Curriculum and Critical Agency: Mediating Everyday Mathematics

Anita Rampal
Faculty of Education, University of Delhi, India

This paper traverses the path of critical education and reflection sought by activist academics who, in various capacities, strove to change curricula for science and mathematics education in India at the state and national levels. The National Literacy Campaign in the 90s had offered space to understand people's lived realities and mediate everyday math in the teaching learning processes, through a constructive critique of the hegemonic and alienating nature of the school subject. Subsequently, within the ambit of the National Curriculum Framework 2005 and the Right to Education Act 2009, the national primary math textbooks attempted to (re)mediate the experience of non-literate adults, and to address diverse children's knowledge through a (re)humanising pedagogy of empathy, despite the constraints of a large bureaucratic and increasingly neo-liberal state system.

Introduction

In the 70s, as part of a group of activist scientists, I was involved with curriculum development for the Hoshangabad Science Teaching Programme (HSTP) in rural government schools of Madhya Pradesh. It was the first inquiry-based science curriculum in the country, which forged compatibility between "academic credibility" and "relevance", conducted through collaboration between voluntary activists, professional scientists, and school teachers. Taking cognisance of the majority of pupils who did not continue school after Class VIII, the curriculum, within the constraints of the State syllabus, gave priority to developing a critical scientific attitude for life, and even excluded concepts usually dictated by the discipline. The emphasis on low-cost and indigenously designed apparatus provided an incentive to teachers to exercise their own creative skills and symbolised an assertion of self-reliance. Pedagogically, it was also important for students to feel comfortable with the apparatus, to alleviate the sense of alienation and

mystification normally associated with science lessons, not just in rural but also in city schools. However, its critics used its philosophy of "low cost" to describe it as "low status" and label it as "backward science" (Rampal, 1992a). Political as well as parental pressure had often to be countered through discussions related to issues of science-technology-society in a developmental context. Incidentally, with the increasing neo-liberal pressures of a bourgeoning IT industry, it now becomes even harder to advocate for low-tech humanistic pedagogies.

The programme had negotiated processes of participatory curriculum development and enactment with the government, and had sought several academics from across the country to be associated in various capacities, from among scientists, educationists, and later, social scientists, child developmentalists, linguists etc. However, the participation of mathematicians was then not similarly envisioned; even decades later, activist mathematicians are often found scouting for and nurturing the "gifted" or "mathematically talented" from among the ordinary millions of students, through joyful activities, math clubs or camps, but not interrogating the school subject. Reflecting from my personal experience, I find that science activism had informed debates and social action in the arena of education and science policy in the 70s and 80s, with several initiatives through voluntary peoples' science groups, leading to a consolidation of the All India Peoples' Science Network, immediately after the Union Carbide Gas Disaster in Bhopal. However, it was much later, in the early 90s, while working with unschooled youth and adults in the National Literacy Campaign, inspired by Freire's critical pedagogy, that some of us began to relook at mathematics from a socio-cultural perspective.

Interestingly, as part of the HSTP even then in the 70s, along with the broader theme of measurement (of length, area, volume, and weight), a chapter on probability was consciously wrested from the traditional secondary school math curriculum, which was not open to restructuring, and developed as part of the middle school science programme. However, even with a focus on inquiry-based learning, the main thrust did not depart significantly from the normative understanding of probability, explored through activities, with only a few references to social contexts.

The chapter on chance and probability in the HSTP science text-cum-workbook began with the example of an erratic schedule

of a local passenger train, and drawing upon the daily dilemmas of commuters, gradually led learners to think about chance, prediction, and what is popularly perceived as "luck". Through activities with coins, dice and *cowries*, and observations on how relative frequencies stabilise with large numbers, it introduced the idea of probabilistic thinking in estimating the percentage of seeds that germinate in a field, or sample testing for soil quality, tests for TB etc. The HSTP textbook encouraged students to work collaboratively in groups, raising questions, seeking tentative answers, collectively resolving doubts, experimenting, and deriving their own procedures using their observations. This participatory learning approach sharply departed from the individualistic image of the subject, through its hidden curriculum that enables some "talented" pupils to learn mathematics, while ensuring that the others understand that they cannot, with due deference towards those who can (Eggleston, 1977).

Interestingly, and perhaps predictably, the chapter on probability became the centre of a political controversy in 1985, even threatening the programme, when the science paper of the middle school State Board examination included two questions on probability, based on the context of "*satta*", the local form of gambling. A politically motivated query was raised in the State Legislative Assembly by a member of the right wing conservative party in opposition. It strongly urged the closure of HSTP, alleging that the programme based on principles of "learning by doing" actually taught students to gamble! However, for the first time in the history of a state Legislative Assembly, an academic argument was presented through a substantial 25-page paper by an MLA (Member, Legislative Assembly), who defended the teaching of chance and probability, along the following lines:

- the historical origin of probability as a field of study lies in games of chance and gambling;
- HSTP does not promote gambling, on the contrary it leads students to understand the dangers of gambling by understanding the mathematics behind it;
- such politicisation of education can prove to be regressive for the scientific and technological development of a country.

The middle school teachers who framed the questions were served an official "show cause" notice but bravely and confidently defended their

action. As active resource teachers of the programme, they replied to the state Department of Education, explaining that having seen the terrible impact of gambling on the lives of daily wage earners in Hoshangabad district, they held that such questions enabled children to construct knowledge and make connections between probability and the slim odds of winning at gambling. In fact, the ability to challenge authority, as had been imbibed by the resource teachers and even students, through the democratic ethos of the programme, displeased large sections of the feudal bureaucracy and political establishment of the state.

