Upper Primary Mathematics Curriculum, the Right to Education In India, and Some Ethical Issues

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The Right To Education Act (2009) promises free and compulsory education for all children in the age group of 6 to 14 in India in schools that follow centralised curriculum. I explore the implications of this regulation for socio-economically marginalised learners, in particular their opportunities for accessing primary mathematics. By revisiting some of the questions raised in an earlier paper about the possibility of realising the existing upper primary curriculum for these learners, I ask if ethical issues are involved in designing and developing a curriculum, particularly when the state designs a uniform curriculum for all.

Introduction

The period between 2005 to 2010 saw significant changes in Indian education. A new curriculum framework (National Council of Educational Research and Training, 2005) was brought into action in 2005. It advocated "learning without burden" and proposed the following five guiding principles for curriculum development: connecting knowledge to life outside the school; ensuring that learning shifts away from rote methods; enriching the curriculum so that it goes beyond textbooks; making examinations more flexible and integrating them with classroom life; and nurturing an overriding identity informed by caring concerns within the democratic polity of the country. Along the lines of the national curriculum framework, focus groups brought out 21 position papers on subject areas and other themes. Revised curriculum documents, syllabus, and textbooks were developed by the national board and the states were required to revise their curriculum frameworks to align with the National Curriculum Framework (NCF) (National Council of Educational Research and Training, 2005).

In 2009, after much debate and deliberation at various levels, the Right to Education act (RTE) was enacted by parliament. This act mandates that the state should provide free and compulsory education to children in the age group six to fourteen. A large number of poor children, many belonging to marginalized castes and tribes, and children from the most backward regions, study in government-run schools where education is free. The RTE act also mandates that children should be admitted to grades appropriate to their age, even if they have not had any prior schooling, stating that: "no child admitted in a school shall be held back in any class or expelled from school till the completion of elementary education" (up to Grade 8), and that: "no child shall be required to pass any Board examination till the completion of elementary education". The onus of bridging the gap between what children know and what they need to know for accessing prescribed content is left to the teachers who are expected to schedule extra classes to make up for the deficit. The act also mandates that the teachers "complete the curriculum within the specified time".

The NCF of 2005 and the RTE act are seen as positive measures, as more and more parents from the socio-culturally and economically marginalised sections want to educate their children. However, it is important to see how curricular choices in elementary mathematics are made and what are the implications for these children.

Curriculum development in India happens largely at two levels. At the national level, it is done by the National Council for Education Research and Training (NCERT) for the central schools and schools affiliated to the Central Board of Secondary Education (CBSE) across the country. At the state level, it is done by the twenty-four state boards of education for the government-run schools in the state, as well as the privately run schools affiliated to the state board. Though the National Curriculum and the textbooks brought out by NCERT function as a reference point for the state level curricula, the state boards are not bound to conform to it. As disciplines like mathematics and science are viewed as neutral and objective, impervious to the socio-political values of those in power, and significant in deciding the learners' career opportunities and economic status, there is often a large overlap in the curricula prescribed by different boards, across states and nationally. At the primary level, the focus of the curriculum is on ensuring that students acquire basic arithmetic competencies, basic ideas in spatial understanding and measurement, and applications to real-life situations. At the upper primary level (Grades 6 to 8), students are expected to move beyond everyday mathematics and engage with abstraction, acquire logical thinking, ease with symbolic representation, and competence to do mathematics in the higher classes (NCERT, 2006a). Typically, the upper primary curriculum deals with integers, rational numbers and their properties, algebra, geometry, data handling and "commercial mathematics". Revisiting the issues raised in an earlier paper (Subramanian, Umar, & Verma, 2014) from the caveat of RTE, I describe the schools, the socio-economic background of the students, their competence at the upper primary level, and the implications for these students of what is taught. As a critical mathematics educator, I argue that curriculum design involves ethical issues as it has consequences for a large number of learners and that curricular choices made by the boards of education, rather than representing the needs and interests of these children, function to further marginalize them. I stress the need for an alternative vision of upper primary mathematics curriculum that is informed by the preparedness of the majority of the learners and serves their interests.

