9. Innovations and initiatives in mathematics education in India

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Introduction

The past four decades (beginning 1970s) have seen enormous changes in the field of education in India and numerous organizations (governmental and non-governmental) have taken steps in response to or in reaction against the policies adopted by the government vis-à-vis education and curriculum documents released from time to time. Universalization of education and education for democracy have become the new agendas for the country. Mathematics has been a subject with a large number of student failures, a reason for students dropping out of school and a cause of fear and anxiety among students. Mathematics and science, which have played the role of gatekeepers for accessing higher education, have for many years aroused interest among several intellectuals to make an effort on the ground and make a difference in children's attitudes to and understanding of these subjects. Various commissions set up by the government have recommended mathematics as compulsory for all students due to its importance for the growth of biological and physical sciences and technology. Thus, many efforts in the form of interventions at various levels have been made in the country. However, these have not translated into detailed documentation or systematic research studies to gather evidence of their actual impact on students' thinking and learning, teacher development or systemic changes. The recent change in the public discourse on general education to a more progressive one, imbibing the constructivist philosophy and keeping the welfare of the child in mind led to further efforts in the field. This article aims to first describe some of these efforts made in the area of mathematics teaching and learning and then raise certain issues and challenges which mathematics education and research in the area faces in this country.

Interventions and initiatives in the teaching and learning of mathematics

The interventions which have been made in the way of influencing the teaching and learning of mathematics have been in varied directions: curriculum development, interventions in schools and classrooms, in-service teacher training, nurture programmes to train students to build capacities to think mathematically and solve problems of various complexities, and popularization of mathematics, largely to attract students to take up higher mathematics.

Curriculum and material development

Some of the earliest attempts to improve teaching and learning of mathematics were in developing alternative curricular materials. The Khushi-Khushi series of books for teaching mathematics at the primary level developed by Eklavya, a non-governmental organization (henceforth NGO), based in the state of Madhya Pradesh and the material designed by another NGO, Digantar based in Rajasthan are two such examples. They associated closely with local schools and teachers and the communities they intended to work with. These attempts were premised on children as active learners and faith in their ability to think independently and create knowledge. They took into consideration children's background (socio-economic, language, local traditions, culture, environment, etc.) in the designing of learning material, understanding that these factors influence learning of mathematics in specific ways and considered these as ways to make mathematics meaningful. These initial attempts were based on some understanding in the areas of child development, language learning and mathematical skills and abilities of children. They relied heavily on Piagetian stages of cognitive development and promoted constructivist and discovery based learning, used games and activities and helped students learn from concrete experiences or structured materials before moving to abstract concepts. However, teachers were given adequate space to change, modify and add to the illustrative material given in the text as per the needs of their classes and children. They paved the way for many subsequent interventions.

Much of the curriculum development activity in the country has been guided by these assumptions and philosophy of teaching and learning but has varied in the way these translated into the design of textbooks and materials. We can see three distinct trends in the designing of these interventions. One set of interventions used plenty of games and activities to introduce concepts and ideas as well as to strengthen procedures. The thrust of these interventions is the use of games and activities and less importance is given to sequencing of concepts across grade levels or ideas within a concept. They also systematically included student generated strategies, giving scope to generate problems given some numerical sentences, and recognition of patterns in numbers and operations.

The Eklavya group made attempts to combine the teaching and learning of different subject areas like language, mathematics and science (Khushi-Khushi, 1998) but this approach worked well only for the initial Grades 1-3. As the students went up the grades, the teaching of different subject areas had to be separated. The Grade 4 Khushi-Khushi has three books, half of one of these books is devoted to mathematics and in Grade 5, one full book is on mathematics. Eklavya's effort, in particular, was a broad based effort in collaboration with the state education department, involved many mathematicians and scientists and aimed to impact the system and society directly. Teachers were integral to the design and development of activities and ideas in such interventions and thus a large number of classrooms were available for trialing them. In the process, these initiatives conceptualized and developed mechanisms for supporting teacher preparation (pre and in-service). The School Mathematics Project started by the Centre for Science Education and Communication, University of Delhi (1992) was another systematic attempt to develop an alternative primary mathematics curriculum in schools. It involved teachers, educationists and scientists, and built on the experiences of Eklavya. This process inspired other groups in the country to take up similar exercises later on, and some state boards (like Kerala and Tamil Nadu) used extensive participatory processes by which large numbers of teachers were involved in textbook preparation and trialling.