Though in 2002, after thirty years, the state government did close HSTP owing to political considerations, much of the insights and experience gained continued to influence restructuring of education in other states of the country and, subsequently, at the national level as part of the National Curriculum Framework (NCF) 2005 (NCERT, 2005a). For the first time there was a large participation of progressive intellectuals and voluntary groups in developing the NCF 2005, its positon papers, syllabi and textbooks (all freely available online), as a response to the agenda of cultural and religious imperialism of the previous government at the Centre. Since then this tension has continued to openly play up in the states, as and when there is a shift in government. Now with a change at the Centre there are again calls for a changed NCF and education policy. Academic bodies are seen promoting often contested chauvinistic claims glorifying ancient science and mathematics.

It is indeed a matter of concern why an enabling legacy, of developing curricula within the sociocultural context of learners and teachers, as was initiated in HSTP in the 70s, did not take us very far in mathematics education in the intervening four decades. The national textbooks for history and political science, as well as the primary textbooks, saw a major shift. However, in sharp contrast to the national primary math curriculum, which I shall discuss in more detail, the middle and high school curricula have continued to remain entrenched within a dehumanising disciplinary domain. This is despite the NCF 2005 and the historic Right to Education (RTE) Act 2009 for children 6-14 years, which mandates "learning through activities, discovery, and exploration in a child centred and child friendly manner" by "making the child free of fear, trauma and anxiety" (Section 29, GoI, 2009). The Act also posits continuous and comprehensive assessment and bans grade retention, any selection for

school admissions, or the conduct of competitive examinations at the elementary stage. However, the pattern of examinations remains tied to rote memorization of procedures and definitions, promoting hegemonic notions of mathematical "ability". It intimidates children and also dissuades some creative teachers, as their efforts to encourage sense making get obliterated by the examination questions devoid of any meaning and contextual relevance.

The present curriculum for middle school math introduces normative probability in grade VII through conventional descriptions of coins and dice, with no attention to the epistemological and pedagogical complexity involved, nor to children's subjective ideas and cultural values, through strong beliefs in luck, destiny, and fairness. We recently followed up on this theme in a doctoral study (Bhavna, 2013), to understand children's probabilistic thinking and discursive practices through contextual tasks. We noted how they articulated their agency through school surveys (to predict and critically analyse patterns of child sex-ratio in the school families, interrogating patriarchal ideologies and gender preference practices), and using that knowledge we developed culturally responsive curricular units. In another ongoing doctoral study, we have seen how children of Class VIII in a government school, subjected to traditional school tests and declared "low achievers", are able to perform sophisticated statistical analysis in culturally responsive assessment tasks, such as studying their Mid-Day Meal programme, or the daily wage labour data from local building contractors. In addition, the "high achievers", too, discovered alternative ways of thinking and problem solving and posing from their peers; this significantly changed the group dynamics and scaffolded them to deeper and higher levels of engagement, from what they could earlier do in a routinely procedural fashion.

A preface to the Report "Learning without burden" (Government of India, 1993), a precursor to the NCF 2005, had noted that the problem of 'drop-out' results from those children being "pushed out" who, in a way, refuse to compromise with "non-comprehension". This helped problematise the "deficit discourse", with a shift towards the nature of comprehension and meaning making, relevance and participation, especially in the context of the curriculum. The Literacy Campaign in the 90s had also highlighted the "push out" phenomenon, stating that had elementary education been more inclusive and equitable in the decades after independence, the country would

not have been faced with abysmally low levels of literacy. The task of developing alternative numeracy curricula for the campaign had, for some of us, assumed a dual nature—exploring and mediating everyday knowledge while offering a constructive critique of schooled math.

Everyday Dilemmas: An Unschooled Mother, a Schooled Daughter

We got insights into the dilemmas of people's everyday lives and mathematical practices, as we interacted with Draupadi, while trying to help her daughter with primary school mathematics. Draupadi's background helps situate her learning as part of her life trajectory, while it "foregrounds" (Skovsmose, 2014) her daughter's experience at school. Draupadi, a middle-aged dalit (a neo-Buddhist belonging to a scheduled caste), had struggled initially to survive in a city through rag-picking and daily wage labour at construction sites. For some years, she had been living in a slum dwelling, working as a domestic help in several middle-class homes. She had missed out on school education during her turbulent childhood spent in a small village. At a very young age, she had had to take charge of her younger brother and sisters, after the death of her father and her mother's mental breakdown. Married at the age of thirteen, she had moved to the city with her husband and her siblings, in search of work. She learnt to read a little in her thirties, from one of her supportive domestic employers. The almost singular motivation of her life had been to send her children to school, to somehow release them from the vicious cycle of deprivation she found herself in. Much to her disappointment, schooling alienated her children, instilling a debilitating sense of failure. Her eldest daughter was "pushed out" in six years. Her son, who initially took interest and attended school regularly, gained recognition as an amateur percussionist in the local community, finally gave up, disillusioned after failing twice in the Class X examination; some years later, he took to alcohol like his late father, when summarily retrenched from a factory job despite his diligence. Sunita, her youngest daughter, was studying in Class V when we first met Draupadi, who desperately hoped that at least this bright-eyed child would complete school; but the odds were heavily against her.

