HBCSE Graduate course
2008-2009

Field work Report

Implementation of "Small Science" in a Mumbai School: Deriving Implications for Teacher Development

Submitted by

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Submission date: 2-05-2009

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1. Introduction:

In this report, I will elaborate how classes 3 and 4 elementary school teachers transact *Small Science*, an inquiry based science education curriculum in one mainstream school in Mumbai, India. Based on these observations, professional development material was developed and tried in a teacher orientation workshop. Future directions for professional development initiatives are discussed in the concluding section.

1.1 The *Small Science* curriculum material

Small Science is an alternative, inquiry based science curriculum being developed at the Homi Bhabha centre for Science Education. The mode of inquiry that is advocated by *Small Science* is structured inquiry. The philosophy of the curriculum is captured in these words from the Teacher's book, class 3, p.1 and 2.

> 'Children are by nature curious and observant. They learn about the world by watching, asking questions, and trying to make sense of what they experience. Science teaching should aim to encourage these natural tendencies. Hence this set of student's books, which have more questions than answers … traditional schooling has always trained students to *answer* questions … As a result students never learn *to frame their own questions* … in the Homi Bhabha curriculum, we do not want students to parrot out a few correct answers. We want them to develop a lively curiosity about the world around them - with a will to pursue these questions through observation and inquiry.'[1]

The elementary school curriculum up to class 4 was developed in the late 1990s. The curricular material includes a Textbook and a Workbook which are students' books as well as a Teacher's book for the teacher which contains the Textbook contents together with a teaching manual which comprises a detailed, first-person narrative account of the curriculum developers' experiences trying out the curriculum.

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[1] *Small Science* Teacher's Book. (1998). Homi Bhabha Centre for Science Education.

1.2 The Teacher's Book:

The first section of the Teachers' Book detail the child centered philosophy of the curriculum as well as methods of assessment. It also points out that of the three books; the Teachers' Book should be the most important to the teacher. Every unit in the Teachers' Book begins with an overview of the objectives of the unit as well as what is new to the unit. This is followed by a detailed teacher's manual that is written in first person that discusses experiences of teaching the curriculum highlighting in a non-prescriptive style interesting student responses, student misconceptions and extra information that may be useful. The activities are discussed in such a manner that the process of finding out is emphasized. Results of many activities are also not provided which will compel teachers also to 'do and see'. In addition, some open ended activities are included which further draw attention to the process of doing science over the product of what is done. This is intended to convey the idea that Science is not a fixed body of knowledge that needs to be disseminated by a mediator (the teacher) but a way of making sense of the world that is accessible to people of all ages and social backgrounds. The curriculum trials were carried out on students of urban as well as rural backgrounds and experiences of teaching these children have been included as well. The teacher's book also emphasizes the need to foster certain values in the children that include caring for the environment and conserving natural resources.

1.3 The Textbook and the WorkBook

Olson (1980)[2] has critically analyzed the authority of the school Textbook. According to him, the sources of authority are due to particular linguistic structures which make the text inaccessible to the student and due to the 'separation of the speaker from the speech and corresponding dissociation of the speaker from the reader' giving an impression of 'textual authority and neutral validity'. These factors additionally make it imperative that teacher becomes a mediator of textual knowledge causing him or her to assume powers of authority as well as knowledge. Intended to break the authoritative nature of the textbook, The *Small Science* textbook speaks to the student. Written in an engaging style and simple language, the textbook needs to be 'done' rather than read, deemphasizing the conventional authority of the textbook and pointing to the fact that the child and the teacher need to co-construct knowledge rather than rely on another source to dole it out to them.

The primary function that the *Small Science* WorkBook serves for the student is for the student to record results of the activities of the textbook. For the teacher it serves as a means to assess students' progress and give feedback to the parents on how their ward is doing. The WorkBook has sections for recording yes-no answers, short answers, long answers, drawings, tables and graphs, thus introducing the child to different modes of expressing their ideas and representing observational data.

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[2] Olson (1980) "On the language and authority of textbooks." Journal of Communications 30, no. 1 (1980): 186-196 as cited in Luke,C, De Castelle,S and Luke,A. (1983). *Curriculum* Inquiry. 13:2. pp. 111-127.

2. The study:

The study involved two phases. In phase I the classroom practices of the two teachers were observed. The aspects explored were, how the two elementary teachers engaged with the *Small Science* text; what they think of the curriculum and its philosophy, the nature of their teaching practices, the institutional factors that circumscribe their practice, the effects of the use of curricular material on teaching practices and student engagement. In phase II, a workshop for teacher orientation was planned taking into account how the teachers transacted the curriculum.

