Culturally Responsive Mathematics Teaching

Implications for Teacher Preparation and Professional Development

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Abstract

School mathematics is often conceptualised as being neutral, decontextualised and culture-free. In consonance with reforms in mathematics education, the National Curriculum Framework (NCF)–2005 envisages a new vision of school mathematics that connects mathematical knowledge and social worlds of children. This epistemological shift places new and challenging demands on teachers and teacher-educators. Challenging the 'deficit theory', the paper acknowledges home, community and culture-based practices as reservoirs of knowledge, which need to be strategically tapped in classrooms. The paper, in this light, discusses the possible ways in which a teacher and teacher-educators can collaborate to address one's sociocultural beliefs and assumptions about knowledge and learners in mathematics classrooms, and develop cultural awareness and responsiveness. Most importantly, the paper argues for a deeper engagement with equity and justice issues in mathematics teacher education.

The traditional 'absolutist' conception of mathematics views it as a body of infallible and objective truths, far removed from the affairs and values of humanity (Ernest, 1991), treating mathematical activity as

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highly abstract, formalised and decontextualised. Such a view assumes a separation between "cognitive processes and the settings and activities of which they are a part" and treats knowledge as "a factual commodity or compendium of facts" (Lave, 1988). At the school level, this conception of mathematics gets manifested in the form of cultural discontinuity between 'academic' and 'everyday' mathematics, resulting in the exclusion of some particular groups. The teacher is the epistemic authority and the emphasis is on students' knowledge of facts and formulas, reducing mathematics to nothing but algorithmic thinking (Ernest, 2009). There is tyranny of one 'right' answer to every question, one meaning for every word and that meaning stays the same for all people and for all times (Fasheh, 1982).

This view of mathematics has, however, undergone a 'Kuhnian Revolution', challenging the infallibility of mathematics and acknowledging its sociocultural character. Redefining mathematics as a fallible social construction and the continually expanding field of human creation and invention provides rationale as well as foundation for 'inclusive' approaches to the subject, wherein "the social contexts of the uses and practices of mathematics can no longer be legitimately pushed aside". Mathematics, then, needs to be "studied in living contexts which are meaningful and relevant to its learners, including their languages, cultures and everyday lives, as well as their school-based experiences" (Ernest, 1991).

In India, a large number of failures happen in mathematics due to its role in alienating children and contributing towards their non-participation (NCERT, 2008), and thus, pushing students out of the system. This poses a greater challenge to our aim of providing equitable and quality education to all, and calls for a fundamental shift in our conception of mathematics and mathematics education.

The Epistemological Shift

Studies in everyday cognition have apparently made visible a new metaphor for learning, which Sfard (1998) calls 'participation metaphor', contrary to the conventional 'acquisition metaphor'. Learning, from this perspective, is reconceptualised as a process that takes place in a participation framework, not in an individual mind. It is not a one-person act, but is rather distributed among co-participants and is mediated by the differences of perspectives among the co-participants. Thus, learning is viewed as an integral and an inseparable aspect of social practice and children as legitimate peripheral participants in adult social worlds (Lave and Wenger, 1991). Closely linking his work to the ideas of Vygotsky and Lave (1988) allows us to shift from a 'claustrophobic view' of cognition to a 'social anthropological' view, wherein cognition is viewed as a complex social phenomenon. 'Cognition' observed in everyday practice is distributed— stretched

over, not divided among mind, body, activity and culturally organised settings. His ideas, thus, mark a shift from 'dissociated' cognition (separation of cognition from the social world) to 'situated' cognition (cognition in practice); from an isolated learner to a learner involved in a 'community of practice'. The perspective implies emphasis on "comprehensive understanding, involving the whole person rather than 'receiving' a body of factual knowledge about the world; on activity in and with the world; and on the view that agent, activity and the world mutually constitute each other" (Lave and Wenger, 1991).

