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ORIGINAL ARTICLE

Influence of socio-economic background and cultural practices on mathematics education in India: a contemporary overview in historical perspective

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Abstract The nature, extent and quality of mathematics learning among young children in India cannot be adequately understood without looking at the larger context of education and the social background of the children. Society, including schools, characterized by large inequalities impacts mathematics learning. Beginning with a brief overview of (mathematics) education in India, in historical and sociological perspectives, an appraisal is presented of the need and nature of mathematics learning revealed by field studies in two communities in a deprived rural setting and a low-income urban setting, respectively. While the latter was economically active, the former was much poorer in work and education opportunities, though had richer cultural practices that involved engagement with mathematical riddles, puzzles, folklores and mnemonic tables. The paper discusses the enabling potential of the knowledge resources, including work-context knowledge, which exist in both the communities despite the prevalent deprivations due to disadvantaged conditions. Yet in both situations mathematics learning remains disconnected from formal school mathematics. Factors within SES that possibly have strong bearings on mathematics learning are highlighted which can scaffold stronger integration with curricular and pedagogic practices. Both the groups presented potentially rich contexts for drawing upon everyday mathematical knowledge that can inform effective mathematics learning, which has been inadequately explored in curriculum and instructional design thus far.

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1 Introduction

The nature, extent and quality of mathematics learning among young children in the Indian context cannot be adequately understood without looking at the larger context of education and the specificities of the social background of the children. There are historical and sociological reasons behind inequities and differences in education and learning, even as the contemporary systemic and pedagogic choices do not adequately take into account socio-economic conditions or cultural practices of different communities in various parts of the country. This has remained one of the neglected domains in the studies looking at socio-economic influence on mathematics learning from an Indian context. Till the medieval period, formal education was the prerogative of a few in India who belonged to a small upper strata in the caste hierarchy, a distinct principle of social stratification in Indian society. If Vedic knowledge was confined to the Brahmins, then Shudras, the lowest *varna* category under the four-fold *varna-system*, or more specifically, the untouchable caste groups, were excluded from education or social intercourse. Social background in terms of caste or community limited the horizon of educational opportunity for an Indian child. Modernization, introduction of democracy, and a constitution promising universal education have gradually changed the scenario, yet the social context remains even now a major determinant of the quality of education, including mathematics education. Economic conditions have emerged as a major factor in the urban areas for determining the living conditions and educational opportunities. In rural areas, however, economic conditions are more correlated with the hierarchical social standing, and socio-cultural factors play an important role in learning. In both rural and urban contexts community knowledge resources, which influence the style and nature of learning, are increasingly disprivileged in the educational strategies adopted in the formal schools (National Council of Educational Research and Training [NCERT] 2005, 2007).

Debates on educational policy in the colonial times were political, both implicitly and explicitly, but pedagogic debates were often philosophical and social in nature. However, in the post-independence era, research in pedagogy became psychological in approach (Nambissan and Rao 2013), which has now extended to include sociological concepts, inquiries and contexts. Issues such as social exclusion, school dropout, low levels of learning among children of marginalized groups, social prejudices among teachers and policy planners, and systemic deficiencies have been included in wider debates lately, though systematic research is still scanty (NCERT 1997).

The *Fifth* and *Sixth Survey of Educational Research* published in the last two decades by the apex body on education, the National Council of Educational Research and Training[1] (NCERT 1997, 2006), have highlighted that mathematics education is a relatively less explored area of research in India and there is a need to examine systematically the effects of larger context and socio-economic background or socio-cultural milieu of learners in Indian conditions, which are in many ways distinctive and different from those in developed countries and most of the other developing nations.

Our aim in this paper is to elaborate some aspects of the socio-economic and socio-cultural background of learners that impact the learning of mathematics. In particular, we highlight the community-based knowledge resources that include elements of mathematical knowledge and the disconnect between these and school-based mathematics. We highlight the enabling potential of such resources for learning of mathematics. Such enabling factors have not been adequately probed in previous research in the Indian context. The diversity prevalent in India makes it difficult to factor the situations into one or a few studies, yet we take two field studies undertaken by us as the point of departure, supplementing it by debates, past and present, and other research findings to gain an understanding of the contemporary scenario. The locations of the field studies have been chosen from urban and rural areas where inhabitants constitute a marginalized section of the population in different ways. The urban settlement contained a mixed population with a large proportion of a minority community, while the rural habitation was of a single subaltern caste group in the Indian state of Bihar. We argue that one way to address the prevalent disconnect between community knowledge resource and formal mathematics learning is by building on potential strengths and community knowledge of the children living in disadvantaged and difficult circumstances.

2 Education, including mathematics education, in India: perspectives and debates

In this section, we touch upon the historical background, past debates, and emerging sociological debates for appreciating the contemporary learning environment in India.