Ten-year-old Sunita had been very upset at not being able to cope with school math and her teacher, who constantly reprimanded and humiliated her for it. She was totally confused by the algorithms taught at school, unable to use her own life experience the way her non-literate mother could effortlessly do. "See, if your mother wants to divide Rs.180 equally between her three children, how much would she give you?" we asked reassuringly. Sunita seemed confounded and stared blankly. Her unschooled mother laughingly provided the answer and wonderingly looked at her. Sunita, for her part, mindlessly manipulates numbers; when a problem is stated in words, she desperately tries to translate it into some mathematical operation between 180 and 3, and often cannot decide which operation to use, the "x" or the "+", or some other. Even when she is told she has to divide 180 by 3, she can only visualise the school method of writing numbers in what is a meaningless and strange pattern to her (for 'long division')—bringing one down, writing something on the right side, some number above, subtracting, and so on.

We next ask Draupadi how much she would need if, instead, she had to give Rs. 180 to each. Again promptly, almost without batting an eyelid she smiles and says "Rs. 180 for three of them? …that's Rs. 540" without knowing any tables and without being able to write these figures down. How did she do it? First, she says, she pictures three 180s in her mind. From the last 180 she mentally gives 20 to each of the first two, "completing" 200 each time, and then added 200 + 200 + 140. She proudly confesses that she challenged her husband, a skilled and literate mason, that she could perform complicated mental computations faster than he could do using his written methods. However, Draupadi does not try to teach her own ways to her daughter assuming that these and better ways are available to those who can write. Unfortunately, it is not so for young Sunita and millions like her. We realised this was not an isolated case of a "slow learner" and her "talented" mother. Most surveys with out of school children said they found school to be "uninteresting" and "difficult" and mathematics to be the "killer" subject. On the contrary, Draupadi, like most adults engaged in everyday mathematics, did not suffer from school-induced "math phobia" and within her everyday purposes was confident of applying a variety of mental algorithms (Nunes, Schliemann, & Carraher, 1993).

We noted that innumeracy was not necessarily linked to a lack of scriptural literacy, but more to the nature of the mathematics

curriculum, divorced from, and dismissive of, the learners' strategies and knowledge. Based on observations of everyday mathematical practices, we developed a Handbook on numeracy for the literacy volunteers, documenting the rich cultural repertoire of knowledge, and presenting an alternate curriculum for adult learners (Rampal, Ramanujam, & Saraswathi, 1998; 2000).

The National Literacy Campaign

During the 90s, Literacy Campaigns were conducted in over five hundred districts of the country, to include non-literate adults in the age group of 15-45 years. To provide a voluntary people's arm to work for the Campaigns as part of the National Literacy Mission of the government, the Peoples' Science Network had formed a special voluntary organisation called *Bharat Gyan Vigyan Samiti* (roughly translated as the Indian Knowledge and Science Committee). Many of us got involved in all the processes of the campaigns, at every possible level. The campaign was participatory, with local teams planning and implementing it under the aegis of the district administration. Teaching was carried out by millions of volunteers without any remuneration; the government bore a low cost (less than US$ 2 per learner), while the community pitched in through volunteer teachers, space for literacy classes, food and shelter for the travelling theatre groups engaged in cultural mobilisation, and so on. For the first time in Indian education, the curriculum and primers were meant to be developed at the district level, in local languages, including some indigenous languages not scripted earlier. Despite the constraints, many districts did come up with their own primers and supplementary materials, especially in the post-literacy phase, based on local contexts such as the coal mines, migration, women's self-help groups etc.

We found that oral numeracy is more natural among unschooled adults than literacy, as they are more familiar with numbers, operations, measurements, etc. than with alphabets. However, in the traditional primers made by the State Resource Centres the literacy and numeracy content came together, the latter often appended to each lesson in an ad hoc manner. As far as reading and writing were concerned, there seemed to be some understanding that teaching would codify speech and verbal thought, through generative words,

and not start mechanically from alphabets. However, there was no such attempt to understand the lived "meaning of numbers" or to look for generative themes; the conventional primers laboured through numbers in an absurdly child-like and linear fashion, 1-10 in chapter 1, 11-20 in chapter 2, and so on. Pictorial illustrations were taken from children's books, and learners were condescendingly asked to count eight ducks or five apples. Moreover, the national curriculum committee tended to "dilute" the expected competencies each time the poor mathematical performance of adults was brought up.

On the contrary, adults wanted to move on fast to more sophisticated and challenging tasks in mathematics, to help them deal with market transactions more confidently. Operations of addition, multiplication etc. made more sense as contextual problems, and adults were capable of doing "word problems" long before they learnt to read and write. However, conventional adult educators, influenced by the school myth of "word problems are more difficult" avoided these and other everyday calculations involving profit and loss, simple interest on loans, or even probability of winning or losing a lottery, considered important by the learners themselves. Similarly, adult educators were wary of fractions and did not try to understand how some adults comfortably negotiated through complex fractions as part of their work. In many southern states, intricate fractions exist in everyday vocabulary, and seem to have some link to the markedly intricate sound and beat patterns used in classical Carnatic music. In Tamil (the language of the state of Tamil Nadu) and Malayalam (of the state of Kerala), people speak of "half of one fourth" as "*araikaal*" or "three fourth of one eighths" as "*mukaal arakaa*". This, interestingly, is not found in the languages or the music of the northern states. Similarly, "dichotomous divisibility" or repeated divisibility by two, significant in the counting systems (with base 12 or 16) or measures used by traditional societies, could be found in use with no place in the primers (Rampal, 2003a).