Another set of interventions has been based on the use of very structured materials in a systematic way, to gradually build new ideas and concepts. Suvidya, a Bengaluru based NGO, developed materials for concepts which are more amenable to such treatment. Navnirmiti, a Mumbai based NGO, designed a range of materials to cover almost all concepts and ideas in primary mathematics, embodying the philosophy of learning by doing. Jodo Gyan, a Delhi based NGO, made further extensions in the same line to incorporate the philosophy of Realistic Mathematics Education and designed material and teaching learning trajectories accordingly. Centre for learning resources, based in Pune is another organization, which has worked extensively with primary level mathematics, developing simple low cost teaching material and teacher training packages for using these materials.

A third set of interventions is more conceptually driven, introducing the concepts gradually and in a logical sequence (does not strictly follow the Piagetian stages of child development), deepening students' understanding through various activities aimed at clarifying the concept and related ideas and procedures (Homi Bhabha Centre for Science Education, a research institution in Mumbai).

Mathematics educators like P. K. Srinivasan and Shailesh Shirali have contributed by writing books and primers with the aim to clarify the content and with numerous examples of interesting problems (e.g. Srinivasan, 2004; Shirali, 2000).

The National Curriculum Framework 2005

Experiences with interventions like the ones mentioned above together with experiences gained through the Adult Literacy Programme (Rampal, Ramanujam and Saraswati, 1998) contributed to the discussions towards the country's new National Curriculum Framework (NCF-2005) (NCERT, 2005) and subsequent revision of the textbooks. The perparation of NCF-2005 was a huge exercise and led to significant changes in the way one thought about teaching and learning of mathematics and the way textbooks for children were written. The framework clearly explicated a philosophy and an approach to teaching and learning and systematically tried to address social justice questions. It was guided by the Constitutional values of India as a "secular, egalitarian and pluralistic society, founded on the values of social justice and equality" (NCERT, 2005). It proposed five guiding principles for curriculum development:

> (i) connecting knowledge to life outside the school; (ii) ensuring that learning shifts away from rote methods; (iii) enriching the curriculum so that it goes beyond textbooks; (iv) making examinations more flexible and integrating them with classroom life; and (v) nurturing an overriding identity informed by caring concerns within the democratic polity of the country.

This effort too held the same assumptions about children, knowledge and teaching-learning as the earlier interventions and emphasised teaching as a professional activity. In line with the earlier experiences of the interventions, the textbooks which were written after the NCF-2005 deliberations, include various voices and backgrounds of children and adults who surround them. The tone of the books is reader friendly and the books have many visuals, games, activities and open-ended tasks. This nation-wide exercise had tremendous influence on state level development of curricular document and textbooks. Some such examples will be given later.

In-service teacher training and teacher education programmes

Teacher education programmes across the country have not changed as a result of the nationwide deliberations during the formulation of the NCF-2005. They continue to be the weakest link in our education system. They do not systematically provide any content specific inputs to help the trainee teacher to get prepared for her job. The Indira Gandhi National Open University made the first and almost the only attempt to run a teacher education programme for primary mathematics teaching with special emphasis on content and conceptual clarity. The School Mathematics Project, which was started by the Centre for Science Education and Communication, University of Delhi, was another attempt to work with primary mathematics teachers in schools. Sandhan, an NGO in Rajasthan, has been associated with two prominent programmes in the region, Shiksha Karmi and Lok Jumbish. They have been involved with training locally recruited

educational workers as teachers, creating teaching-learning material for children in mathematics and other subjects and setting up support structures for them in collaboration with other organizations. A more detailed account of teacher preparation programmes and their professional development can be found in Kumar, Dewan and Subramaniam (this volume).

Mathematics popularization activities and nurture programmes

Leading mathematicians spread across the country in many national level institutions (Indian Institutes of Technology, Indian Institute of Science, Institute of Mathematical Sciences, Tata Institute of Fundamental Research, Indian Statistical Institutes, etc.), many individuals, and the National Council of Educational Research and Training contribute towards popularizing mathematics among students, teachers and the community at large. *Ganit Mela* and *Metric Mela* (mathematics fairs held in villages where adults are involved in answering questions raised by children based on estimation) organized in different parts of the country are some attempts to take mathematics to the community.

In this country of great diversity, we also have a very promising group of students spread across the country and across grade levels. Initiatives have been taken to retain their interest in mathematics and motivate them to pursue a career in mathematics. Some such programmes are the Mathematics Training and Talent Search (MTTS), Rural Mathematics Talent Search (RMTS), Mathematical Sciences Foundation (MSF) and the Mathematics Olympiad. These aim to promote independent thinking among students, make challenging mathematics accessible to them, show applications of mathematics in various walks of life and interact with experts in the field. The MTTS programme is meant for students pursuing undergraduate and postgraduate degrees. The RMTS aims at identifying and nurturing talent in the rural areas of Orissa. It holds a mathematics competition at the grade 6 level, designed on the lines of the Olympiad competition. The selected candidates are trained for the next three years, meeting them twice every year. MSF is involved in arranging innovative programmes related to the teaching, understanding, learning and application of mathematics at the school, college and post-graduate levels. The mathematics Olympiad activity is undertaken by the National Board for Higher Mathematics and aims to support mathematical talent among high school students in the country. It culminates in the selection and training of the Indian team for the International Mathematical Olympiad every year. An important part of these nurture programmes is providing scholarships for students even at the undergraduate level for pursuing mathematical study, and enabling their systematic interactions with research mathematicians. This site provides interesting research problems and another possible solution to get important mathematics accessible to a large number of students.

