Mathematics and Tribal Children

A major reason for tribal children doing less well in school mathematics seems to lie in the way the subject is taught in schools at the primary level. Though tribal communities have an extensive and rich knowledge of mathematics and everyday science, classroom teaching is completely divorced from their experiences. The National Curriculum Framework, 2005 appears to have failed in making an explicit commitment to adopt a cultural perspective on mathematics education that is necessary to protect the self-esteem of tribal children and impart to them a meaningful education.

MINATI PANDA

Despite adopting multi-pronged educational approaches and policies in post-independent India, why has the status of tribal education not improved significantly? Why do tribal children show poor performance in almost all the school subjects and more so in science and mathematics?[1] Why are the dropout rates[2] (51.37 per cent drop out by class V and over 80 per cent by class X) so high among these children? Moreover, children from these communities are found to be occupying abysmally low positions in science and mathematics performance in school final exams.[3] Why should all this happen, especially when these communities have extensive knowledge of science and mathematics?

A major reason for tribal children doing less well in school mathematics seems to lie in the way the subject is taught in schools in India at the primary level. Many tribal communities have extensive and rich knowledge of mathematics and everyday science [Barber and Estrin 1995; Panda 2004a]. But the classroom teaching is completely divorced from their everyday experiences and knowledge. Many successful learning strategies employed by the members of these communities are not recognised in the formal classroom contexts [Lave 1988]. In fact, non-tribal teachers as well as educational administrators devalue such strategies, popularly known as folk practices. In practice, tribal children are discouraged from using these strategies in the class.

Learning in any content area is something that takes place as a result of an interaction between what students bring to a task or a setting and what they encounter. The nature of learning depends on what these children already know, what they are motivated to learn and how the new experiences are presented to them. In the areas of mathematics and science teaching where a number of symbols and notations are used, it is important to establish a link between tribal children's past experiences and knowledge base derived from everyday cognition.

Tribal Knowledge Systems

After independence, policies have been revised several times in order to make education relevant for tribal children. Several print materials (though of doubtful quality) were developed by the State Councils of Educational Research and Training (SCERT) and Tribal Research Institutes (TRIs) in the tribal languages for primary classes, which were used only occasionally as supplementary readers in the schools. The culture and everyday cognitions of tribal children hardly influenced the main readers, i e, textbooks. In fact, the textbooks and the classroom transactions continue to be predominantly monocultural and also monolingual in all subject areas. Among different subject areas, mathematics teaching suffered most in tribal area schools because the tribal children come to school with a very different number system (which is not often linked to written symbols). They use different heuristics and algorithms to solve day-to-day mathematical problems. In school, they are fed mercilessly, with a series of written symbols, notations and formulas without any effort at linking these to their past experiences.

In fact, the acceptance of the idea that mathematical knowledge is part of the culture has been fairly half-hearted among the policy-makers and textbook writers. Though anthropological and socio-historical research strengthens this view by revealing more and more of the rich tapestry of mathematical knowledge existing in hundreds of folk cultures around the world, there is a kind of in-built resistance to linking mathematics teaching to community knowledge.

Mathematical ideas develop everywhere because people may live in different cultures, but they do similar things like arguing, comparing, searching, working to find food, enjoying themselves, fighting with each other and also carrying out other economic and commercial activities [Dorfler 2000]. Six operations which people engage in across all cultures are counting, measuring, designing, locating, playing and explaining [Dorfler 2000]. These activities involve an enormous amount of mathematics. In fact mathematical understanding is culturally conditioned and created across cultural contexts. However, unlike in many written cultures, in tribal cultures (most of which are oral) mathematics and science practices are not recorded, formalised and passed on beyond the context of their immediate usefulness. For this reason, this body of knowledge is not recognised by the academia as a structured body of knowledge, but rather remains a set of ad hoc practices.

The other reason for which such potential mathematical knowledge is not used in the school is our fixation with modern mathematics and the Eurocentric approach. In fact, it is now time to acknowledge that mathematics is not just about sums, fractions and equations. In recent years, the feeling of exasperation at being entangled in such a narrow definition of mathematics has been noticed among pedagogues and textbook writers. But the fear of a grand paradigmatic shift that probably implied a larger societal change in the area of power relations among cultural groups kept the bottom line defined. The bottom line here is the ubiquitous "child" and the use of those examples from society that are familiar to the majority of children but are "believed" to be shared by, or are at least familiar to, the children of minority groups.