Learning while Doing: From the Everyday, to the Centre

Unlike traditional cognitive theories that isolate and distance the learning "mind" from its experience, theories of situated learning do

not separate thought, action, and feelings of the learners. While in the traditional case it is "learning" that is problematic, in the socio-cultural perspective "knowledge" becomes complex and problematic (Lave, 1996). We had become aware of some of these issues while working with adults coming to the Literacy Centres, and as part of developing alternate curricula for them we mediated their knowledge into the teaching learning processes. The campaign, where effective, had led to markedly increased demands for schooling of children with high enrolment in those districts. But the formal system remained rigid and unresponsive to their aspirations.

We had seen that adult learners engaged in a host of mathematical transactions, such as sorting, measurement, estimation, making patterns, etc. (Gerdes, 1985; Greer, Mukhopadhyay, Powell, & Nelso-Barber, 2009) as part of their activities related to life and labour. New ideas or skills needed to be reinterpreted through the learners' own mediatory mechanisms, of assigning meaning to them, and, more importantly, testing them out in real-life settings. However, teaching practices used in traditional adult literacy classes never attempted to encourage such mediation and failed to engage learners in reflection of any kind.

Oral societies have invested tremendous effort and ingenuity in devising mnemonic techniques, such as *shlokas, mantras,* and *sutras,* rendered through elaborate rhythmic patterns, to memorise, preserve, and transmit their rich bodies of knowledge. A poetic ode to estimation and measurement, this old poem in Tamil reflects an amazing range of length measures from the atomic to an astronomical scale, through the use of rich life-world imagery. This excerpt from the English translation however does not give a sense of rhyme and the sounds of the original.

8 atoms	= 1 speck in the sun's ray
8 specks in the sun's ray	= 1 speck of cotton dust
8 cotton specks	= 1 hair point tip
8 hair tips	= 1 small sand particle
8 sand particles	= 1 small mustard seed
8 small mustard seeds	= 1 sesame seed
8 sesame seeds	= 1 paddy seed
8 paddy seeds	= 1 finger width
12 finger widths	= 1 span

2 spans	= 1 cubit
12 cubits	= 1 stick (kol)
500 "kols"	= 1 "koopidu dooram" (calling distance)
4 "koopidu dooram"	= 1 "kaadam" (about 1.2 kms.)
	and so on…..

The measure "*koopidu dooram*" or "calling distance" is known to have been used as a traditional measure in many early metrological systems, suggesting empirical knowledge that sound travels only a finite distance and different frequencies attenuate at different distances. Economic historians have noted that, unlike the metric system, which is wholly arbitrary and dependent on convention, folk measures should not be termed "conventional"; those are truly "representational" and therefore have a social "meaning", determined through peoples' activities (Kula, 1986). The dominance of qualitative "value" over purely quantitative considerations in the social thinking of pre-industrial societies is found to be striking. For instance, land measures were not directly "addable", and accounted for the quality of soil, labour-time for tilling, or the amount of seed needed. Similarly, the "measure sold" was different in size from the "measure bought"; a heaped container is bought from the farmer while a flat one is sold to a customer at the same price, to take care of the costs of transaction; even now we are given 13 glass bangles at the rate of a dozen (to cover possible breakage). Such forms of measurement often co-exist with the standard systems but most educators refused to appreciate the ingenuity and significance of such measures, dismissing those as "crude", inaccurate, or "primitive".

As part of the teaching methods we devised, measurement and estimation began in the local measures before the metric system was introduced. For instance, the Numeracy Handbook (Rampal et al., 1998) for volunteers points out the different body measures used:

> Extensive use of body measures is important, particularly for length. Exercises can be done with units like finger-width, finger-length, span, cubit, feet, fathom, etc. For depth, people often use units like ankle-deep, knee-deep, man-deep, etc. In addition, units like a *chatai*-length, a *dhoti*-length, length of fish etc. are also useful.

When it comes to volume measures, similar units are available such as:

- Taken as a pinch: salt, snuff, herbs, medicinal powder, etc.
- Scooped up by the fingers: mustard seeds, cumin seeds, *haldi* powder, etc.
- A handful: flour, pulses, sugar for sweets, peanuts, flowers, soil, etc.
- A palmful: "*prasad*" during ritual prayers received with a cupped palm, etc

The Metric *Mela:* A Festival of Estimation and Measurement

A plethora of creative activities to estimate and measure gave rise to the popular concept of a Metric/Math *Mela* (Fair) conducted by the volunteers and learners themselves, where the village turned out in all its fineries to participate. Incidentally, even the Test for the Literacy Campaign was organised as a large celebratory event where learners turned up in colourful clothes. The following excerpt from our Numeracy Handbook (1998, pp. 48-50) shows how the *mela* was conducted and encourages other volunteers to do so too:

> Even as you approach the mela, you can hear the songs on the loudspeaker. You wish somebody would reduce the volume, but it is undeniable that the din caused does add to the festive atmosphere. Indeed it seems to go with the festoons, streamers, and the general riot of colour, with noisy children running about adding to the mela mood.
>
> A couple of volunteers come forward to welcome you, assuring that you are about to have a "totally new" experience, and that this mela is entirely run by their students, the neo-literates of the village. You have heard this before, when they went door to door yesterday inviting everyone in the village to come, and even offered attractive prizes!