2.1 Historical perspective

Mathematics education as a distinctive concern of educationists or mathematicians is a relatively new phenomenon in the Indian context, and there are few systematic studies exploring its relation with the socio-economic background of children or communities. However, we note that in many important educational experiments right from the era of struggle for independence from British rule, social concerns, indigenous traditions of learning, or knowledge formation and equity issues have been seriously addressed. The most notable example was the scheme of 'Nai Talim' or 'Basic Education'[2] designed under the inspiration of Gandhi (1951). Under Nai Talim, education, including learning of mathematics, was to be given through the medium of crafts, which implied productive work, since Gandhi was advocating a self-supporting system of education (NCERT 2007). This must not be equated with child labour, since work in Gandhi's view is a means of education in the broadest sense of the term, including character-building and preparation for life. The eminent educationist Tagore's vision of education was more culture-oriented, but in his social action and Sriniketan experiment he proposed a system of education related with life and society focusing on education for developing individual self-reliance (Dasgupta 2008). Nai Talim and Sriniketan were educational experiments with distinct philosophical

[1] NCERT is the apex academic authority at the national level in India that designs curricula for school education and teacher education, and also textbooks.

[2] The idea of 'Basic Education' was formulated under Gandhi's inspiration and guidance at an Educational Conference in Wardha, India, in 1938.

perspectives and a clearly designed pedagogy drawing on cultural resources and community practices.

In the post-independence period, the report of the first Indian Education Commission (Kothari 1966) and the subsequent first National Education Policy (1968), and the views of Ivan Illich, Paulo Freire, Everett Reimer and other Latin American educationists of the 1960s, influenced the development of new initiatives. In the Indian pedagogic interventions of the early 1970s where teaching of science and mathematics figured prominently, for example in the Eklavya experiment in Madhya Pradesh, building upon the knowledge resource available as the community knowledge or 'collective wisdom' for teaching science and mathematics in a formal set-up was emphasized (Mukund 1988; Rampal 1991). At the policy level concerns were raised about the issues of equity (Naik 1982). In recent times, there has been debate on exclusion issues in education. If concerns about the education of Dalits,[3] minorities, and girls till recently focused on enrolment, pedagogic and quality issues have become more central now (National Council for Teacher Education [NCTE] 2009). There has also been growing focus on science and mathematics education in the country, though the progress is slow and limited. The influence of socio-economic conditions is an increasing area of attention and this theme is seen as an emerging area of research in the *Fifth Survey of Educational Research* (NCERT 1997). However, after more than almost two decades, this area of research has remained largely unexplored (Banerjee 2012). The fifth and sixth educational surveys have deplored the 'lack of systematic educational, in-depth studies' and the undertaken projects' lack in methodological rigor and 'absence of enterprise to explore the new' (NCERT 1997, p. 9; 2006). In addition, the impact of cultural factors have also been inadequately studied except possibly to some extent in the context of Muslim minority education.

The magnitude of the influence of socio-economic conditions on mathematics education can be appreciated even by a fleeting glance at the macro-economic situation. In 2004, 77 % of India's population working in the unorganized sector lived on a meagre amount of Rs 20 (one-third of a euro in 2009) per day (Sengupta 2007) and 92 % of the workforce was in the informal sector[4] (Press Information Bureau 2009). Some researchers have noted that Indian school education is not able to significantly help; rather, it further alienates the deprived sections of society (Rampal 2007). There are reports about low levels of learning: only 40.7 % of children studying in grades 3–5 in rural areas could do simple subtractions, while only an almost equal percentage (40.6 %) of children in grades 6–8 could do simple divisions (ASER 2012).

2.2 Sociological debates around education

If sociology of knowledge developed as a full-fledged academic discipline during the twentieth century, distinct focus on sociology of education emerged as a research domain in the last half a century globally as well as in India (Nambissan and Rao 2013) with a stress on a 'society characterized by social and economic hierarchies and cultural diversity'. However, similar research with a focus on mathematics education has not happened so far, though 'education in contemporary India is marked by sharp inequalities, rising aspirations and diverse and deeply contested discourses regarding meaning and purposes of education' (Nambissan and Rao 2013, p. 1). A variety of issues have emerged in the course of the debates in sociology having a bearing on mathematics education, which is a universally accepted core component of school curriculum and an important higher education discipline.

In the hierarchically arranged Indian society, education of the marginalized section of the population has remained restricted to mere reproduction, be it any form of knowledge including the teaching–learning of mathematics. Such a role of education appears to be in consonance with Bourdieu's (1973) conceptual framework of *reproduction* of knowledge for the colonized people and *production* of knowledge by the metropolis. The indigenous production and prevalence of knowledge, much too diverse and multi-layered in a vast country such as India, is disprivileged and remains unused in the pedagogic practices designed from above. Textbook production is invariably centralized, usually focused on the urban middle class, away from the lived reality of the bulk of Indian children. Curriculum and textbooks then promote a deficit expectation with regard to children living in difficult and underprivileged situations.

2.3 Work-contexts and mathematics learning

Socio-cultural studies in mathematics and science education have highlighted that cultural resources and *funds of knowledge* of people from non-dominant and underprivileged backgrounds are often not leveraged in school teaching and learning practices (Gonzalez et al. 2005). Their knowledge from everyday-life experience is not valorized and built upon in the classrooms, nor is their identity acknowledged or affirmed (Barton and Tan 2009). Access to school education that is seen by the underprivileged

[3] As a social group the 'scheduled caste' are usually referred to as 'Dalits' and they often face social discrimination and prejudice. According to the 2011 population census, Dalits formed more than 16 % of India's population.