Upper Primary Mathematics in India

A significant step in curriculum development in mathematics following NCF 2005 is the stated shift in focus in the national curriculum "from mathematical content to mathematical learning environments, where a whole range of processes takes precedence: formal problem solving, use of heuristics, estimation and approximation, optimization, use of patterns, visualization" (NCERT, 2006a, p. v). The syllabus for upper primary mathematics lays emphasis on "the need to look at the upper primary stage as the stage of transition towards greater abstraction, where the child will move from using concrete materials and experiences to deal with abstract notions" (NCERT, 2006b, p. 80). Consistent with these aims, the upper primary mathematics books focus on the discipline, though they build on the spirit of the primary textbooks, while the textbooks of the Madhya Pradesh state government (to which the schools that we work with are affiliated) impart content largely in the form of rules and algorithms and encourage drill and practice, even though they claim that the national curriculum framework has been taken into consideration while developing them.

In spite of very significant differences, there is a major overlap between the two boards in the content of the upper primary curriculum. For the strand on Numbers and Number Systems, beginning with natural numbers, integers and their properties in Grade 6, the syllabus moves on to introduce decimals, rational numbers, their representation on the number line, factors, multiples, exponential notation, prime factorization of numbers, ratio, proportion, percentages, and finishes with finding square roots and cube roots, including the algorithm for finding square roots in both the boards.

Algebra begins in Grade 6 with introduction of symbols to stand for numbers. While the NCERT textbook limits itself to writing linear polynomial expressions and equations in one variable at the Grade 6 level, the state board introduces higher degree polynomial expressions in two variables and the operations of addition and subtraction on them, ending with solving linear equations in one variable in Grade 6. But by Grade 8, both boards cover the three operations on higher degree polynomials in two variables, factorization or division, and algebraic identities.

In Geometry and Measurement, the content begins with giving some idea of what geometrical objects such as points, lines, and line segments mean, then moves on to polygonal figures, the notion of angle, using the geometry kit to measure angles, construct triangles, quadrilaterals, perpendiculars and angle bisectors, properties of triangles and quadrilaterals, circles, three-dimensional objects. Formulas for finding the perimeter, area, and volume are either derived or presented. Apart from these Numbers and Number Systems, Algebra, and Geometry, there is some exposure to data handling, probability, and statistics, and commercial mathematics.

In other words, both curricula take a particular view of what constitutes mathematics and center the curriculum on it, though within the community of mathematics educators, at least, academic or research mathematics, which constitutes the discipline of mathematics, is referred to as "mathematicians' mathematics", and is seen as one of many kinds of mathematics. This situation is not singular to the Indian context as can be seen by glancing through upper primary curricula in other countries.

Elementary Mathematics: A Report From Classrooms

Eklavya, a reputed NGO in central India, in which the author was a fellow, carried out explorations and sustained experiments in elementary mathematics (Agnihotri, Khanna, & Shukla, 1994; Batra, 2010) over a period of about seven years and used three different settings: four private, English-medium schools catering to children coming from low-income groups; Muskaan, a school run for scrap-pickers in an urban location; and three government-run schools in a rural location, of which one is a primary school for girls where the team worked with the same set of children from Grade 3 to 5. In most of the schools we worked with, we directly taught the students.

Government schools in India cater to the poorest sections of society. This also means most of their students come from marginalized castes or tribes. In one government school, 68% of the children belonged to “Other Backward Castes”, 17% were Dalits (Scheduled castes), and 10% were *Adivasi* (Scheduled Tribes). Most of the children going to a government school do not have geometry boxes and carry a single notebook in which they copy everything. Government provides one meal a day, a set of school uniforms, and the required textbooks. Parents of the students are either illiterate or barely literate and children do not get any support from the parents in their studies nor can they afford paid tutors.

Student absenteeism was a common feature in both the government schools that we worked with. Part of the reason for absenteeism lies in the fact that they are bored at school as very little teaching happens. Our regular visits to the school only confirmed this, as it was common for teachers to leave the classroom, assigning the students some writing work or asking them to memorize the tables. While part of this pattern could be attributed to the bias teachers carry against the caste/class background of the students, a significant part of it also has to do with the lack of training and continued support for the teachers to cope with teaching first-generation school learners. Other reasons for absenteeism are corporal punishment, paid labor, and domestic responsibilities.