Figure 1: Festival goers. Source: *Numeracy Counts* (1998) Rampal, Ramanujam and Saraswathi)

Even as you join the queue, you ask why "metric" *mela,* but receive no clear response. The volunteers, young girls themselves, giggle a bit and are mysterious—you'll find out soon. …….. Even as you move along, you are intrigued by your red card, and you take a look at it. It has a big table with each row having a description and some blank entries. Passing over routine items like height, weight etc. you are intrigued by entries like "weight of a feather?", "length of *lauki (gourd)*"etc. Wait a minute, what is that—"length of nose"?! They are not going to measure the length of your nose, are they!?

The Card

Name : Male/Female	Card No.. Address :
My Height : Cms	My Weight: Kgs
Length of '*lauki*' :	Length of Nose:
Length of a chalk	Little finger:
Weight of an egg:	Weight of the cabbage:
Weight of a feather:	
Which has more water?:	
Volume of water in a bucket:	Volume of water in a bottle:

The first stall you go to has a person with a measuring tape, who measures your height, enters it in your card and makes an entry

in her own register as well. In the next one, as expected, someone measures the length of your nose!

While you now have a pretty good idea of what the mela is about, and why it is a metric mela, the whole thing falls into place only in the evening, when there is a festive cultural programme followed by the much-awaited prize-giving ceremony. This is a virtual riot as there are prizes in a most interesting variety. There is one for the person with the longest nose, and one for the person with the shortest nose. The person who got the closest estimate for the weight of cabbage gets the cabbage itself as a prize, and similarly the one who got the length of the drumstick right gets the drumstick. Prizes for the tallest, shortest, heaviest, lightest ... Indeed there are prizes for almost everyone, and you get the prize for … getting the weight of the chicken feather correctly!

The prizes are given away by the neo-literate who ran the stall, and this is in itself a novel experience for her and for the village. She also talks about how many got close to the answer, how many gave wild guesses (with some examples, causing much mirth). Interestingly, in all the stalls, though people gave their answer in whatever units they pleased, they have been converted to metric units before recording. Thus the term "metric mela!".

The Meaning of Numbers

To begin with, learners were encouraged to consciously think of numbers in their lives, which could later lead to various group activities on issues of community resources through methods of participatory resource management. We had suggested to the volunteer teachers to begin with maintaining a number diary for their Literacy Centre. The teacher would ask them to make a simple number statement about themselves. For instance: "I weigh 53 kilograms", "My uncle has eleven toes", or "There are 7 people in my family". The teacher would initiate a discussion with a series of questions:

- How many films do you remember having seen in the last five years?

- How many mangoes can you expect to buy for ten rupees?
- What is the number of the bus you take to go to ..... from .....?
- What is the cost of one kilo of wheat?
- How many stars do you have on your *lehenga* (skirt)?
- How many buckets of water do you use every day?
- How many trees are there in your village?

The volunteer teacher was asked to give exercises based on the numbers that had arisen out of these discussions. Another exercise involved the teacher to say a number and ask the learners to respond with some objects of that quantity. For instance, the teacher would say "100" and a learner may respond with "100 jasmine flowers"; learners would also be encouraged to ask questions of each other, to look consciously for numbers and contribute to the growing collective database of familiar numbers.

Questions which required estimations of large numbers were deliberately posed:

- How many mangoes does a tree yield in a year?
- How many leaves does a typical mango tree have?
- How many *rotis* do you make in a year? How many do you eat yourself?
- How many stars are there in the sky?
- How many people live in our village?
- How many hairs do you have on your head?

Such discussions showed that learners understood that there is no limit to the growth of numbers. A challenging game took the form of bidding, "whatever number you tell me, I will tell you a greater number". Gradually, when numbers got into the thousands, the teacher could go for much larger increments, and even when they did not know the exact relationships, say, between a thousand and a lakh (hundred thousand), it was enough to know the latter was much bigger. This honed their own estimation skills; some of them had seen estimation done during the leasing of fruit trees, where contractors would predict the likely yield of a tamarind or mango tree (Rampal, 2003b).

Exercises for large estimates were based on a series of Fermi-type questions. We began with posers such as, "What is the number of

cups of tea drunk this morning by the entire village?" and proceeded to discuss strategies to estimate. This further led to interesting group activities of planning, say, for a village feast, with estimates and quantities, and elaborate descriptions of the recipes. Needless to say, volunteer teachers were required to be trained to handle such sessions effectively. Some also conducted participatory resource mapping. They could estimate the number of children below the age of ten years, the number of cows and buffaloes, and so on, and later graduate to more systematic enquiries, which generated valuable databases. In several places detailed maps were drawn by the neo-literates themselves, and were used for watershed management programmes for the village. This helped the group develop a critical understanding of their world (Jordan, 2012), with the possibility of seeking more control over their lives. Indeed, a neo-literate woman who estimated the number of *rotis* she had cooked in her life claimed that the exercise changed her perspective about herself, her life and women's work!

The National Primary Math Curriculum

Using the rights framework, tying quality to equity, which requires high expectations from, and opportunities for, *all* children to perform well (Boaler, 2008; Nasir and Cobb, 2007), we addressed "math for all" by restructuring the nature of primary mathematics. The NCF position paper (NCERT, 2006a) calls for a multiplicity of approaches, for liberating school math from the tyranny of the one "right" canonical answer, through learning environments that promote abilities for mathematization, invite participation, and offer *every* child a sense of success. A "participationist" (Sfard, 2008) vision of learning mathematics, unlike the acquisitionist approach, requires that learners begin by participating in collective mathematical discourses, of the home, community, or school, and progressively learn to communicate mathematically with themselves. The challenge of designing curricula for schools as diverse and ubiquitous as are in India is immensely daunting, to ensure representation of diverse discursive mathematical practices, through pedagogies of empathy that enable democratic participation (Rampal, 2010; 2013).