[4] Informal sector enterprises stand for unincorporated proprietary and partnership enterprises while unorganised sector subsumes cooperative societies, trusts, private and public limited companies in addition to informal sector enterprises.

communities as meaningful, relevant and connected to their life settings has remained elusive. What is offered in schools at present is a structured educational package detached from most students' everyday-life experiences, including experiences in work-situations, yet accepted as legitimate knowledge since it acts as the 'gate-keeper' to different kinds of opportunities and future social well-being (Skovsmose 2005). The legitimacy and necessity of the 'formal' school mathematics renders all other forms of mathematical knowledge not only insignificant but also ineffective. The disparity of academic achievements, including mathematics learning, is further enhanced by the hierarchical social structure (Kantha 2009) but the strategies to overcome the hindrances remain to be identified.

While school and workplace are seen as two sites of learning (Lave 1991), home, neighbourhood contexts and 'tuition' (after-school private lessons) are the other crucial sites that researchers in mathematics learning must look at. The dichotomy of failure in school mathematics but competence in everyday mathematics arises due to knowledge gaps that prevail among children of different socio-economic groups (Resnick 1987) which appear due to the lack of connection between informal, intuitive knowledge and formal, school knowledge. The knowledge domains of school learning and out-of-school contexts are perceived as dichotomous, whereas the interpenetration between them can be useful sources of building connections between the two and holds strong implications for classroom pedagogy that remain to be unpacked.

It appears that more than individual aspirations, or even learning abilities and potential, contextual factors such as social environment, caste or community background, habitation, workplaces, neighbourhood with its socio-cultural features, and type of school where children study are likely to determine the trajectory of learning in general and mathematics learning in particular. Our studies suggest that while cultural factors in the form of community activities have a more significant role in mathematics learning in areas away from the metropolis, socio-economic conditions tend to be the dominant influence in urban centres.

3 Indian studies on mathematics learning

3.1 Indian scenario: curricular debates

The pedagogic document for school education currently operative in India, the *National Curriculum Framework* (NCF) prepared by NCERT (2005), marks a paradigm shift by adopting a constructivist framework. It has laid emphasis on equity and the need for connecting school learning with the child's environment. The document underlines that 'our children need to feel that each one of them, their homes, communities, languages and cultures, are valuable as resources for experience to be analysed and enquired into at school; that their diverse capabilities are accepted' (NCERT 2005, p. 14). It argues that connecting school learning with the child's lived experience is needed, 'not only because the local environment and the child's own experiences are the best entry points into the study of disciplines of knowledge, but more so because the aim of knowledge is to connect with the world' (p. 30). Drawing upon the constructivist approach of NCF-2005, some states have prepared their own curriculum frameworks, and the state of Bihar (in which one of the field studies is located) took the lead in this respect. Education of neglected children was emphasized in the *Bihar Curriculum Framework* (BCF) (State Council of Educational Research and Training [SCERT] 2008). BCF underlined that 'the social and physical environment of a neglected child leads to a different conceptual development than that of a middle class child. This does not mean that her conceptual development is inferior, rather because it is different from the expectations of the curriculum, it constitutes a handicap' (SCERT 2008, p. 33). The disadvantaged child needs help in extracting the meaning. The *Framework* further notes that their learning style cannot be rated as efficient, as it is slow, physical, non-verbal, problem-centred and concrete-oriented. The curriculum places a deficit expectation from teachers about disadvantaged children and calls for constant engagement with such children to acquire a verbally oriented learning style and ability to deal with abstraction (SCERT 2008, p. 33). Ironically, deficit perspectives underlie much of the educational reform discourse in India, even though NCF was largely able to eschew it.

3.2 Indian studies on mathematics in work-situations

In many Indian studies, children's participation in work and habitation in urban low-income areas are interpreted as impediments to their ability to meet the academic demands of schools, which are at variance with their own experiences, leading to low academic performance on standard measures (Rampal 2007; Weiner 1991). If participation in work reduces the time and energy that a child can devote to studies, problems relating to habitation could have serious debilitating effects on health and education. But, it has been argued, with considerable merit, that work-contexts may have a positive bearing on mathematics learning (Nunes et al. 1993). If put to meaningful use, a better understanding of underprivileged children's knowledge and cultural resources may be tapped by the teachers in designing effective mathematics teaching and learning processes (Taylor 2012). There are some studies in the Indian context that have explored the potential of lesser-privileged social backgrounds for mathematics learning. These studies explored the contours of everyday and workplace mathematics, and highlighted the characteristic features of such knowledge, the ways it is acquired and its difference from formal school-taught mathematical knowledge. While some studies highlighted that diversity of goods handled helped the vendors acquire greater proficiency skills (Khan 2004), others found that the use of 'extemporaneous mental schema' encompassed problem-solving strategies (Naresh and Chahine 2013, p. 327) and that spatial visualization and estimation skills often shaped the measurement knowledge and proportional reasoning in work-contexts (Mukhopadhyay 2013; Saraswathi 1989).