Parental ambitions for their children, particularly boys, could be considered high as they take the first opportunity to enroll their children in private schools in which the medium of instruction is English. However, it would be difficult to believe that the children got direct help from their parents to support or supplement what they were taught at school. In the private schools, unlike in government schools, it was rare to find a classroom without a teacher. However, the teachers' own subject matter knowledge and pedagogical content knowledge, their comfort level with the language of communication and instruction in the classroom, the number of classes and hours they teach in a day, and the class size were major limitations.

A Description of the Classrooms

Referring to the physical space of the school and the classroom described by Bopape in South Africa, Skovsmose (2007, p. 84) says:

> How could it be that this hole in the roof has not been seriously addressed by mainstream research in mathematics education? Learning obstacles can be looked for in the actual situation of the children and with respect to the opportunities which society makes available for the children. The actual distribution of wealth and poverty includes a distribution of learning possibilities and learning obstacles. This distribution is a political act. Paying attention to this means re-establishing the politics of learning obstacles.

The physical ambiance and the amenities of classrooms are marked by the socio-economic class of the children. The classrooms in government schools have no furniture for children. They usually sit on "tat pattis" (mat rolls made of jute) or "dhurries" (thick woven material like carpets) spread on the floor. During winter when the floors are too cold to sit on, they huddle together. Cleaning the classrooms is left to the students. As the classrooms double up as dining hall, the students have the choice of sitting in classrooms with food lying around or sweeping the classroom for the second time in a day. Typically, the government schools have no power supply. The classrooms in private schools catering to low income groups are small, packed with benches and desks leaving very little room for the teacher to walk around. The situation becomes worse when rain-water leaks from the ceiling. In contrast, Novodaya schools and central schools run by central government and private schools catering to economically better off children have much better facilities with spacious classrooms, enough furniture for children, built-in shelves, and electricity. The differences in physical amenities are important because they make a difference to what is possible to teach. On a rainy day, with children sitting on dirty and wet floors, in winter with children too poor to afford warm clothing huddled together, in classrooms where the traffic noise can drown the din of children, well-designed curriculum, good textbooks, well worked-out lesson plans, and the beauty of mathematics seem the last things on anyone's mind.

Teaching Learning Activities in the Classrooms

Typically, the main activity that children carry out is copying from the board or from commercially available keys; problems are already worked out. On several occasions we found Grade 6 students copying how to simplify expressions like (118-{121+(11x11)-(-4)-(+3-7)}) and 4x2-[9x2-{-5x3-(2-7x2)-6x}], the question whether "the difference between 65 and 56 is zero" is true or false, or how to "subtract 13x-4y from the sum of 6x-4y and – 4x-9y", though they could not carry out simple division or subtraction on their own. In private schools, teachers may assign children homework and their notebooks may contain signs of inspection by the teacher. In the government schools, there is no evidence of any feedback being given for written work that children hand in. Given that this is what serious (and, understandably, tedious and boring) learning means, any attempt to engage children in discussions to understand and solve problems seem like "khel" (play) for them. In the private schools where "covering the syllabus" is important, children themselves sometimes express anxiety over losing precious time in khel.

A Description of Learning Levels: Oral Versus Written Mathematical Skills

In our interactions with Grade 6 children from government school, we found that many of them help their parents at the vegetable market or shops and nearly half of them could solve simple arithmetic problems orally, but when asked to write the same problem symbolically, they had difficulty. Inability to read and write numbers clearly makes it impossible for them to use algorithmic approaches. On one occasion we found that only 13% of the children in Grade 6 could write two-, three-, and four-digit numbers correctly on hearing the number words. The following year, we found only about 70% of the children in Grade 6 could do three digit addition without error, only about 55% of the children could subtract a three-digit number from 1000 or multiply a three-digit number by 3. For most of the children there was no concept of writing down the steps in a systematic manner; they would do some rough calculations and write the answer. Our experience with class 3 children was similar – most of them could not write two-digit numbers. This may also happen because number words for two-digit numbers in Hindi do not follow the order in which they are written. The Hindi equivalent of thirty-six for example would be something like "six, thirty" (Khan, 2008). Children going to private school were better, but we found that there were quite a few students in Grades 6 and 7 who would write 3110 as a successor of 319 and 70036 or 700306 instead of 736.