The syllabi and textbooks changed, though much of the challenge of changing classrooms remains. Given the resource starvation of

most of our elementary schools, textbooks form the only curriculum materials available for children and teachers, and these are being used by a large majority, leaving some private schools which prescribe books by private publishers. There are no concrete objects, games, or manipulatives in the classroom, no school library, and teachers' education does not steer them to mediate such resources. Low paid contractual appointments, frequent testing and a push towards privatisation further demoralises teachers especially those working in schools of the poor. Curricular reform involves sustained, unhurried and layered negotiation, within and outside the system, from policy documents to classroom practices, involving administrators, teachers, parents, teacher educators, and the media, to change mindsets about how children learn, how that may be assessed, and what basic provisions are conducive for that learning to happen. It has happened, at some places at some times, but is nevertheless an ongoing struggle.

As Chairperson of the NCERT (National Council of Education and Research and Training) Textbook Development Teams for the Primary Stage (Classes I-V), I had initially engaged with the writing of the syllabus (NCERT, 2005b) and textbooks for Environmental Studies (EVS), the subject that is meant to integrate Science with Social Studies. However, when the draft manuscript of the math textbook first came to me I was dismayed to see its didactic traditional form, contrary to the NCF. With barely three months to meet the publication deadline, I was requested to restructure the team and also work on it myself. As I look back, this was a crazy additional commitment to make, as another part-time voluntary task, along with my regular University teaching assignments. The urgency, however, allowed greater freedom within the bureaucratic institutional set-up, to select school teachers, teacher educators, academics, and also an array of sensitive artists, who broadly shared the social constructivist perspective, even if not necessarily exposed to critical math education. My experience with the numeracy curricular resources gave me the conviction to mediate children's everyday knowledge—for dealing with numbers, measurements, estimations, shapes, symmetries, and aesthetics—through contextual examples from art, craft, architecture and music.

Moreover, as we had done for the EVS textbooks, we sought real life protagonists to inspire and animate our thematic chapters. These included Kiran, who runs a junk shop in the city of Patna (The Junkseller, Class IV), the masons - Jamaal, Kaalu and Piyaar - who built

the school in Murshidabad (Building with Bricks, Class IV), the cooperative of fisher-women running a fish-drying factory (Fish Tale, Class V), or Pedki Devi from Jharkhand who fought against her late husband's brothers, for publicly torturing her to "exorcise" her from being a "witch", to appropriate her land after his death (Time, Class III), and whom we had filmed during the post-literacy campaign.

Its form needed to depart from that of the traditional textbook so that its voice resonated with more contextual "lived" resources (Gueudet, Pepin, & Trouche, 2012), through diverse genres of expressive narratives, folklore, auto/biographical stories, household recipes, travelogues, diaries, letters, records such as birth certificates, humour, fantasy, etc. even through tentative, tacit, and exploratory representations. We moved away from traditional inanimate illustrations which offer stunted, stereotyped, and monotonous images, to diverse representations including folk and tribal art, photographs, children's art, cartoons, and contemporary art informed by multicultural sensibilities. Each page was designed as a visual text, which could be processed by children in a non-linear manner. Though separate teachers' handbooks could not be developed, the textbook spoke to teachers through annotated comments. These notes shared reasons for dealing with concepts differently, observations about students' thinking, suggestions for out-of-class activities, encouraging them to look for lived resources in specific cultural contexts, persuading them to promote participation in place of the dominant modes of transmission.

Cross Disciplinary Themes

The National Curriculum Framework 2005 had recommended breaking down of the rigid boundaries between different subjects, to help develop a more holistic approach of learning from the child's environment and culture. This was attempted in the NCERT primary textbooks within the three subject areas of language, math, and environmental studies (EVS). For instance, the theme of "mapping", which traditionally comes under middle school geography without addressing children's understanding of several underlying concepts, was introduced across the primary subjects of language, EVS, and math. Some research had shown us that even privileged children (aged 8-10 years) exposed to maps at home and in school, drew maps of their own

Map I (age 13 yrs)

Map II (age 10 yrs)

Map III(age 8 yrs)

locality showing locations in a linear arrangement (Map II and III), though the actual road formed a closed loop. When asked, on site, why they made a road that kept going up the page, they confidently explained that while walking on that path they always went ahead and never turned back! The experience of walking on the road shaped the map they made, without their being able to imagine it from an aerial perspective. It was a 13 year old girl in the locality who drew a closed loop for the road (Map I) though the orientation and scale of her map was still impressionistic and very different from that of the cartographer.