Most of these studies noted that many school dropouts, or those having incomplete school education, could use their mathematical skills competently in economic activities and that their cumulative understanding of skills and strategies was acquired from such contexts. Often such workers or school students belonged to less privileged social environments, to caste or community backgrounds that required them to supplement their family income and get into earning, and such requirements shaped and governed their mathematics learning. Such studies—as also does our field data—suggest that there is a disconnect between students' mathematics learning potential and their knowledge resources on the one hand and the actual existing classroom practices, pedagogy and textbooks on the other, which may account for low performance in school situations. Interventions for quality improvement to bridge the disconnect remain to be designed and explored.

4 Two field studies in two different milieus

4.1 The context

To profile the locale of the two field studies, we begin with contrasting exemplars of the perceptions of the members of the two marginalized communities living in adverse socio-economic conditions. One is from a rural setting in Bihar, an economically backward state in India and the other is from a metropolis in an economically advanced state, but the respondent lives and works in a low-income settlement.

4.1.1 Exemplar-I

I have taught my son the kind of hisaab [arithmetic] he's going to need in life.

What are our children going to learn in school? Why do we send them to school?

This is an excerpt from a conversation with Dular (pseudonym), a 35-year-old male 'Mushar',[5] during a field visit in the winter of 2008/09 to three *Mushari* (hamlets where Mushars live) in Bihar. The first poignant remark has at least two distinct meanings: a confident claim that 'we can teach our children adequately in our own ways', and a sense of resignation that there is not much point in sending their children to school.

4.1.2 Exemplar-II

The second exemplar is from interactions in an urban study with middle-grade school students, some of whom work to 'supplement' their family income:

> Abdul (pseudonym), a 12-year-old boy, studies in Grade 6 of a municipal corporation-run school located in a low-income settlement in Mumbai. His interest in studies brought him back to school after a two-year gap. During the interregnum the financial condition of his family forced him to work, shifting to Mumbai from Bihar in search of employment. After working in a garment manufacturing workshop, Abdul found a 'morning-session' school, where he could attend classes while continuing to work in the afternoon and evening.

'Good' school education is inaccessible in both settlements. We noted during our classroom observation in Abdul's school that current pedagogy and textbooks remain detached from students' life experience and focus mainly on algorithm-based skill development without much promotion of conceptual understanding. Students' cultural knowledge is not leveraged or affirmed in the classrooms.

The two exemplars show two different contexts of poverty and exclusion. The frustration in the first of a parent stands in contrast to the aspiration of a young boy in the second.

The indignation, disdain and frustration noticeable in the first exemplar is consistent with the impressions that we gathered in our interaction with the Mushars, for whom schooling is an alienating experience which is for them never benign but humiliating and oppressive. The Mushars face an uncertain future with a real fear of lagging behind in the 'race' that modern economic conditions force on everyone. Such experiences reinforce the disconnect between home and school, which might explain the reason for Dular not valorizing school learning. In contrast, Abdul

[5] Mushar (meaning 'rodent-hunters') is a subaltern caste whose members dwell in different parts of north India. They are considered 'untouchables' and come under the category 'scheduled caste'. As a common practice, people from this socially marginalized community face social segregation and live in groups generally on the outskirts of villages and do not have much access to the formal education system.

in the second exemplar perceives schooling as important and valorizes learning of 'essential' concepts of mathematics. During interactions, Abdul asked the researcher to teach him division and fractions since he required them at work. He also revealed his desire to start a business (a workshop) of garment-making of his own. This 12-year-old's predicament of running his family and arranging for his ailing father's medicines has made him realize that owning a tailoring workshop can pull him out of his miseries, and mathematics learning can help him in future, though his ambitions are governed and limited by his background and situation.

While Abdul looks at school education and mathematics education as a gateway to future 'well-being', Dular in the first exemplar seems to reject the school-education offered in its present form, which, according to him, has nothing much to deliver. Dular's submission can be seen as a reflection of the social relegation that subaltern communities such as the Mushars are subjected to that often comes with the indiscreet labelling of 'low performers' in schools.

It further appears that, more than individual aspirations, contextual factors are likely to determine the scope and trajectory of mathematics learning in both cases, though the social and economic factors have more potentially enabling influence in the urban case.

4.2 The locale of the studies

The field of the urban study, a large low-income settlement in Mumbai, has a vibrant economy in the form of micro-enterprises involving household-based workshops and small-scale manufacturing units, which provide employment to the dense population living there. Practically every household here is involved in income-generating work in which children take part from an early age. The immigrant unskilled workers find jobs in the workshops and some of them become apprentices in small factories. The economically active settlement is multilingual and multi-religious (Muslim majority) and people from different ethnicities coexist. Common household occupations include embroidery, *zari* (needlework with sequins), garment stitching, making plastic bags, production of leather goods, recycling work, etc. The goods produced here are sold not only in Mumbai but are sent to other cities and even exported.

The rural study was of three Musharis in Bihar that were settlements on the outskirts of villages near Patna, a historical town in north India. According to the 2001 population census, the literacy rate in the Mushar community is 9 % (Bihar-Census 2001, p. 2). Mushars do not have much access to formal education but they have a working knowledge of basic arithmetic and knowledge of mathematical riddles and puzzles as part of cultural practice (Bose 2009). Without land or regular work, most of the community members live in abject poverty. They earn their livelihood by working as labourers in farmlands or in the brick kilns and by selling country-made liquor.