Several decades ago, educational philosophers, like Dewey and Gandhi, proposed a new vision of education centred around productive work and community-based practices. Dewey (1929) noted that "the true centre of correlation on school subjects is neither science, nor literature, nor history, nor geography, but the child's own social activities".

As a consequence of the current reforms in mathematics education, the NCF–2005 advocates a shift from achieving 'narrow' to 'higher' goals of 'mathematising'; a shift in focus from mathematical content to mathematical learning environments; offering multiplicity of approaches, procedures and solutions (NCERT, 2006). The shift from the conventional noun 'mathematics' to the verb 'mathematising' poses a challenge to the conventional epistemology of mathematics. This shift, according to Millroy (1992), signifies a move from mathematics as an abstract "accomplished fact" to experience and process of mathematics.

Taking into cognizance the new epistemology of mathematics, the NCF–2005 acknowledges the "cultural grounding of mathematics" when it notes that "mathematical competence is situated and shaped by social situations and the activities in which the learning occurs. Hence, school mathematics has to be in close relation with the social worlds of children where they are engaged in mathematical activities as part of daily life" (NCERT, 2006, p.11). Such a conception of mathematics necessitates a fundamental reconstruction of school mathematics at all levels — curricular choices, pedagogy, assessment and teacher education. To respond to the shift envisaged and to address the diverse ways of knowing, learning and communicating in and out of school contexts in India, significant efforts have been made at the curricular level and designing new textbooks. Emphasising on an integrated approach to learning mathematics, chapters have been developed thematically and are based on real-life contexts, offering connections not just within mathematics but across subject areas. However, as Gay (2009) puts it, "the best curricula and instructional materials are only as good as the teachers who implement them", calling for a radical departure from the existing approach to teacher education and professional

development so as to translate the NCF's vision into reality.

Towards a Culturally Responsive Pedagogy

Dominant ways of teaching mathematics involve presenting the standard algorithm to students, followed by drills and practices. Such practices are antithetical to learning with understanding and the goal of mathematisation as envisaged by the NCF–2005. There is a mismatch between teaching practices and goals for mathematics education and between teaching strategies and students' ways of thinking, learning and problem-solving. For teachers and teacher-educators, the changes envisaged place new and challenging demands and responsibilities.

Since visible teaching practices that occur in a classroom are partly a result of hidden interpretive lenses a teacher holds (Aydin, et al., 2010), one of the major challenges is to bring about changes in their beliefs as a crucial precursor to real change in teaching. It has been found that a teacher's beliefs about the nature of mathematics and its teaching-learning influence the teacher's planning, decision-making, pedagogical and assessment practices. Many assumptions of teachers come from attitudes and beliefs prevailing in wider social contexts. Leonard (as cited in Gay, 2009) calls for a thorough understanding of subject-associated perceptions and socialisations of mathematics; how they are manifested and affect students from diverse groups so that teachers can develop strategies to counteract them. Teachers need to challenge erroneous assumptions that link success in mathematics to some innate ability that only a talented few possess, and thus, deconstruct what mathematical 'ability' and 'achievement' constitute.

Teachers, usually, expect less from students belonging to the marginalised sections of the society. The blame for failure is often attributed to their inability and, at times, to their backgrounds. Such failures are seldom linked to the way mathematics is taught in schools, the curriculum and the nature of mathematics itself, in short, the way school mathematics is structured. Differences and diversity that these students bring to the fore are thought of as a classroom problem rather than as potentially important learning resources. Knowledge that these students bring to the classroom go unacknowledged and unrecognised. Therefore, the children feel denigrated by a system that appears to assume that they know nothing about the realm of mathematics (Nelson-Barber and Estrin, 1995). At the same time, mathematics education remains devoid of not just rich content and processes that these students bring but also certain well-developed ways of knowing, learning and problem- solving rooted in children's everyday experiences (ibid. pp.174), thus, accentuating tension between knowledge and experience acquired

in and out of school (Carraher and Schliemann, 2002).