Noting the real-life relevance of developing an understanding of mapping, which adults and even University students seem to fumble with, the primary math books included several chapters even though the syllabus (rather routinely framed) had not focused on it. Chapters were developed on the concepts of projections and perspective, aerial views of a site or object from different heights (as seen by a mouse riding on a hydrogen balloon), about directions, scaling, representation, etc. Iconic and pictorial maps were made for specific contexts, linked to narratives, such as children finding their way to the beautiful monument of Taj Mahal, which gradually progressed to abstract schematic representations. A chapter in Class V (NCERT, 2008) encourages the comparison of an iconic map with an aerial photograph, of India Gate on Raj Path, a well-known location in New Delhi which most children get a chance to hear about or watch on television during the Republic Day Parade. In addition, several creative formats were used, such as diaries or travelogues for a historical monument, visuals and pictorial maps, as well a treasure hunt game. Simultaneously, the EVS textbook developed the ideas of mapping by exploring a historical fort, or through a chapter "*Sunita Williams in Space*", based on the true experiences of a NASA astronaut of Indian origin, who eloquently described her thoughts as she looked at the earth from space, and even poignantly

wondered where the "lines" or boundaries got drawn which, from there, could not be seen between India and its neighbouring countries.

Special Thematic Chapters: Authentic Contexts

We developed special thematic chapters to deal with varied issues of work, entrepreneurship, heritage, craft knowledge, history of monuments and pre-historic cave paintings, etc. using contexts that invoked and integrated concepts already learnt. For instance, *Building with Bricks* in Class IV (NCERT, 2007) begins with the true instance of a school being built by local masons, who are taken to visit the nearby mosque to observe the amazing variety of floor patterns built by their ancestors three hundred years back. They return inspired and make their own brick designs for the school courtyard. With modern bricks different from the older thinner ones, the masons generate different symmetries and patterns, which students are encouraged to analyse in photographs we had taken during our visit. The chapter goes on to measure a brick, to study its faces, see its projections and how (as the first example of a cuboid) it can be represented in two dimensions. It prompts students to observe photographs of other brick patterns from different parts of the country and analyse the designs in traditional architecture. There are examples from the work of Laurie Baker (without naming him), a Gandhian architect who devised low-cost environment-friendly buildings. It finally travels to a brick kiln, to understand the process through visuals; students are first introduced to the large number "one hundred thousand" (a lakh), as the number of brick kilns in the country.

The process of thinking of large numbers (as done in the numeracy curriculum), relatively and in familiar contexts, through orders of magnitude, is adopted throughout the books where, for example, they connect 100 with the scoring of a century by a famous cricketer, or are asked to recall where they have heard of a "lakh" (one hundred thousand). Similarly, the number one crore (ten million) is first introduced in the thematic chapter "The Fish Tale", as "the number of people whose lives are related to fish—who catch fish, clean and sell them, make and repair nets, and boats, etc" (NCERT, 2008; p. 10). Indeed, "Asking students questions, such as, 'How long does it take to count to 1,000?' or 'Have you lived more or less than 1,000 days?' provides them an opportunity to think about 1,000 in a personal context, thus

helping them better understand the size of 1,000 in a variety of contexts" (Macintosh, Reys, & Reys, 1995, p. 216).

The Junk Seller is based on the true story of a young woman Kiran, who had, against all the odds of living in a poor, highly patriarchal, rural society, managed to set up her own enterprise in the city of Patna. She narrates her struggle, her early dislike of math in school and her acknowledgement of how it is now an integral part of her present vocation, which has indeed helped change her life and the situation of her family.

I studied in a Hindi medium school in my village. My father wanted girls to study like boys. I loved Hindi and Science, but I hated Maths! Today Maths is most useful for my work. I could never imagine this in school.
What about you? Do you also find Maths difficult?_____
What is the most difficult thing in your Maths book?_____
Which do you think is the easiest lesson? _____

When I was young my father died in an accident. So my mother worked as a servant in some houses. We had a difficult time. I had to leave school after Class VIII. I wanted to study more but my mother got me married. My husband's family lived in a mud house. … He had a tea stall.

I thought of starting my own business. I thought I should open a bangle shop or a tailor shop. But my uncle said that we could earn a lot by opening a junk shop.

People laughed and teased us about our work. They called it *ganda kaam* or "dirty business"'. But I did not think so. I knew this idea would work (NCERT, 2007, pp. 60–61).

Through this visual narrative with on-site photographs, the unit deals with her loans, her junk sorting and selling, hiring of collectors, recycling of materials, etc. It challenges several prevailing notions of gender and mathematics, the stigma of "dirty work" attributed to certain castes and their supposed low position in society, and also the traditional focus on a "great man" as a role model. It inspires young women with a sense of "social agency" to develop their entrepreneurial abilities to transform lives. Later, Kiran proudly told me that many visitors come to her shop just to see the "textbook hero".

Interestingly, this focus on cultural relevance and real life contexts caught the public imagination. Leading national newspapers and TV channels, which followed the development of the new textbooks through 2006-2008, enthusiastically reported on the primary math texts. Full page or lead stories, normally unusual to see on this theme, came with headings such as "NCERT's Bold New Experiment Brings Maths Closer to Life". This story began with:

> Ever thought you could study geometry from brick patterns on the walls of a tomb in Murshidabad? Or arithmetic from a junk-seller in Patna? Well that's what the new Class IV math textbook by NCERT is all about: maths and real-life (Mukherji, 2007).

I took this mediation with the media very seriously. As reporters called to get their stories, short of conducting a tutorial on the subject, I asked them to comparatively look at the old textbooks before our meeting, and then tell me the differences they saw. This generated a lot of interest in the primary math textbooks especially among young reporters, who kept recalling their own unpleasant experiences, and contributed in shaping public expectations about the reform.