The beliefs that are held privately by teachers and parents from the majority communities that the children of majority groups may not gain much from the discussion of mathematics by minority groups have further reinforced existing classroom practices.

The NCF's (2000)[4] submission that the multi-cultural complexion of society demands a multi-cultural approach to mathematics however remains at the level of rhetoric especially when actually translated into development of print materials like textbooks, activities, etc, and pedagogic practices. According to this ethos, children should have been introduced to different number systems and also several measuring and counting devices used by the various cultural groups in this country. But the common fear across the masses – both common man and professionals – that such an approach may confuse the children and increase the cognitive burden on them brought the pendulum back to its original position [for a detailed analysis of NCF 2000, see Panda 2004b].

The philosophic thrust of mathematics education as spelt out in NCF 2000 is aimed towards encouraging students to explore maths concepts and solve problems related to their everyday experiences. But the NCF 2000 document is silent on how to build symbolic and axiomatic knowledge on that foundation. Probably, instead of prescribing the methods and ways of doing it, the decision was left to the implementation agencies such as textbook writers and teacher trainers. This should have been ideal in a complex multicultural society like ours where each district, even the block, is unique in multicultural composition of its population. But in the given circumstances of the teacher's negative attitude towards these knowledge systems as valid sources of knowledge and textbooks mirroring the dominant class's values, perceptions and cultures, very little could be expected from the teachers, teacher trainers and textbook writers.

Moreover, the existing attitude towards indigenous knowledge systems was grossly misconceived and patronising. In last 50 odd years, we have only satisfied ourselves by mentioning them in policy documents or in our reactions to existing policy documents, that too in a sporadic manner. Even today, the emphasis in school mathematics is entirely on conceptual understanding, application of concepts, algorithmic performance, problem solving processes, etc. The attitudinal and other affective aspects of mathematics learning are to a large extent undermined; leave aside the inclusion of the everyday mathematical cognitions of the tribals in textbooks and classroom transactions.

Mathematics and NCF 2005: A Critique

The recently formulated NCF 2005 appears to be philosophically a much more consistent document than NCF 2000. The new curriculum framework begins with an overview of our past experiences with curriculum and sets out new goals for education in the first chapter. The first chapter discusses the social context of education and the guiding principles of the new national curriculum framework. The second chapter discusses threadbare the basic assumptions the NCF 2005 makes about the learner whose role has been rightly described as active, who is rooted in a specific cultural context and is a co-constructor of knowledge. It deals with most fundamental issues, like what is knowledge and understanding in general; how children's knowledge is integrally linked to local knowledge[5] and how knowledge is re-created,[6] etc. It acknowledges local knowledge traditions and argues for making the experiences of the socio-cultural world a part of the curriculum. In various places, the scientific knowledge embedded in the local cultures is discussed to establish a link between children's knowledge base as well as the natural learning processes.[7] In each of these sections, various local knowledge traditions and their curricular and pedagogic relevance in the area of science teaching, social science teaching and teaching of ecology, etc, are discussed. But, local mathematical knowledge systems and the process of mathematics learning in communities do not find equivalent emphasis even once in the first two chapters. Therefore, the first impression one gets after going through the first two chapters is that the underlying assumptions of mathematics learning has not probably moved far from the pre-Kuhnian[8] position that mathematics does not have much to do with communities, its knowledge and value systems. The following paragraph taken from NCF 2005 dealing with "how mathematics is generally learnt" reinforces this doubt:

> Mathematics has its own distinctive concepts, such as prime number, square root, fraction, integral and function. It also has its own validation procedure, namely, a step-by-step demonstration of the necessity of what is to be established. The validation procedure of mathematics is never empirical, never based on observation of the world or on experiment, but are (sic) demonstrations internal to the system specified by the appropriate set of axioms and definitions (paragraph 2.5.3. *Forms of Understanding*, NCF 2005).