According to Gay (2009), "Culturally responsive teaching is always influenced by who, when and why it was created or configured, and for whom and for what purposes." Going beyond content knowledge and pedagogic content knowledge, teachers need to have knowledge about students' cultural and linguistic backgrounds to help build bridges between school and community as well as between academic abstractions and live sociocultural realities (Mukhopadhyay, Powell and Frankenstein, 2009). They should also help develop positive social and cultural identities, what Ladson-Billings (1995) called 'cultural competence', in which students are able to "maintain their cultural integrity while succeeding academically" (Gutstein, 2006). This can be done by exploring mathematics latent in diverse cultural practices, such as geometric ideas in art, architecture, folk crafts, oral algorithms used in streets, mathematical ideas in folk riddles, games and puzzles, examining historical evolution of concepts, highlighting contributions made by different cultures and 'other' people in mathematics. The *Sourcebook for Assessment of Children's Learning in Mathematics* states that "these are the cognitive resources that children already have access to, and which can be drawn upon by the pedagogic processes at school" (NCERT, 2008). Also, as Masingila (1994) puts it, posing the problems that are meaningful to the problem-solver motivate and sustain problem-solving activities.

Liberating mathematics from the tyranny of procedures and memorisation of formulas, and emphasising on learning with understanding and teaching with meaning calls for a re-examination of classroom practices and nature of assessment. While using numbers, symbols and words with children, teachers seldom pose questions to explore the meanings and images created in the young minds (Fasheh, 1982) — a concept often described by invoking the standard algorithm for its calculation (Millroy, 1992). Millroy notes, "It is easy to confuse the two issues of the meaning of the concept and of knowing how to calculate it, so volume is length times width times height seems an adequate explanation for the concept." Thus, a significant question it raises for mathematics educators to be analysed is — "what does it mean to understand a concept?" (Millroy, 1992). Since culture influences our ways of thinking, knowing, proving the logic we are using, classificatory schemes as well as the concept we are forming, teachers need to encourage subjective ways of looking at mathematical expressions and concepts, while exploring local and cultural meanings associated with them (Fasheh, 1982). Contextualisation is, thus, necessary to capture the meaning of students' classroom learning, participation and

performances on classroom tasks, as Nelson-Barber and Estrin (1995) note that when ways of knowing particular groups remain unacknowledged in assessment practices, they cannot pretend to have valid outcomes.

The social organisation of a classroom may include or exclude students from particular groups. Many students in mathematics classrooms belong to marginalised or oppressed sections of the society. Girls, Dalits, tribals and students with disabilities are often considered intellectually inferior when it comes to learning and solving mathematical problems. In mathematics classrooms, these students often employ various coping and passive-resistance mechanisms, such as non-participation, withdrawal, silence, evasiveness and ingratiation. Atwater and Riley (1993) explained that students from marginalised and traditionally under-represented community are estranged from mathematics due to alienation from its texts and content. To be successful in school mathematics, it requires them to continuously challenge messages of inferiority transmitted to them about their abilities, backgrounds and prejudiced accounts, which misrepresent contributions their communities made to the discipline. Drawing from the mathematical ideas embedded in their culture, home and community-based practices position them as active participants, thinkers and problem-solvers, rather than as passive recipients of mathematical knowledge. Teachers need to raise and critically reflect on questions, such as, "who is in the different levels of mathematics courses?" and "who is having a voice in mathematics classrooms and why is that happening?" (Atwater, 1996). Teachers need to transform classroom learning environments in order to "create modes of social interactions in which students not only bring their individual thinking to the fore, but in some instances also engage in processes of inquiry and validation of ideas through mathematical practices of explanation, clarification, challenge, and justification of their ideas" (Wood and Turner-Vorbeck, 2001).