4.2.1 Sites of formal learning

The five-storeyed school building in Mumbai's low-income settlement is located in a large compound and five different schools with different languages (mediums) of instruction coexist in the same building, each on a separate floor. The local civic body runs these schools. Irrespective of the medium of instruction, most students speak in local dialect (a mix of Hindi and Marathi). All teachers come from different parts of Mumbai (none from the locality) and commonly speak Marathi or Hindi/Urdu. The administrative set-up is different for each school. In contrast, the Mushars did not have access to a formal school. Though there was a two-room government-run primary school in the neighbouring village, it remained dysfunctional as the single appointed teacher as well as the students seldom came. It was reported to the researchers that classes were mostly not held in that school. Mushars could not afford to send children to private schools. At the time of the field visit, no Mushar child from the Musharis visited was going to school.

4.2.2 Episodes from school and home: children's condition

Children from both the Mumbai settlement and the Bihar Mushari suffer deprivations of various kinds in their surroundings. In both the locales, we noted that children learnt to sustain with limited resources. While in the urban case, classroom teaching does not involve group-work, work outside school essentially depends upon group-work and division of labour. Teachers are generally aware of students' background knowledge but the transaction of lessons relies almost exclusively on textbooks and students' knowledge resources are not used. In both the studies we noted the focus given to rote memorization of multiplication tables and facts—in both formal classrooms and oral community practices. Children in both locales reported their involvement in the daily household chores such as buying provisions from the nearby local shops and assisting parents in maintaining accounts, in which they use context-specific strategies different from those learnt at school. In the Mumbai study, we noted that use of homes as workplaces creates hindrance for students' studies. In the Musharis, school facilities, including a classroom or even teachers, were more deficient and practically non-existent.

A majority of parents in both the cases have incomplete basic education while some have no schooling at all, and their knowledge, skills or cultural practices are of little use for school-based learning. In the urban context, school education is valorized, and we observed urban parents in the low-income settlement opting for 'tuition' (private lessons after school hours) even at the cost of hard-earned money and valuable time.

4.3 Sample and methods

Data for this paper is drawn from the Mushar study and also from the larger ethnographic study on the everyday mathematical knowledge that middle-graders from an urban low-income settlement draw from the varying extents of their engagement in work practices. For the urban study, a representative sample of 31 students was chosen from grade 6 classes of English and Urdu schools and data was collected in three separate parts: (1) semi-structured interviews to understand students' family background, socio-economic status, parental occupations, productive work done at home/elsewhere and students' involvement in them; (2) interviews based on a structured questionnaire to understand students' basic arithmetical knowledge; and (3) semi-structured interviews about their work-context knowledge. In this paper, we try to unpack the emergent aspects in the relation between low socio-economic conditions and mathematics learning.

In the Mushar study, data was collected with the key informant's help after building a rapport with the community members and through visits to their dwellings and fields where they worked. The interactions were in the form of semi-structured interviews. Altogether 17 and 15 people were interviewed in two separate rounds in three Musharis that were visited. The main data sources in both studies were audio records of the interviews, audio transcripts, field-notes and photographs.

5 Work-contexts, surroundings and mathematics learning

In this section, we aim to show that mathematics is embedded in varied work-contexts in micro-enterprise and 'cultural practices', that is, activities structured around leisure time particularly in rural contexts. However, there is divergence as well as disconnect between mathematics embedded in out-of-school contexts and that used in formal settings.

5.1 Mathematics in work-contexts

In both the Mushar and the urban communities, work was seen as an avenue for skill development apart from income generation. The urban settlement is dotted with a variety of work-contexts that create opportunities to use and learn arithmetical computations, different aspects of measurement knowledge, estimation skills, optimization, decision-making, accounts keeping, 'making judgments about fairness of a deal' and so on (Bose and Subramaniam 2013). Different work-contexts may require different kinds of mathematical knowledge that workers acquire. Therefore, getting involved in 'any kind of work' is valorized in the community since it builds networks with people including the *seth* (workshop owner who provides jobs), helps in learning manual skills and is a better utilization of time. It is assumed that learning such work-related skills early would be 'useful later on'. Abdul's case shows how children pick up mathematics embedded in different work-contexts. Over 4 years Abdul went through different stages of learning in shirt-stitching work and moved from being a novice to an expert. He then switched to another job (three-quarter trouser making) to learn a different skill and earn a better wage. Using his mathematics knowledge, Abdul compared his earnings in both jobs by calculating his wage and the number of pieces he could stitch in a day. Children like Abdul learn to handle their finances, including putting money in locally operated saving schemes such as *chit funds*, which depositors believe give easier access to credit than banks. Such investments entail complex calculations and decision-making that children pick up. Our detailed interaction with other students in the sample indicated that work-contexts provide them with rich sources of mathematical knowledge which never gets linked with learning in a formal setting.