This paragraph clearly provides the perspective of modern mathematics taught in present day schools, which is to a large extent western in origin. It takes a particular position not only in terms of what constitutes mathematics, but also in terms of mathematics as an ontological system, which is of modern western mathematics. Western mathematics is axiomatic whereas Indian mathematics found in the everyday practices of many cultural groups in India is not. Young Indian children come to school with mathematical knowledge rooted in the epistemic practices of their community. Such knowledge systems are not axiomatic, instead they are governed by the societal norms, values and also world views along with some pure mathematical considerations. Such fusion of societal or extra-mathematical considerations and the logico-deductive nature of this science are unique to oral traditions. Disregarding this knowledge system and the forms of knowing rooted in a particular epistemic practice of a community means disregarding children's past experiences and knowledge systems. From a pure academic and conceptual point of view, there is nothing wrong with the NCF paragraph cited above. But from a cultural perspective, the paragraph seems to have taken an epistemic position that is not ours.

Vision for School Maths

This problem is also evident in the way the major concerns and the vision for school mathematics have been spelt out in NCF 2005. The two major concerns of mathematics curriculum spelt out in the document are as follows:

> The twin concerns of the mathematics curriculum are: what can mathematics education do to engage the mind of every student, and how can it strengthen the students' resources? (p 38).

None of the sections dealing with mathematics has attempted to define "students' resources". In the absence of clarity, one does not know whether the resources here refer to cognitive resources, like intra-discursive resources built on the basis of a set of axioms and logic, or to those intra discursive resources built on the basis of a few as-if assumptions[9] people make in the community about a mathematical object and therefore mathematical reality. A closer scrutiny of the vision statements made in the document on school mathematics further reinforces this apprehension.

> 3.2.1 Vision for School Mathematics
> – Children learn to enjoy mathematics rather than fear it.
> – Children learn important mathematics: mathematics is more than formulas and mechanical procedures.
> – Children see mathematics as something to talk about, to communicate, to discuss among themselves, to work together on.
> – Children pose and solve meaningful problems.
> – Children use abstractions to perceive relationships, to see structure, to reason out things, to argue the truth or the falsity of the situation.
> – Children understand basic structure of mathematics: arithmetic, algebra, geometry and trigonometry, the basic content areas of school mathematics, all offer a methodology for abstraction, structuration and generalisation.
> – Teachers engage every child in class with the conviction that everyone can learn mathematics (p 38, NCF 2005.)

The vision here does not mention the specific needs of numerous cultural groups in India who use different kinds of number systems (many of which exist as oral practices) and algorithms, and speak different languages. Nor does it mention how these can inform the classroom processes in multicultural schools in India. In fact, universal statements like these tend to push away folk mathematics from any kind of academic discourse limiting the scope of its inclusion in the curriculum. Is the omission of a cultural perspective in the beginning inadvertent or intentional? A closer look at the document seems to affirm the latter and not the former.

Difference vis-a-vis Other Sciences

All other learning areas such as natural sciences, social sciences, ecology, etc, are found to be rooted in the cultural practices of the learners, which provide legitimacy to such knowledge forms. Chapter 3 that deals primarily with the curricular areas, school stages and assessment makes the omission of such a perspective in mathematics education more evident. This chapter deals with eight curricular areas such as language, mathematics, natural sciences, social sciences, art education, health and physical education, work and education and education for peace. All sections other than mathematics talk of children's knowledge systems in their community and suggest how to bridge the gaps between the community practices and knowledge and the school knowledge. The section on science curriculum deals with the vision, that includes both the "what" and "how" of science curriculum (see pp 41-45, NCF 2005). The question of what includes community knowledge and academic sciences, the former providing validity to the latter. The question of how legitimises the children's natural process of learning science from the environment by suggesting it is a legitimate part of the teaching learning processes.

The section on "natural science" in its attempt at defining good science education mentions six basic criteria of validity of a science curriculum. These include cognitive validity, content validity, process validity, historical validity, environmental validity and ethical validity (see page 42, NCF 2005 for details). The sections on historical validity and environmental validity place science in the wider context of the learners' environment, view science as a social enterprise and look at how social factors influence the development of science. Section 3.3.1 on "Curriculum at Different Stage" for natural science education mentions that curriculum for the primary stage is consistent with the criteria mentioned above. This section talks about the natural environment, artefacts and people and also how children learn science through these.