Decades ago, the Kothari Commission (1964–66) recommended breaking the isolation of teacher education institutions from realities and problems constituting school and community life, and isolation from universities and researches undertaken. These institutions continue to exist as insular organisations and need to be revitalised. This calls for a convergence of institutional linkages (Batra, 2005) and comprehensive research base that can contribute to restructuring teacher education in accordance with the current reforms in mathematics education.

There are inconsistencies between the 'New Vision' of teacher education as envisaged in the National Council for Teacher Education (NCTE)–2009, acknowledging the socio-constructivist principles and the actual practices of teacher-educators, which still follow

teacher-dominated approaches. Since teachers are expected to use culturally-responsive strategies and pedagogical practices that recognise mathematics culture interface can be nurtured by engaging with teachers' sociocultural contexts, both in learning and teaching mathematics. In other words, teacher education programmes must offer exemplary models to teachers to teach maths to their students in culturally-responsive ways as they themselves are being taught (Gay, 2009). Thus, mathematics teacher-educators should attend to the culture of their students in order to enhance their abilities. Teacher-educators can provide opportunities to pre-service teachers to share examples of mathematical ideas and practices in their own cultural environments. Such activities may help develop openness for mathematical practices in other cultures as well (Gerdes, 1998), thereby helping develop cross-cultural competencies. In order to strategically tap students and their communities' 'funds of knowledge' (Gonzalez, Moll and Amanti, 2005) in mathematics instruction, teachers can plan small researches — observing and participating in diverse community practices, and conversing informally with children about everyday life and work contexts, in which they gain and use mathematical knowledge. Beginning from initial teacher preparation, teachers need to be given opportunities to integrate children's multiple mathematical knowledge bases in their planning and instruction (Turner, et al., 2012).

'Becoming' a Critical Mathematics Educator

According to Gutstein (2006), it is important to distinguish between using mathematics in real world settings, as in shopping, travelling, working, and building from those that explicitly ask students to investigate injustice. Thus, students learn to see mathematics not only as a meaning making tool but also to use it as an analytical tool in order to understand inequality and restructure the society for justice and equity.

The current 'mathematics for all' reform requires us to go much beyond than just enacting pedagogy of access — providing adequate resources to all students in mathematics classes. Such focus on access in a system that continues to reproduce inequities in the society seems limiting and problematic. The very notion of equity in mathematics education needs to be problematised and reconceptualised to include identity and power aspects (Gutierrez, 2012). This necessitates a move towards 'pedagogy of transformation' that helps unveil injustices in the society and empowers students to transform their worlds (Aguirre, 2009). Learning to teach for social justice requires both pedagogy of access and pedagogy of transformation.

Drawing from Darling-Hammond's model of equity pedagogy, Bartell

(2011) cites four key factors that guide teachers in learning to teach for social justice — self, society, students and schools. Here, 'self' includes "reflecting on how one's beliefs about teaching and learning are influenced by cultural, historical and economic contexts, in which they grew up", viewed as gaining "sociocultural consciousness" (Villegas and Lucas, 2002); 'society' refers to "understanding how economic, political and social power structures interact with teachers' understanding of teaching and learning"; 'students' include "understanding one's students in non-stereotypical ways while acknowledging and comprehending the ways in which culture and context influence their lives and learning" and taking into consideration an evolving understanding of the above three factors, 'school' includes "developing and enacting classroom practices that support students". There is a need to address each of these factors so as to challenge the inequitable structures that hinder the participation of students from particular groups, in order to engage each child with a sense of success.

Applying Freire's critical education theory to mathematics education, Gutstein (2006) advocates two dialectically-related pedagogical goals of "reading and writing the world with mathematics".

Reading the world with mathematics means "to use mathematics to understand relations of power, resource inequities, disparate opportunities between different social groups, and to understand explicit discrimination based on race, class, gender, language and other differences".