Our interaction with Mushar children showed their emergent mathematical knowledge from agro-based labour practices such as weighing of grains, counting and maintaining accounts of sacks of grains, calculation of price and wages, use of indigenous and multiple units and so on. Cultural practices of liquor-making, proportion of ingredients mixed, quantity produced and sold, and maintaining such accounts were done orally and kept in memory.

5.2 Mathematical knowledge in culture

The Mushars formed a homogenous social group living together as a community and sharing long-standing traditions. It is reasonable to expect older cultural practices to survive in some form in such a setting rather than in an urban setting where the community consists of mixed social groups. Thus among the Mushars, and in the state of Bihar more generally, one finds interesting modes of transmission of mathematical knowledge and skills through riddles, activities during festivals, or mnemonic tricks for tables or calculations. We came across several instances of such practices in the Mushar community's leisure activities and evening gatherings where folklore, mathematical riddles and puzzles were shared. Mathematical tables of fractional numbers (such as quarter, half, three-quarters, one and a quarter, one and a half, two and a half and so on) were familiar to many individuals. These are part of the community's *funds of knowledge* that are passed on through oral practices and traditions. However, community elders reported that such cultural practices are gradually fading out as the schools no longer use or acknowledge them. In the urban settings, the loss is even more rapid as compared with rural parts. We noted that while in the urban low-income settlement, social relationships are economy driven and cultural practices are confined only to festival celebrations, Mushars' social relationships and practices were structured around frequent leisure activities.

5.3 Participants' mathematical knowledge and strategies

One of the aims of both the field studies was to understand the nature and extent of students' everyday mathematical knowledge and opportunities available to gather such knowledge. We looked at children's learning of symbolic mathematics (knowing formal number-names, place-values, use of algorithms, etc.), competence in problem-solving, conceptual understanding and ability to move towards abstraction to get a broader picture of the connections between everyday and school mathematics. We observed that in both cases children preferred to solve contextual problems drawing on their everyday experience rather than using school-taught algorithms. They used convenient strategies, common sense and workable 'guesses' to arrive at acceptable answers.

5.3.1 Number-sense, arithmetical operations, currency-knowledge, estimations and other strategies

From the formal expected learning perspective, we noted that some urban settlement students had difficulty in reading and writing numbers bigger than three digits, made place-value errors or wrote numbers the way they are called out (for example, writing '1000100' for 'one thousand one hundred'); Mushar children preferred not to write any numbers. However, both the cohorts had a sense of 'bigness' of a number derived from their currency knowledge. They had knowledge of different currency denominations and their conversions and they could handle even bigger numbers using currency as a cue. We noted from our observations that currency as a support for learning is not adequately built up during classroom teaching. While solving context-based proportionality problems, children in both groups used addition as a build-up strategy and made convenient groupings to arrive at the required results. In the case of subtraction, they mostly used a 'count-on' technique orally. Multiplication problems were attempted as 'repeated addition' by taking convenient groupings and smart build-up strategies (suitable decompositions). Multiplication tables were preferred by only a few of the Mumbai cohort while others, including Mushars, used oral convenient decomposition strategies. Most children faced difficulties in using the formal algorithm for division. However, they could use currency knowledge as a tool to cross-check the validity of answers to mathematics problems, which gave them a sense of the acceptable answer and allowed them to detect errors.

We observed that exposure to everyday contexts helped children to develop good approximation and estimation skills. They often came up with approximations that were close to the correct answers. Price estimation was strong and evident from their estimation of what articles could be bought with a given amount of money. Estimation of the balance amount was correct for many students who mostly used oral techniques.

5.3.2 Knowledge of fractions

Most children in both cohorts comfortably used binary fractions that are part of everyday discourse, such as *aadha* (half), *paav* (quarter) and *aadha-paav* (half-quarter or one-eighth). However, fractions other than these were difficult to comprehend for most of them and poorly developed despite these being present in the school curriculum. Their everyday experience does not include such fractions, or any kind of visual support for arbitrary equal partitions. In their experiential world there is not much insistence on precision, or fair division.

5.3.3 Issues of fairness

Fairness is seldom taken into consideration in the world of work, which is governed far more by possibilities and bargains. For a child in a Mushari or for poor children in the metropolis, fairness is not easy to grasp. Wages are often not correlated with hours of work, entitlements are not equally or fairly distributed in society, rewards and punishments are socially manipulated to favour a few over the majority. To cite an example, when the researcher discussed with a student from the Mumbai study whether she was satisfied with the wage for making *rakhi* (decorative wrist-bands), she answered in the affirmative. On further questioning, she could only tell the retail price of one dozen *rakhi*—at least Rs 60 (one *rakhi* is sold for Rs 5; 1 USD = Rs 60 approx.)—whereas for making one gross (12 dozen) *rakhi*, she received Rs 15 or less. The researcher helped her calculate the retail price of one gross *rakhi*—Rs 720—and compared it with her wage (Rs 15 or less), but the discussion did not trigger any concern about fairness of wages in the student. In another instance, when a Mushar adult was asked to calculate the price of 4 *maun* (1 *maun* $\sim$ 40 kg) of wooden logs that he was cutting, when the price of 1 *maun* was Rs 16, he used a build-up strategy by adding 15 four times and adjusted the balance by adding 4. He, however, mentioned that he would take whatever amount is given to him and not get into a fight. These interactions bring the paradoxical relation of mathematics and justice to the fore—on the one hand, mathematics can lend power to calls for fairness, justice and sound decision-making, while on the other acute disempowerment removes the incentive to learn mathematics.