Similarly, the section on social sciences (3.4 Social Sciences, p 46, NCF 2005) has a sub-heading called 'The Proposed Epistemological Frame' which provides the foundational logic derived from children's cultural experiences in drafting of new syllabi for social sciences and answers both the "what" and "how" of social science teaching. This is followed by the sub-heading 'Planning the Curriculum' (section 3.4.2, p 47, NCF 2006, draft), which effectively deals with how to build school knowledge on everyday experiences. Such an approach adopted in both natural science and social science helps in bringing children's culture onto the centre stage of science teaching in schools.

Why is such a visible difference found in the philosophical thrust in these two sections vis-à-vis mathematics? Is it only accidental? Or, is it because of our continued belief that forms of knowledge and knowledge acquiring processes in mathematics are fundamentally different from natural science and social sciences? Is it our belief that mathematics probably has much less to do with culture than the natural science and social sciences? The consistency found across different chapters in the treatment of mathematics as a universal subject, in terms of having nothing much to do with societal values and concerns, suggests that the omission is not just accidental. On the contrary, the designers of the curriculum framework do not seem to be fully convinced about the role of culture in mathematics learning or are half-hearted about it, at best. When one flips through the pages of NCF 2005, one, of course, finds mention of cultures and cultural experiences in a loose and sporadic manner in some parts dealing with mathematics. But this is not enough or, at the least, not so consistent to give an impression of a perspective. Moreover, acceptance and discussion of people's mathematics per se is conspicuous by its absence in the entire document.

Paragraph 3.2.2, "The Curriculum", is also written in culture-neutral language. In fact the way it is written, it can address children from any culture/communities from anywhere in the world. The two paragraphs dwelling on curriculum for the pre-primary and primary stages provide evidence in support of the argument I am making here. The first paragraph that deals with curriculum for the pre-primary stage is given below:

> At the pre-primary stage, all learning occurs through play rather than through didactic communication. Rather than the rote learning of the number sequence, children need to learn and understand, in the context of small sets, the communication of word names counting, and between counting and quantity. Making simple comparisons and classification along one dimension at a time, and identifying shapes and symmetry are appropriate skills to acquire at this stage. Encouraging children to use language to freely express one's thought and emotions, rather than in predetermined ways is extremely important at this and at later stage (p 40, NCF 2005).

The section on primary stage (see p 40) deals primarily with developing a positive attitude among children towards mathematics, going beyond arithmetic and dealing with areas like shapes, spatial understanding, patterns, measurement and data handling, and developing both computational skills and the skills of language in communication and reasoning. This paragraph contains one sentence where children's experiences are talked about; "Mathematical games, puzzles and stories help in developing a positive attitude and in making connections between mathematics and everyday thinking" (p 40). This is, in fact, the lone statement in the first two chapters that explicitly talks about children's community experiences in mathematics and, also, how to integrate these into the classroom learning of mathematics.

Several ethnographic studies have clearly shown that tribal communities have their own number system and also methods of performing basic algorithmic functions [Panda 2004a, 2004b]. They differ in their experiential basis of mathematical knowledge [Harris 1999; Panda 2004a, 2004c], use of specific language (e g, use of specific linguistic categories, metaphors and metaphorical projections of reality) and symbols [Harris 1999] and also the process of mathematical enquiry [Barber and Estrine 1995]. The implicit rules of everyday mathematical cognitions in these communities are determined to a good extent by non-mathematical considerations like social values, beliefs, expectations, experiences, relations and social institutions [Lave 1988]. Panda (2004c) explored the cultural reasons for why Saora children reject certain kinds of mathematical propositions and discourses in the classrooms. If all these are true, the compelling truth is that unless tribal children's mathematical knowledge and experiences are integrated into classroom practices and, continuity established between their home and school, they will find mathematics education uninteresting, culturally barren and dead. When one examines NCF 2005 from tribal child's perspective, the document appears to have failed in making an explicit commitment to adopt a cultural perspective on mathematics education. If we look at the whole document from a philosophical and theoretical perspective, the document adopts a pure cultural psychological perspective explicitly in all other curricular areas except mathematics.