Writing the world with mathematics means "using mathematics to change the world". To actualise these pedagogical goals requires teachers to enact what Freire calls 'problem-posing pedagogies', distinct from problem-solving ones, constituting an education that "involves a constant unveiling of reality... that strives for the emergence of consciousness and critical intervention in reality" (Freire, as quoted in Gutstein, 2006). In Giroux's (1988) words, this could be conceptualised as "making the pedagogical more political, and the political more pedagogical".

Providing opportunities with real-world projects based on 'generative themes' can serve as the starting point for problem-posing pedagogies and examining the idea of 'fairness' in real lives. These themes can be searched for with the students within the ideas, experiences and contradictions which give meaning to the sociocultural realities in which they are situated. This can also be done by using statistical examples that require students to probe the society's structures and underlying ideologies (Gutstein, 2006), such as investigating unfair wage patterns, allocation of GDP to various sectors in neo-liberal regimes and State's abdication of its responsibility in health and education sectors in order to understand power relations and

unequal resource allocation in the society (Gutstein, 2003). Further, the mathematical ideas of simple and compound interest can be studied and taught through a critical analysis of different loan schemes.

Such an approach to teaching mathematics, according to Skovsmose and Greer (2012), "transcends the aim working for equity within mathematics education to enacting vision of equity through mathematics education by teaching content and raising political consciousness together".

Critical mathematics educators always find themselves in a "continuous state of becoming" (Stinson, Bidwell and Powell, 2012). Although learning to teach for social justice is a complex and lifelong process and not a matter of one graduate course. Teacher preparation programmes must take steps for prospective teachers' initial engagement in this process (Bartell, 2011).

Attempts at revitalising school education in India will have little success, if the 'agency of teacher' remains unrecognised (NCFTE, 2009). Teaching has to be revitalised into a transformative profession and teachers need to be viewed as "transformative intellectuals" to address the larger issues of social justice and equity in education, in general, and mathematics education, in particular.

References

Aguirre, J.M. 2009. Privileging Mathematics and Equity in Teacher Education: Framework, Counter-Resistance Strategies, and Reflections from a Latina Mathematics Educator. In B. Greer, et al. (Eds.), *Culturally Responsive Mathematics Education*. Routledge, New York.

Atwater, M.M. 1996. Social Constructivism: Infusion into the Multicultural Science Education Research Agenda. *Journal of Research in Science Teaching.* Vol. 33. No. 8, pp. 821–837.

Atwater, M.M. and J.P. Riley. 1993. Multicultural Science Education: Perspectives, Definitions and Research Agenda. *Science Education.* Vol. 77. No. 6, pp. 661–668.

Aydin, S., N. Boz and Y.Boz. 2010. Factors that are influential in pre-service chemistry teachers' choices of instructional strategies in the context of methods of separation of mixtures: A case study. *The Asia Pacific Education Researcher*, Vol. 19. No. 2, pp. 251-270

Bartell, T.G. 2011. Learning to Teach Mathematics for Social Justice: Negotiating Social Justice and Mathematical Goals. *Journal for Research in Mathematics Education.* Vol. 41, pp. 1–35.

Batra, P. 2005. Voice and Agency of Teachers — Missing Link in National Curriculum Framework. *Economic and Political Weekly.* Vol. 40. No. 40, pp. 4347–4356.

Dewey, J. 1929. My Pedagogic Creed. *Journal of the National Education Association.* Vol.18. No. 9, pp. 291–295.

Ernest, P. 2009. New Philosophy of Mathematics: Implications for Mathematics Education. In B. Greer, et al. (Eds.), *Culturally Responsive Mathematics Education*. Routledge, New York.

____. 1991. *The Philosophy of Mathematics Education*. The Falmer Press, London.

Fasheh, M. 1982. Mathematics, Culture and Authority. *For the Learning of Mathematics*. Vol. 3. No. 2, pp. 2–8.

Gay, G. 2009. Preparing Culturally Responsive Mathematics Teachers. In B. Greer, et al. (Eds.), *Culturally Responsive Mathematics Education*. Routledge, New York.