5.3.4 *School and work-context mathematics: different requirements*

We noted that the notions of abstraction vary between work-contexts and differ from abstractions handled at schools. For example, diverse measurement work-contexts implicitly use abstract notions such as construction of units and sub-units, chunking of measures, partitioning, unit iteration, covering, use of convenient units and modes (such as templates) which are available to students as part of the everyday mathematical knowledge. The school curriculum, in contrast, treats learning of measurement as a skill development and then moves towards abstraction without building on the knowledge resource already available to the children from the work-contexts. Similarly, conservation of attributes, transitivity and seriation—that are the foundation of comparison, thence the backbone for developing critical understanding of measurement—are not sufficiently emphasized while handling abstractions in the school context. Thus, experience in work-contexts or in cultural practices though helps in broadening children's learning potential but is not leveraged in the formal learning situation.

The above examples indicate that the whole gamut of everyday experiences, including diversity of cultural and work practices, shape students' everyday mathematical knowledge. However, the inter-penetration between everyday and school mathematics shows that learning in one domain has relevance for the other which remains to be unpacked. From the standpoint of the socio-economic influence of mathematics learning, analysis of such hybridized embedding of one domain of knowledge into the other remains an area that calls for systematic exploration and brainstorming.

6 Discussion and implications

While no generalization is relevant for such a vast and diverse country as India, mathematics learning is to a large extent determined by context across diverse settings. There is a hierarchy of schools in rural and urban areas reflecting the social stratification. Apart from region, language and socio-economic background of the child, systemic, historical and other sociological conditions define the context of education. Current pedagogic practices create and accentuate the features of mismatch or disconnect within learnings at different sites, namely, home, neighbourhood contexts, schools and work-contexts of children. We draw on the discussion in earlier sections and highlight some of the factors within socio-economic conditions that have possible bearing on mathematics learning.

6.1 Contextual factors of mathematics education

If workplaces, economically active neighbourhood and the surroundings were learning sites for the children of the urban low-income settlement, it was the community knowledge and cultural practices that were instrumental in the Mushar children's learning. The Mushar settlement was much poorer in work and education opportunities, while the urban settlement created several learning opportunities for everyday mathematics through work-contexts. For the Mushar, mathematics remains embedded mostly in cultural practices. Unfortunately, formal school systems do not offer an institutional platform where formal education can tap community resources or experiences at workplaces for mathematics learning.

We observed that Mushars are socially excluded and neglected in the society, and remain marginalized by the formal education parameters which label them with low literacy, low enrolment and low levels of performance in schools, even while their own culture and community practices encode mathematical learning. Although children in the urban settlement come from a low socio-economic background, their aspirations are high. In reality, however, there are limits to realizing their aspirations and their learning of mathematics. Children of higher social or economic strata are increasingly shifting to private schools with better facilities, and opportunities for mathematical learning in terms of quality of schooling show a downward trend (ASER 2012).

6.1.1 *Need-based and need-limited learning*

Our extended field visits indicate that economic, social and cultural practices influence students' learning strategies to meet different needs, namely, the optimal use of limited resources including time and labour, management of household chores, routine purchase of provisions, and maintaining traditional activities, customs and religious practices. Arguably, the low socio-economic conditions of the households influence the knowledge and skills that are gathered and valued within the community. The everyday experience of the community and the children calls for a reality perspective and smart strategies to survive and manage where resources are scarce. The community valorizes the acquisition of such capabilities through a variety of work experiences. Everyday mathematics as embedded in work and other practices is often part of such learning.

The discussion in the previous section indicates the forms of mathematics that is learnt from different sites, highlights factors that influence mathematics learning, and points to both strengths and limitations in the children's capabilities with regard to mathematics. The nature and extent of their everyday mathematical knowledge depends upon the world they live in and their daily struggle for existence. The actual levels of formal mathematics learning happening in schools could be way below the official 'expected learning outcomes' quoted in the educational policy documents, but learning from their everyday experiences is encouraged and valorized in the community and can form a base for school learning. As researchers have pointed out, sensitivity and awareness about such learning can allow teachers to connect abstract mathematical notions with the rich and varied experiences of students and to teach more effectively (Nasir et al. 2008).

6.2 Socio-economic origins of errors, inadequacies and incompleteness

Children's own experiences in adverse social conditions or work-situations contain significant openings for drawing them into mathematics. However, it would be equally important to note the limits and incompleteness of their mathematical knowledge and skills, which are embedded in practices, and then to transcend their first-level tasks to equip them for coping with higher goals of mathematics. As observed earlier, students' knowledge of written numerals and enumeration of large numbers are not error-free or adequate. While students' calculations are quick and often usable, these remain largely oral, and children's capacity with written mathematics is limited. Approximation, estimation and the strategies used by students sometimes lead to correct/accepted values, but their knowledge of fractions remains incomplete.