Similarly, most of the children in Grades 6 and 7 cannot link the fraction words they know with the fraction symbols, and think 1/3 is bigger than ½ even though the primary curriculum introduces fractions in Grade 3 and finishes all operations on fractions by Grade 5. Some of the private school children may be able to use standard algorithm for comparison, addition, and subtraction of fractions mechanically, even though the fraction symbol may not mean anything to them.

Our Design Experiments and Findings

As our objective was to evolve alternative approaches to teach mathematics at the upper primary level, we began our explorations with integers for Grade 6 students and rational numbers for Grade 7 in one of the private schools. Soon we realized we needed to develop an alternative approach for teaching fractions right from the primary school level, which we did, continuing alongside an interaction with Grade 6 students on numerical representations and the division algorithm, algebra, measurement, and geometry. A brief report from these interventions and explorations follows.

An Alternative Approach to Teach Fractions

Following our collaborative work with the Homi Bhabha Centre for Science Education team that combined the share and measure meanings of fractions, and drawing from the work of Streefland (1993), we took up a longitudinal study beginning in Grade 3 and worked with the same set of children up to Grade 5 in a government primary school for girls.

We introduce a fraction as the share that a child gets when, for example, 7 "rotis" (circular homemade bread) are equally shared among 8 children, beginning with unit fractions. Children draw 7 circles on top to represent rotis and 8 stick figures to represent children for the symbol 7/8, divide and distribute, writing the share of each child below. One distribution scheme might result in the relation 7/8 = 1/2+1/8+1/8+1/8 = 1/2 +3/8, another might result in 7/8 = 1/2+1/4+1/8 (Umar, 2010; Verma, 2010). Through this experience, they know how to compare unit fractions. Over a period of time, they also learn the equivalence of different division schemes and can move from one to another with ease. Children carried out measurement activities using a unit scale and subunits from ½ to 1/10. In the third year (Grade 5) we introduced representation of fractions on the number line, equivalence of fractions, and gave an idea of how to use equivalence to compare or add fractions.

There follow some instances of students' reasoning schemes that emerged spontaneously. Nikita (Grade 5) compares 4/5 and 7/8 as follows. First she divides each of the 4 rotis each into 5 equal parts giving each child 4/5. Then she shares out 7 rotis among 8 as 1/2+3/8, quickly changes her mind about 4/5 and writes it as ½+1/10+2/10 =1/2+3/10 and concludes that 4/5, which is equal to 1/2+3/10, is less than 7/8, which is equal to ½ +3/8 because 1/10 is less than 1/8. There are several such instances of spontaneous reasoning that children come up with because for them, over a period of three years, the fraction symbol means many things. Pooja devised a scheme to represent 1000+300/700 on the number line by declaring that "no one can divide the gap between 1000 and 1001 into 700 equal parts. So we will divide into 7 equal parts and assume that each part represents 100", though she was not sure how to write one thousand and one and hesitantly wrote 10001. We found that students were able to hold on to the meaning of the fraction symbol as a share and model many "word problems" in the language of share, and answer correctly (Umar, 2010).

Though the experiment convinced us that children can be taught fractions in a meaningful way from Grade 3, it also gave us an opportunity to understand the limitations in a government school context. Most of the children had difficulty reading, and so arguments that children came up with were oral, which the teacher documented after the class, though children certainly could write equations like 7/8=1/2+1/4+1/8.

Partial Quotients Method for Division

In continuation of the work with the same students, now at Grade 6 level, we found that many of them could not carry out the standard division algorithm as it made no sense to them. We introduced the Partial Quotients method currently used in the NCERT Grade 5 textbook that works with the whole number rather than individual digits as the standard division algorithm does. Some of the Grade 6 students needed the support of materials such as matchsticks to distribute and record the results, while many others could carry out division using the Partial Quotients method on paper and pencil; more importantly, almost all the students were able to relate to division in a meaningful way (Khemani & Subramanian, 2012).