Institutional and state level initiatives

The Homi Bhabha Centre for Science Education, Mumbai is the only institute working in a focused manner in the area of mathematics education. It contributes to the field of mathematics education through its many research projects, a doctoral programme and the epiSTEME series of conferences which are held every two years and provide a platform for sharing research ideas with participants within and outside the country. These then feed into the many consultative activities which the institute is engaged in, both at the level of teacher development and student learning. In the recent years members from this institute and a few individuals from other organizations have made efforts to publish their ongoing work as short and long research papers and chapters in books. Bose and Subramaniam, 2011; Naik and Subramaniam, 2008; Banerjee, Subramaniam and Naik, 2008; Subramanian, Subramaniam, Naik and Verma, 2008; Menon, 2009 are a few examples.

Initiatives at several other levels by individuals and teacher organizations spread through the country have shaped the way mathematics teaching and learning is viewed in the country today. Groups like the Tamil Nadu Science Forum (TNSF), Kerala Sastra Sahitya Parishad (KSSP) and teacher associations like the Kerala Mathematics Teacher Association (KMTA), Association of Mathematics Teachers in India (AMTI) have played major roles in the past two decades in mobilizing teachers to form networks, conducting teacher trainings in order to enrich their content knowledge, connecting their mathematics knowledge to the world around them, expanding their knowledge by giving them tools to look at the same concepts and ideas in multiple ways. The participation of teachers in these activities is entirely voluntary and the interest of some mathematicians in this endeavour makes the activity exciting. The experience and contributions of TNSF and KSSP have fed into the development of state level new curriculum framework, textbook writing and material development. During the nationwide Sarva Shikha Abhiyan (SSA, Education for all) movement in the 1990s, TNSF actively contributed to the development of activity based learning material. Similarly, teachers, teacher educators and mathematicians have made efforts to bring technology into the secondary and higher secondary mathematics classrooms to make that learning space lively and enjoyable – engaging students in problem solving, challenging projects and providing support to understand the abstract concepts dealt at this level. The TIME (Technology and Innovations in Mathematics Education) series of yearly conferences deals with this theme.

Concluding remarks

Mathematics education is not an established discipline in this country and few systematic studies exist in this area. Due to the efforts of many, a substantial amount of work

has happened by way of improving teaching and learning of mathematics. But a lot more needs to be done. Impressions of researchers or teachers involved in developing alternative curriculum and carrying out the classroom interventions indicated significant improvements in children's attitudes towards mathematics. They also indicated better understanding of the content but systematic studies are required to assess their actual impact on students' learning. In the absence of strong empirical evidence and sound theoretical background, policy formulation becomes a difficult task. This holds true for the NCF-2005 as well where studies are required to critically examine the translation of guidelines given in the document to the textbooks and in the classroom. A few small scale studies, carried out in the primary and middle school grade levels, do indicate that a lot needs to be still achieved to fulfil the visions of the document. This may also indicate the need to critically examine the underlying assumptions in the design of the framework and the textbooks and the organization of content across grades. One needs to address the question of children's learning of mathematics as a discipline (with certain concepts, ideas, language, symbols, ways of reasoning and arguing, dealing with abstractions and generalizations) till the middle school level, which may serve as the terminal point of education for many children in this country. One also needs to ponder whether changing the framework and revising the textbooks would automatically lead to the desired overall change.

Teacher preparation continues to be the weakest link in our education system. The departments and colleges have not been able to come up with a good model of training teachers at both the pre-service and in-service levels. Simultaneously, efforts have to be made to develop capacities among teacher educators and administrators in the system.

There are relatively few individuals who are contributing to innovation in mathematics education in this vast country. As can be seen from the above description of initiatives, much of this comes from a few individuals or from a few non-government organizations. There is no systemic structure to support and strengthen such work. Although the list of contributors is not an exhaustive list and there are many others, including private support in the form of corporate social responsibility today, one needs to worry about quality of the various efforts made and critically look at the underlying philosophy. There is also no forum where different groups and individuals showcase their work and discuss issues relevant to mathematics education in the country.

Similarly, assessment is another area which has not radically changed since the NCF-2005 came into being. This is also one area which needs serious rethinking and research.

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