Gerdes, P. 1998. On Culture and Mathematics Teacher Education. *Journal of Mathematics Teacher Education*. Vol. 1, pp. 33–53.

Giroux, H. 1988. *Teachers as Intellectuals: Toward a Critical Pedagogy of Learning*. Bergin and Garvey, Westport, CT.

González, N., L.C. Moll and C. Amanti (Eds). 2005. *Funds of Knowledge: Theorising Practices in Households, Communities and Classrooms*. Lawrence Erlbaum, New Jersey.

Gutierrez, R. 2012. Context Matters: How Should We Conceptualise Equity in Mathematics Education? In B. Herbel-Eisenmann, et al. (Eds), *Equity in Discourse for Mathematics Education*. Springer, Dordrecht.

Gutstein, E. 2003. Teaching and Learning Mathematics for Social Justice in an Urban, Latino School. *Journal for Research in Mathematics Education*. Vol. 34. No. 1, pp. 37–73.

____. 2006. *Reading and Writing the World with Mathematics: Toward a Pedagogy for Social Justice*. Routledge, New York.

Lave, J. and E. Wenger. 1991. *Situated Learning — Legitimate Peripheral Participation*. Cambridge University Press, UK.

Lave, J. 1988. *Cognition in Practice — Mind, Mathematics and Culture in Everyday Life*. Cambridge University Press, UK.

Ladson-Billings, G. 1995. 'But that's just good teaching. The case for culturally relevant pedagogy. *Theory into Practice*. Vol. 34. No. 3, pp. 159–165

Masingila, J.O. 1994. Mathematics Practice in Carpet Laying. *Anthropology and Education Quarterly*. Vol. 25. No. 4, pp. 430–462

Mukhopadhyay, S., A.B. Powell and M. Frankenstein. 2009. An Ethnomathematical Perspective on Culturally Responsive Mathematics Education. In B. Greer, et al. (Eds), *Culturally Responsive Mathematics Education*. Routledge, New York.

National Council of Educational Research and Training. 2006. *Position Paper 1.2 of the National Focus Group on the Teaching of Mathematics*. NCERT, New Delhi.

____. 2008. *Sourcebook for the Assessment of Children's Learning in Mathematics*. NCERT, New Delhi.

National Council for Teacher Education. 2009. *National Curricular Framework for Teacher Education: Towards Preparing a Professional and Humane Teacher*. NCTE, New Delhi.

Nelson-Barber, S. and E.T. Estrin. 1995. Bringing Native American Perspectives to Mathematics and Science Teaching. *Theory into Practice*. Vol. 34. No. 3, pp. 174–185.

Schliemann, A.D and. D.W. Carraner. 2002. The Evolution of Mathematical Understanding: Everday versus Idealised Reasoning. *Developmental Review*, Vol. 22. No. 2, 242–246.

Sfard, A. 1998. Two Metaphors for Learning and the Dangers of Choosing Just One. *Educational Researcher.* Vol. 27. No. 2, pp. 4–13.

Skovsmose, O. and B. Greer (Eds). 2012. *Opening the Cage: Critique and Politics of Mathematics Education.* Sense Publishers, Rotterdam.

Stinson, D.W., C.R. Bidwell and G.C. Powell. 2012. Critical Pedagogy and Teaching Mathematics for Social Justice. *The International Journal of Critical Pedagogy*. Vol. 4. No.1, pp. 76–94.

Turner, E.E., et al. 2012. Promoting Equity in Mathematics Teacher Preparation: A Framework for Advancing Teacher Learning of Children's Multiple Mathematics Knowledge Bases. *Journal of Mathematics Teacher Education.* Vol. 15, pp. 67–82.

Wood, T. and T. Turner-Vorbeck. 2001. Extending the Conception of Mathematics Teaching. In T. Wood, B. S. Nelson, and J. Warfield (Eds.), *Beyond Classical Pedagogy: Teaching Elementary School Mathematics.* Lawrence Erlbaum, New Jersey.