2.1 Method

A 'participant observer' data collection strategy was used, which involved observing the classroom and taking field notes, interacting with the teachers and examining student WorkBooks. A blog was created where my reflections on the field notes are put up. The website address was shared with the teachers as well as students. A total of 14 class periods of class 3 and 20 class periods of class 4 were observed with each class period spanning 40 minutes. An entire classroom session of one of the teachers was audio taped and transcribed. A teacher orientation workshop was planned and executed based on observation of teaching practices. Eleven primary teachers attended the workshop. In the workshop, teachers were shown a video on students' misconceptions [3] regarding the concept of evaporation and were given an activity sheet based on student's responses in the *Small Science* WorkBooks regarding the concept of evaporation to analyze and discuss. Following this, the teachers discussed their experiences teaching *Small Science*.

2.2 Introduction to the School and the teachers

The School where I conducted my study is located in a rapidly growing, busy urban locality. Mainly catering to middle class children, The school building comprises four or five floors of a multi-storied building. The vernacular medium section runs in the ground floor. I conducted my study in the English medium section. The school lacks a playground and runs in two shifts, catering to secondary school in the morning and elementary school in the afternoon. The classrooms are rather small and cramped and house about fifty to fifty five students. One of the teachers told me that most of the children come from the upper caste Hindu communities. The students had four periods of Science every week which spans about forty minutes.

The teachers whose classes I observed are Geeta (name changed) who teaches class 3 and Reshma (name changed) who teaches class 4. Geeta has taught primary school for 6 years and has a Bachelor in Commerce (B.Com.) and a Bachelor in Education

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[3] How do our children think? Video series on student misconceptions. Educational Initiatives, 1996.

(B. Ed.) degree while Reshma has a teaching experience of 22 years and has a diploma in Education. Neither of the teachers are Science Graduates. Apart from Science, the teachers teach all the other subjects in their respective classes.

I. Phase I

2.3 Teachers views about the *Small Science* curriculum

During the course of the study I asked the teachers what their experiences were transacting the curriculum using the curriculum with the intention of gleaning how well they have imbibed the objectives. Geeta found *Small Science* interesting to teach. She referred to the curriculum as being 'activity based'. According to her, the first chapter titled 'the living world' did not have much in it to teach. What I gathered that she was referring to was that there was not much in terms of facts to deliver. Chapter I in class 3 has the objective of introducing students to the richness and variety of their immediate surroundings. It encourages children to identify and observe common plants and animals around them. In terms of pedagogy, it places on the teacher the onus of gathering the information of local plants and animals which Geeta appeared to find difficult. Reshma also seemed to echo Geeta's thoughts. She felt that one often needs to 'dig out' information 'to give to the children'. I also had a discussion with a few other teachers in the school staffroom. Although they seemed to find the *Small Science* curriculum good, they complained about how difficult it was to correct the WorkBooks. They said that the new Maharashtra State Board Science textbooks also seemed similar being 'activity - based' and using it would not *require* them to carry out the activities in the classroom. I looked through the Maharshtra State Board textbooks and found that the Textbook had neatly divided sections for facts and activities. Unlike *Small Science*, where activities are not explicitly labeled as activities; the Maharshtra board textbooks have specially delineated sections for activities and facts, perhaps making it convenient to omit the activities and focus on facts.

2.4 Institutional factors circumscribing teacher's practice:

The Teachers' Book spells out in detail the number of periods required to explore each aspect of the phenomena being investigated. The estimated time required to complete the syllabus as per the *small science* curriculum is 164 class periods for class 3 and 239 class periods for class 4. The teachers have about 4 periods of science classes every week which adds up to about 96 hours of science classes per year, if one were to assume that students had 9 months of school deducting holidays. This falls a way short of the time recommended by the curriculum developers to complete the syllabus.

The mode of evaluation recommended by the *Small Science* curriculum is continuous and situated. This however was not implemented by the school. The school still follows the formidable summative assessment system with mid-term tests, terminal exams and annual exams in the end. As a preparation for these exams, the children are made to work

out questions in a worksheet which are questions selected from the WorkBook. The questions test mostly content knowledge in the style conventional question papers while in the workbook these are based on observations and activities. In addition to the written exams, the students have an internal exam (which carries 20 marks out of 100; the remaining 80 marks are carried by the written exams). Geeta informed me that internal marks are awarded based on 'how the student is(performs) in classes and how 'he or she has completed the WorkBook'. On further probing, I understood that if the student answered questions and completed her/his WorkBook they were awarded good marks.