Conclusion

Many of us who argue for culturalising mathematics pedagogy do so with a belief that such an approach is necessary not only for protecting the self-esteem of tribal children but also for giving them a meaningful and culturally valued education. Indulgence in mathematical conventions and ways of speaking is partly an emotional willingness. The learners, be it tribal children or any other, must indulge in mathematical discourse willingly and this participation cannot be forced on them by persuasion or cogent arguments [Dorfler 2000]. Presently, the mathematics curriculum, syllabus and the textbooks do not represent tribal culture, their value system and knowledge. As a result, tribal children are forced to participate in a convention of mathematical discourse, which they neither own nor remotely identify with [Panda 2004a]. This explains the research findings that the tribal children find mathematics textbooks and pedagogy culturally cold and barren and gradually lose interest in mathematics [Panda 2004a].

Therefore, speaking from an equity point of view, the new curriculum framework needs to identify some of these rough patches, which unless crossed or filled up may fail to address the needs of the tribal children. The document could be more emphatic and also explicit on the epistemological frame of mathematics curriculum. Such a frame should take into account peoples' mathematics and its ontological aspects as well. Beside this, the document needs to go one step further by suggesting how to build the symbolic and axiomatic knowledge on the everyday knowledge of tribal children. EPW

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Notes

1 For detailed statistics, see *Baseline Study Report* by NCERT, 1993, *Report on Learning Achievement of Students at the end of Class V*, Department of Educational Measurement and evaluation, NCERT, New Delhi, 2004, p 35.

2 Ministry of HRD, Department of Secondary and Higher Education, 2004; *Selected Educational Statistics, 2002-2003*, Government of India, New Delhi.

3 See pp 35, 36, *Report on Learning Achievement of Students at the end of Class V*, Department of Educational Measurement and Evaluation, NCERT, New Delhi, 2004. The categorywise data on achievement scores at the end of class V show that compared to SCs and others, the tribal children performed lowest in all the subject areas like EVS, language, mathematics and science in all the states and also in national average. The gap is highest in mathematics (see page 35 for national averages).

4 See National Curriculum.

5 See Para 2.7 Children's Knowledge and Local Knowledge, p 27, 2.8 School Knowledge and the Community, p 29, Chapter 2, NCF 2005.

6 See section 2.6 *Recreating Knowledge*, p 25, NCF 2005.

7 See section 2.5.2 *Knowledge in Practice*, p 23 and p 25, and 2.7 *Children's Knowledge and Local Knowledge*, p 27, 2.8 *School Knowledge and the Community*, p 29, Chapter 2, NCF 2005.

8 Before Kuhnian revolution in 1945, mathematics was treated as a body of infallible, objective and timeless truths far removed from the affairs and values of humanity. This resulted in development of many methods of didactic education, which assumed a separation between knowing and doing, treating knowledge as an integral, self-sufficient substance, theoretically independent of the situations in which it is learnt. The primary concern of schools often seems to be the transfer of this substance, which comprises abstract, decontextualised formal concepts. In post-Kuhn phase, mathematics is treated as a changing body of knowledge, the product of human inventiveness and, therefore, as fallible as any other knowledge. According to Kuhn, if mathematics is a fallible social intervention, then it is a process of inquiry, "a coming to know", constantly expanding with human inventiveness, with no end. These assertions redefined what mathematics is at theoretical and philosophical level. The post-Kuhn phase is also marked by contributions made by Vygotsky and Lave. According to them, the activity in which knowledge is developed and deployed is not separable from or ancillary to learning and cognition, nor it is neutral, rather it is an integral part of what is learned.

9 Mathematics is a special form of semiotic activity that includes all forms of discursive acts including language use in a particular culture. Various mathematical discourses are carried out by the children and adults in various eco-cultural settings and routine daily life activities. Many as-if assumptions underlie these discursive acts, which help children develop an as-if attitude. Such an attitude plays an instrumental role in the development of mathematical thinking among the children. For more details, see Dorfler (2000) and Panda (2004b).

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