Explorations in Negative Numbers

We attempted to introduce negative numbers through games and meaningful situations to Grade 6 and 7 students in two of the private schools we were working with. We found that, while students could carry out addition of integers, subtraction and ordering posed major challenges; also students did not relate to negative numbers in any meaningful way, though with practice they could carry out addition.

Explorations in Algebra

In our effort to assess what levels of abstraction children can engage with, we adopted a procedural approach to introduce algebra to Grade 6 children in a government school. Any trial in algebra is very challenging because children cannot write simple arithmetic expressions or even numbers properly. So we made children compute solutions for verbally stated arithmetic expressions and we wrote down on the board what they said and used these as the basis to introduce algebraic expressions. For example, they could be asked "think of a number, double it, add 5 to it, subtract the number you thought of, add another 5, subtract again the number you thought of, and tell me what you got" and report how they calculated. The whole equation was recorded by the teacher for the benefit of all to see. For example, if a child said "I thought of the number 3" and proceeded with the calculation, it would be recorded as: $(2x3)+5-3+5-3 = 6+5-3+5-3 = 10$. After a few examples they realize that the number they doubled got subtracted twice and so only 10 will remain. After much discussion and reasoning, we also arrived at the equation $2x+5-x+5-x = 10$ by saying "x represents the number in someone's mind which we do not know". Almost always they were able to notice the pattern, say what would be the result and why. In one rare instance, a student even made a purely mathematical remark by saying that "the result of $2x-5+3-1$ would always be an odd number" meaning if we substitute natural numbers for x we will only get odd numbers. While students participated in these exercises eagerly, it was clear that barring three or four students in the class, the rest would not be able to write these expressions on their own. In other words, our attempt to make them see algebra as generalized arithmetic and work with symbols rather than numbers did not succeed.

A Call for Re-visioning the Upper Primary Curriculum

According to the annual statewide surveys, 50% of children in Grade 7 cannot divide a 3-digit number by a single-digit number. By contrast, children from marginalized backgrounds who engage in economic activity to supplement family income bring oral arithmetic skills to the classroom from their workplace (Khan, 2004).

However, if we refer back to the upper primary curriculum in force, we see that there is very little that it has to offer these children, irrespective of whether they study in government schools or private schools catering to the poor. From the point of view of the curriculum, these children are disposable. Any curriculum design begins with many assumptions that include normative notions about childhood, about the nature of the disciplinary knowledge that it plans to impart and its relevance to the learner, about the learners' prior knowledge, cognitive capabilities, their interest in what the curriculum proposes to deliver, about teachers' competence and conviction to teach the content. Since a curriculum does not exist in a vacuum but is realized in practice, one way to know what these assumptions are is to inspect whom it turns out as successful at the end and what purpose the curriculum serves them. If the upper primary mathematics curriculum turns out predominantly urban and semi-urban middle-class children as successful, then it would be fair to say that the curriculum is premised on their prior knowledge and support structure and that it functions to meet their aspirations. In other words, the curriculum would not thrust on the normative students the kind of mathematics that they cannot cope with, as it does with children from the marginalized backgrounds. On the other hand, if the curriculum had a vision for those from the marginalized who constitute the bulk of students who drop out of school at various stages, then it would attempt to incorporate mathematics that will add value to their lives. It is impossible to conceive of an upper primary mathematics curriculum that will engage learners (whatever their socio-cultural and economic background might be) with operations on polynomial expressions, if the learners we have in mind are those whom we described in the previous section – children who have the same reasoning skills but have not been trained in written mathematics. Oral arithmetic competence, while necessary and important, cannot serve as a sufficient platform to launch teaching of algebra as generalized arithmetic but the cognitive and computational skills involved in oral arithmetic can be productively used in mathematical projects designed to understand some of socioeconomic realities. Children for whom school learning is synonymous with copying meaningless symbols, and whose reading, writing, and arithmetic skills at Grade 6 level are at the level of what is expected of a Grade 2 child, cannot be the children the upper primary curriculum has in mind if the content of the curriculum were to remain what it is. Curriculum design, as any other human endeavor, involves ethical as well as political considerations. However, adopting a specific understanding of what constitutes mathematics, and where it is useful, allows us to believe that curriculum design in mathematics is neutral, linear, and cumulative.