2.5 Examining teaching practices:

I believe that one major challenge to the implementation of an IBSE curriculum is large classrooms. Classroom management seemed to be a major concern for the teachers and I found that many a time interesting and thought provoking student responses were ignored. An activity in Unit III of the class 4 textbook involves getting children to make sounds with air. The students were not allowed to make sounds but instructed to 'write down' what noises could be made. Another study carried out in the same school has pointed out to the excessive emphasis on filling up the WorkBook.

Qualitative notions related with length, area and volume are introduced in Small Science class 3. In class 4, in the unit on sky and weather students have to apply these ideas to understand the use of a rain gauge. In the real situation, however, there are always errors in measurement. In order to help students reconcile the mathematically ideal notions of measurement with the complex real situations that they encounter, the following questions occur in the section on 'exercises'.

Figure it out:

1. Suppose you have two containers, one wide and the other narrow. Both have upright sides. You keep them together out in the rain. Would the height of the water collected in both the containers be the same, or different? Why?
2. Now suppose both the containers have water up to a height of one centimeter. Would the amount of water in them be same or different?
3. Suppose you keep two identical containers: One on the terrace and one on the open ground. Would they collect the same or different amounts of water?

The aim of these questions is to get students to apply mathematical notions of quantity, height, area and volume and predict the outcomes on that basis. It is hoped that after actually carrying out the rain gauge activity students would reflect on their results and guess the reasons behind them.

The teacher's book discusses the activity and points to the fact all the children did not get the same results despite keeping their rain gauges next to each other. The aim of the activity is to get the children to think of what may have caused the water levels in the containers to be different. In Reshma's class, though the rain gauge activity was not done, the question was discussed. She read out the first question and waited for the children to

respond. There were mixed responses. Some said yes and some said no. She finally said that the quantity of water in the two containers will be the same. A group of girls sitting in one side of the class tried to point out that the question that was being asked was about the height of the water not the quantity, the teacher appeared confused and said 'write whatever you want'.

For the second question, where the answer is not disputed, there were mixed responses from the student. Though a majority of students said 'different' some appeared to think it was 'same'. The teacher however failed to deal with the response in a scientific manner. She subscribed to the 'majority' principle and said that since majority think that it is different the answer should be different.

Yet another aspect of teacher practices that I would like to highlight is how student WorkBooks get evaluated.. I was informed that as a compromise between the *Small Science* requirement of assessment through workbook and the parents' and teachers' demand for regular exams, 20% internal assessment marks are awarded for how children fill up the WorkBook I analyzed student WorkBooks from three divisions of the same class and found that the teachers had not made any attempt to correct mistakes the children had made; whether conceptual or grammatical. Question marks punctuated spaces which were not 'filled up'. Only handwriting was commented upon and one finds remarks like 'neat' or 'write neatly'. In addition, some answers were also identical across divisions indicating that they may have been dictated.

2.6 Using the *Small Science* curriculum material; effects on:

a. Teaching practices

It has already been mentioned that *Small Science*'s emphasis is on getting children to think through careful questioning and development of scientific skills and attitudes through engagement in activities. However, the teachers still seemed to harbor a traditional view of what it is to teach Science and therefore interpreted the textbook, WorkBook and the teacher's book from that perspective. This in turn had unintended effects on classroom discourse. One of the main aspects of traditional teaching method is teacher centeredness of classroom discourse in which the teacher is often forced to maintain a running monologue. In the absence of *conten*t to deliver in *Small Science*, I often observed that the teachers brought in unrelated information which may be irrelevant to the phenomenon being discussed or age incompatible information which children may have found difficult to understand, in an effort to maintain their monologue and hence their control of the classroom proceedings. In class 3 for e.g, to teach the unit 'our bodies', the teacher used a highly advanced 'body parts' chart which may be appropriate for middle school or high school students. Her defense for it was that there was not 'enough' to teach the children. She did not appear to understand that her engaging with and responding to students' responses would itself have been a worthwhile learning experience for them.