It is worthwhile to examine in depth the choice of achievable goals and appropriate pedagogic strategies of mathematics education in the light of the strengths and weaknesses of learners placed in adverse conditions. While there are utilitarian goals of mathematics and the subject provides us with tools for problem-solving for a variety of situations, mostly concrete and real, at another level mathematics becomes a formal system of logic and symbolization, with sometimes its practitioners revelling in its purity and non-application. Possibly someone starting from initial exposure to mathematics in work-contexts may be more comfortable with the former kind of mathematics and heuristic devices, but how to build on experiences gained from everyday contexts needs to be explored through teaching studies. Furthermore, the issues concerning transition from concrete to abstract, and informal to formal, will also require study in depth for similarly placed groups as well as individual learners. The possible learning trajectories need to be anticipated and explored for children in difficult circumstances taking into consideration their potential strengths and community-specific resources. Moreover, it is important for teachers to acquire knowledge about, and sensitivity towards, community-based knowledge resources that students bring into the classroom.

6.2.1 Lesson of unfairness and disconnection with everyday experiences

Practical situations from real-life experiences often shape the way children from low socio-economic backgrounds think about and perceive mathematics in the world around them. The inequities and lack of fairness in the society intrude into their understanding of mathematics. For them, the rules of mathematics are not rigid, but flexible depending upon the situation. The sharing of goods and eatables need not be equal for them, and division need not be fair. Here comes a disconnect between what children study in schools and what they see and experience in the world outside. The underlying principles of textbooks or school mathematics are at variance with their lived experiences, particularly in the urban setting where their encounter with mathematics as embedded in contexts of practice is different.

6.2.2 Demands for justice and quality as rights

Study of socio-economic conditions is connected to political domain on the one hand and cultural practices on the other. On the political side the idea of equity and fairness is intertwined with the idea of justice and the concept of rights. Rawls' classical theory of 'justice as fairness' (Rawls 1958) underlines that fairness can be realized through 'just institutions'. The concept of justice is articulated today by means of human rights, which is often translated into legal rights. If the caste system of India is an old institution, schools and colleges are fairly new ones, visualized as instruments of social transformation. When these new institutions did not fulfil their expected role, the constitution was amended and legislation was brought forth in 2010 conferring the right to education (RTE) in a neighbourhood school as a fundamental right. The common school system recommended by the First Education Commission (1966) and accepted in the subsequent Educational Policies (1968 and 1986) could have qualified to be termed as provision for just institutions in education, but in a much diluted form it is now incorporated in the Right to Education (RTE) Act as neighbourhood schools. Basic schools under Nai Talim was another alternative where work itself was the medium of learning, but this initiative has been all but abandoned long ago. For ensuring justice or fairness to children from families with low socio-economic status, schools as institutions must function equitably and emerge as efficient sites of learning, independently or in relation to homes, neighbourhoods or workplaces of poor children.

6.2.3 Workplace or schools as legitimate sites of learning to overcome background handicaps?

It is unfair to expect a child to get his or her education at the workplace, but as the *National Curriculum Framework 2005* advocates strongly, schools should be brought closer to society, thus tacitly accepting other sites of learning as legitimate. There has been legislation in place in India since 1986 prohibiting child labour in many occupations or processes. The implication is that school is the natural site of learning for a child, and no burden of labour can be imposed on her or him. There are clear norms and standards laid down for a school in the schedule of the Right to Education (RTE) Act, along with provision of adequate numbers of trained teachers and other facilities, to which each child in the age-group 6–14 years is entitled, though these have not been ensured within the deadline provided in the Act. In fact there are various systemic issues which need to be resolved for quality education and obviously an ambitious mathematics curriculum cannot be faithfully transacted without that. Hopefully, even inequity-related issues will be differently defined in rural areas inhabited by marginalized groups or slums in urban areas in the not too distant future due to some compulsions introduced by the RTE Act. Divisions may then be a little more equal and fair, both in mathematics and in society!

7 Concluding observations

Historically, Indian society has a long tradition of its own multiple ways of transmission of knowledge, including use of mathematics, which takes different forms in different cultures and different strata of society. This tradition started fading out gradually with the advent of the colonial system of education in urban India, which has now acquired greater pace with new technologies, economic changes and universalization of formal education. Yet the inequitable socio-economic conditions and social arrangements limit and define the scope of mathematics learning, the pattern varying significantly in urban and rural contexts. As field studies confirm, cultural factors still matter in rural areas, while disconnect between school mathematics and experiential learning, inherited or acquired, is a universal phenomenon across different settings.

Despite some recent initiatives to improve (mathematics) education in India, especially for those who are at the bottom of the social and/or economic hierarchy, the education system continues to perpetuate such classification and exclusion. The language of education is a language of hope that opens possibilities of social inclusion and a better life for every child. Plural and contextualized pedagogic choices factoring in experiential knowledge and cultural resources will need to be explored for diverse groups of children. In the past also this has often been attempted, formally as well as informally, though not always with great success. The analysis presented in this paper provides evidence of how the exclusion operates systemically, and yet there are possibilities. This diagnosis may provide directions for removing the malaise on the one hand and making profitable use of the available resources on the other hand.

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