 3. Model of colour mixing	1. Model of blood circulation system 2. Model of heart 3. Model of hand-pump
4. Experiments	1. Extension of rubber band with weight 2. Relationship between dropping and bouncing height of a ball 3. Relationship between the length of shadow and time 4. Relationship between pressure and volume of air 5. Preparation of carbon dioxide and showing its properties 6. Relation between surface of water and evaporation rate	1. Relationship between pressure and area 2. Relationship between water (liquid) pressure and depth 3. Expansion of air with heat/temperature 4. Speed of thermal transmission in an iron rod. 5. Thermal expansion of a wire 6. Properties of a magnet
5. Investigations	1. A survey of the diseases spread in the village over the last one year 2. A study of the immunization of children in the village over last one year 3. A study of lung power of students	1. Collection and classification of small plants and leaves in the village 2. A study of weight-height relationship of students 3. A study of water absorbing capacity of different soils
6. Science-related drawing skill	1. Oblique drawing	1. Isometric drawing
7. Science of toys	1. Rubber-band driven drum cart	1. Jerking movement toy with a crown cap

Table 4. Curriculum outlines of practical science extended to grades four and five.

References

Gupta, A. (1995). *Little science*, Bhopal: Eklavya.

Harlen, W.E. & Elstgeest, J. (1992). *Unesco sourcebook for science in the primary school,* 26, p 59. Paris: UNESCO publishing.

Kishore, L. (1991). *Teaching of physical science*, Delhi: Doaba House.

Kishore, L. (1999). An experience with in-service trainers in using paper as a method for STM integration at primary level, *CASTME Journal*, 19(2), 59-63.

Piaget, J. (1954). *The construction of reality in the child.* New York: Basic Books.

Prajapati, M.B. (1999). Primary science education by self-making active scientific toys and instruments, *CASTME Journal*, 19(2), 42-45.

Sharma, R.C. (1984). *Modern science teaching*, Delhi: Dhanpat Rai & Sons.

Sood, J.K. (1989). *New directions in science teaching*, Chandigarh: Kohli Publishers.

Verma, R. (2005). Training of KRPs in preparation and use of low-cost TLM in science. *School Science*, 43(4), 74.