I have mentioned that the teachers' expressed a wish to shift to the Maharashtra board textbooks because they would not have to correct the WorkBook. The reason for this I realized was that the *Small Science* WorkBook to some extent *mandates* that the teachers at least discuss if not carry out activities in the classroom, for the simple reason that the sections in the WorkBook cannot be left blank and need to be filled up.

b. Students' engagement in the classroom

Although the teachers did not encourage too much of student talk in the classroom, the students seemed fairly alive and interested. Some of the student responses have been discussed in the online professional development material. There were cases where even if the teacher did not do the activity in class, the students did it. There was also a case when the teacher did not do an activity, the child sought clarification about what the activity was about. These instances may have come about due to the fact that the Textbook directly speaks to the child using simple, accessible language.

Phase II:

2.7 Planning the teacher orientation workshop:

The Report on the working group on international collaboration in the evaluation of inquiry based science education (IBSE) [4] programs clearly outlines the roles of the teacher in an IBSE classroom. Some of the teacher roles that I felt were relevant for a structured inquiry classroom for 8-9 year olds are:

1. Providing opportunity for students to encounter materials and phenomena to explore or investigate first hand

2. Arranging for discussion in small groups and in whole class about procedures that are planned or have been used to identify alternatives and ways in which the approach to particular investigations might be improved

3. Encouraging tolerance, respect and objectivity in class discussion

4. Providing access to alternative procedures and ideas through discussion, reference to books, resources such as internet and other sources of help

5. Teaching the techniques needed for advancing skills, including the safe use of equipment, measuring instruments and conventional symbols

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[4] Harlen, W and Allende, J.E. (eds). (2006).Inter Academy Panel (IAP) report of the working group on international collaboration in the evaluation of inquiry based science education.

6. Encouraging students through comments and questioning to check that their ideas are consistent with the evidence available

7. Helping students to record their observations and other information in ways that support systematic working and review

8. Using questioning to encourage the use of inquiry skills

My observations in phase I pointed towards the need for exposing the teachers to student-oriented, constructivist teaching practices. We decided therefore to do the following for the workshop:

1. Show the teachers a video on student misconceptions which we thought may make them realize the need for understanding and listening to what children think and not take for granted that learning will occur if they continue to adhere to the chalk and talk method.

2. Examine student WorkBooks closely and prepare an activity sheet for teachers that will get them thinking about the roles (mentioned above) that they need to adopt to successfully implement inquiry in the classroom.

3. Show them a classroom video which shows a teacher teaching science through questioning in a large classroom of students. We felt that the video may be relevant because the classroom conditions in the video seemed comparable to their classrooms, particularly the classroom size.[5]

2.7.1 The activity sheet

The activity sheet was prepared based on student responses to some questions taken from the *Small Science* WorkBook on the concept of evaporation and condensation. The WorkBook pages were taken from another school which uses *Small Science* which is a fairly progressive school. We decided to use these WorkBooks because we were reasonably sure that the activities were done in that school. The classroom culture also seemed to permit student autonomy, because there were a variety of student responses, as opposed to one dictated answer although a few answers appeared to be dictated. The answers were scanned and inserted into the activity sheet, and questions were asked regarding the nature of student answers. (See appendix)

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[5] Teaching Science through Questioning.(2001). Part of video series by PRISM

The questions generally probed teachers understanding of whether:

- The answers were indicative of whether the student has observed the phenomena under investigation appropriately
- The students have inferred from the observations appropriately
- The students' conceptual understanding

Some answers which looked dictated were also included in the worksheet to take up as a discussion point. Apart from diagnosis of student responses; a Textbook analysis exercise was included as well where teachers were asked to compare a traditional Textbook with the *Small Science* Textbook in terms of treatment of a concept. The concept that we chose was evaporation and condensation and the Textbooks that we got the teachers to analyze were the Maharashtra State Board Textbooks, for class 4 and 5. Our assumption was that this activity will get the teachers to reflect on how an inquiry based curriculum would differ from a traditional Textbook in terms of presentation of a concept. This may also be a step towards empowering the teachers to look at textbooks more critically as opposed to being passive agents of transmission of knowledge.

2.7.2 Teachers' responses to the workshop

After the video on student misconceptions on the water cycle was shown to the teachers, I asked the teachers if they have any comments on it. The teachers agreed that these misconceptions were present in their students as well. One of the teachers however pointed out that *the* problem was that when the students answer, they are not able to 'put into correct words' and consequently 'they cannot answer in one sentence' when they get into middle school. We decided to take up the point later.