The RTE act could be interpreted to mean schooling as contributing to the development of the deprived children in other ways even if they cannot access subject knowledge. However, such an interpretation could apply to children from the dominant class as well, and in fact that would allow a re-visioning of mathematics curriculum that goes beyond preparing the learner to engage with higher mathematics. More specifically, upper primary mathematics curriculum could also contribute to critical understanding of one's social reality and provide a scope for empowerment. Incorporating such content would allow for collaborative and meaningful learning for all children, including those who may have oral competency but are not well trained in primary school mathematics. Skovsmose (2011) gives some examples how this can be done even in a small way, and that could be a starting point for re-visioning the curriculum.

References

Agnihotri, R., Khanna, A. L., & Shukla, S. (1994). *Prashika: Eklavya's innovative experiment in primary education*. New Delhi: Ratna Sagar.

Batra, P. (Ed.). (2010). *Social science learning in schools: Perspectives and Challenges*. New Delhi: Sage Publication.

Khan, F. A. (2004). Living, learning and doing mathematics: A study of working class children in Delhi. *Contemporary Education Dialogue, 1*(2), 199-227.

Khan, F. A. (2008). Formal number systems in the context of early schooling. *Contemporary Education Dialogue, 6*(1), 5-24.

Khemani, S., & Subramanian, J. (2012). Tackling the division algorithm. *TSG-7 International Conference of Mathematics Education: ICME-12*, Seoul, South Korea. Retrieved 31, May 2013, from http://nime.hbcse.tifr.res.in/indian-participants-at-icme-2012

National Council of Educational Research and Training (2005). *National curriculum framework*. New Delhi: Author. Retrieved May 31, 2013 from http://www.ncert.nic.in/html/pdf/schoolcurriculum/framework05/nf2005.pdf

National Council of Educational Research and Training. (2006a). *National focus group on teaching of mathematics report.* New Delhi: Author. Retrieved May 31, 2013 from http://www.ncert.nic.in/rightside/links/focus_group.html#

National Council of Educational Research and Training (2006b). *Syllabus for classes at elementary level*. New Delhi: Author. Retrieved May 31, 2013, from http://www.ncert.nic.in/rightside/links/syllabus.html

Right of Children to Free and Compulsory Education (2009). Retrieved 25 October, 2014 from: http://www.ncte-india.org/Norms/RTE-1.pdf

Skovsmose, O. (2007). Students' foregrounds and the politics of learning obstacles. In U. Gellert & E. Jablonka (Eds.), *Mathematisation and demathematisation: Social, philosophical, and educational ramifications* (pp. 81-94). Rotterdam: Sense Publishers.

Skovsmose, O. (2011). *An invitation to critical mathematics education.* Rotterdam: Sense Publishers.

Streefland, L. (1993). Fractions: A realistic approach. In T. Carpenter, E. Fennema & T. A. Romberg (Eds.), *Rational numbers: An* *integration of research* (pp. 289-325). Mahwah, NJ: Lawrence Erlbaum Associates.

Subramanian, J., Umar, Md., & Verma, S. (2014). Some ethical concerns in designing upper primary mathematics curriculum: A report from the field. In B. Sriraman et al. (Eds.), *The First Sourcebook on Asian Research in Mathematics Education: China, Korea, Singapore, Japan, Malaysia and India. (International Sourcebooks in Mathematics and Science Education).* Charlotte, NC: Information Age Publication.

Umar, M. (2010). From fraction to proportion. *Seshnik Sandharb, 2*(11) (Original No. 68). Retrieved May 31, 2013 from http://www.eklavya.in/pdfs/Sandarbh_68/45-57_From_Fraction_to_Proportion.pdf

Verma, S. (2010). One hour of my class. *Seshnik Sandharb, 2*(12) (Original No. 69). Retrieved May 31, 2013 from http://www.eklavya.in/pdfs/Sandarbh_69/57-64_One_Hour_Of_My_Class.pdf