The Notion of Time—Beyond Clocks and Calendars

Chapters on the concept of "time" in textbooks across countries routinely only deal with clocks and calendars, describing various units and devices of measuring time, and "informing" the child that a day

is made up of 24 hours, an hour of sixty minutes, while a week is 7 days, and so on. Why so? Indeed, if learning about "time" is viewed through a socio-cultural framework, a richer canvas can be drawn, to begin with the contexts in which children already know about time, also about subjective notions, while gradually scaffolding their understanding through progressively more challenging tasks and investigations.

The Class III (NCERT, 2006b) chapter on Time begins with asking children to correct some funnily jumbled up time markers used in a visual story, depicted in a folk art *pattachitra* style (which traditionally uses cyclic representations for time). Drawing upon childrens common sense and real-life observations and estimations of, for instance, how long it takes for a fruit to fall from a tree, for curd to set, for a litre of milk to boil, or a baby to come out of her mother's stomach (a deliberate attempt at subversive humour), it leads them to think of several processes that elapse in different orders of time - in years, months, hours, minutes, or seconds. We ask:

> Have you seen someone knitting a sweater? Or, someone weaving a cloth? Do try to find out from a potter how long it takes to make a pot. Also tell us if you take hours or minutes to have your bath! (Is it years since you last had one? Ha, Ha!).

Our voice tries not to be moralising, but empathetic, to help value the person, her craft and labour. Cultural narratives—about celebrating "a thousand full moons" as is done when a person completes eighty years, or about the "time line" of a woman's life, when time flew, and when it stood still as she recalls the death of her husband, and how she fought against his scheming relatives who declared her a "witch" to snatch her land—have been incorporated through exercises that bring diverse lived experiences into the classroom. This also departs from the approach of curricular "infantilisation" or "Walt Disneyfication" (Giroux, 1996), which believes that children should be protected from the "harsh realities" and injustices of the real world —at least in textbooks, no matter what actually happens to them in the real world—and therefore resorts to the comforting contexts of comic cartoon characters (Rampal & Subramanian, 2012).

Concluding Thoughts

Conservative curricula allow at best a tokenistic approach where "celebratory" multicultural representations are limited to viewing diversity through the lens of the essentialised "other", without critical engagement about issues of "difference", discrimination and dominance. In fact, when some upper class teachers wondered if "witches" should be discussed with young children, it was pointed out that no questions were generally asked on the suitability of a Harry Potter book or even about viewing violent cartoons about witches on television; then why was the cursory mention of a real person falsely declared a "witch" so problematic? Instead, wasn't it important and inspiring for children, rich and poor, to know that there were serious attempts to resist this exploitative practice against women?

Symbolic mediation between the home and school language is an important dimension of creating possibilities for meaning making, especially since mathematics (along with science) is increasingly being taught in English, though a regional language may be chosen for the social sciences. Even in the case of HSTP, where we worked in Hindi, the regional language of the state of Madhya Pradesh, I had sought a possible "orality" for the discourse of science (Rampal, 1992) realising that its formal "distanced" register did not ensure a bridging with the children's languages. Working on the NCERT primary math textbooks we consciously forged an "articulation" (Skovsmose, 2012) of different discourses through multiple genres and did not concede to the premature use of technical terms where more accessible alternatives were available. We also gave voice to children's imagery and intuitive, tentative ways of thinking, as in this excerpt from the chapter which takes them on a trip to the famous pre-historic cave paintings (NCERT, 2007, p. 28):

> Anjan: What is Bhimbetka?
> Ms. Raina: It's a place with lots of cave paintings made by people ten thousand years ago.
> Sumonto: Ten tho…uu…saa…nd years! I cannot even think of one thousand years back!
> Gopi: Oh! One thousand years is a big thing. I cannot even think of one hundred years.
> Gauri: I can think of 100 years because my father's grandmother is 100 years old.

Manjeet: That means those caves are almost a hundred great grandmothers old!!
Everybody bursts into laughter – Ha! Ha! Ha!

Indeed we also found ourselves reworking the translations of the primary textbooks (from Hindi to English for EVS, and vice versa for math) which were scripted in alienating registers. However, articulations are an ongoing process; transitions from the home to school, primary to middle school, then on to high school, or from school to life beyond, at the University or the workplace, or the other way round, are not smooth.

Transacting a mathematics curriculum in a socio-cultural framework "to read the world" also requires what Freire (1970, p. 62) calls "problem posing pedagogies", as distinct from problem solving ones, so that education "involves a constant unveiling of reality ... that strives for *critical intervention* in reality". It requires distinguishing between using mathematics in real world settings, usually limited to shopping, travelling, or building, from those that ask students to critically investigate issues of injustice, through a sense of collective social agency (Gutstein, 2006). The "general notion that problems can be given ready-made to students is highly questionable. Instead, teaching through problem-solving implies acknowledging that problems arise for students as they attempt to achieve *their* goals in the classroom. The approach respects that students are the best judges of what they find problematic and encourages them to construct solutions that they find" (Cobb, Wood & Yackel, 1995, p. 222).

Effecting mediation between everyday and formal math is indeed challenging and involves working against valorisations of knowledges and voices (Abreu, Bishop, & Presmeg, 2001). In this case it certainly needed deliberation among the curricular team; also with the institutionally nominated traditional subject experts who resisted any change and, as an ongoing process, with teachers, parents, teacher educators, and administrators of the larger system. This constant mediation involves bridging or "making relationships visible" between multiple mathematical practices and sites of learning, such that it creates a "resource" for learners' and teachers' construction of meaning (Skovsmose, 2012, p. 352).

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