When the activity sheet was handed out to the teachers, they seemed vary about writing down their responses. So the questions were discussed orally. Out of the eleven teachers who participated, only about four were confident about disclosing their answers and views. The others mostly listened. Except one teacher out of the eleven, the teachers seemed to lack criticality in evaluating the answers. For example, one teacher pointed out that Roopa's reasoning (see Appendix) was wrong while some others pointed out that Meena and Raj 'understood better and were able to reason better'. Only one teacher was able to understand that Roopa had reasoned based on her own observation. None of the teachers were able to notice that Meena's and Raj's answers were identical and therefore could have been dictated or copied. While trying to figure out question 4, part I, one teacher pointed out that Raj had used the word 'moisture' which was more scientific than the word 'water droplet' that Meena had used. In the midst of discussing part I, one teacher brought up the point that variety in answers is not something that the parents appreciate. She said that the parents 'call up other parents and make sure that the children write the same answer'. She also pointed out that many a time children come to school with the answer already written down 'from the previous year's WorkBooks' and that 'If

we allow student to do free thinking they will not be able to fare well in the X^{th} board exam'.

In the activity sheet, part II was designed to test the teachers' knowledge about the experiment. Most of the teachers seemed unsure about the outcomes of the experiment. One teacher said that both the glasses will get wet, while another said that the glass with the cloth wrapped on it will get wet, only a little later than the first glass. When asked why she said that the cloth will absorb water from the atmosphere. A discussion ensued where the teachers' misconceptions were addressed. To the question on why students may be asked to guess the outcome of the experiment the teachers responded fairly satisfactorily with some of them saying that by beginning with a guess students will not take for granted their day to day observations and their thinking process will start.

The teachers were unable to interpret the problems with students' answers in Part III and we had to point them out. One of the teachers again pointed out the practical difficulties of transacting the curriculum in a student-centered manner. She said that correcting the WorkBooks becomes very difficult when students write a variety of answers, and that it becomes difficult to encourage students to answer in the class when the portions need to be completed. To this, Professor Ramadas responded that students are not expected to write completely different answers, but are required to discuss the answers in class and come to a consensus about what may be the right answer and then write down that answer. To tackle the problem of brevity (inability to write in one or two sentences) she said that it is important that the teacher help the child to frame short sentences. The teachers responded by saying that it is impossible to let everyone in a classroom of 55 speak to which she responded that the students should take turns to speak. She further emphasized the need to stop dictating answers in class because it kills the ability of the child to express her/himself and also leads to rote learning in higher classes due to lack of ability to comprehend the texts.

When asked to carry out the Textbook analysis, the teachers pointed out that the traditional textbooks had definitions given which was not the case with *Small Science*. One teacher said that for a child, 'the definition, one or two experiments and a few examples are enough for the children to understand a concept'. Another teacher also said that there is 'very little to explain' in the last chapter of class 3, Making houses. To this, Professor Ramadas pointed out that the unit on making houses is an introductory unit for students to understand properties of materials and their relation with use, and these are the students' first concrete experiences with the discipline of chemistry.

Implications of the study:

The classroom observations and the teachers' responses to the orientation workshop point to some implications for further work with teachers:

1. **The need for improving teachers' subject knowledge:**

The teachers' responses to part II of the activity sheet, and my observations of their classrooms point to the fact that they need to improve their subject matter knowledge. This will help them to be more confident in encouraging as well as dealing with students' responses. There is also a tendency among the teachers to trivialize Primary Science in the sense that they appear to think that it is easy and therefore easy to teach. These attitudes need to change. The online professional development material to some extent tries to bring about these attitudinal changes by talking about first person experiences of engaging in and reflecting on the activities in *Small Science*.

2. **The need for a shift in teachers understanding of nature of science as well as Science teaching**

The teachers' comments on the practical difficulties of enacting the curriculum seemed to indicate that they hardly reflected on the discipline of Science itself or what it means to teach Science. If the teachers are to feel the need for implementing inquiry based learning in their classrooms; they should feel that Science itself is a process that makes sense of the physical phenomena around us through inquiry and reflection. As teachers, they seemed to feel that their duty is only to prepare the children for middle school, one of which was training the students to write concisely in one or two sentences.

Further work needs to be done to change the teachers' attitudes towards the discipline as well as to get them to reflect about what their roles are as Science teachers. Only then will they be able to implement true inquiry in their classrooms and bring about a classroom culture that is more democratic, non-hierarchical and where true learning occurs.

Acknowledgements:

1. Professor Jayashree Ramadas
2. Ms. Vinisha K
3. Ms. Ruchi S. Kumar