8. The preparation and professional development of mathematics teachers

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Context and background

The need for adequate preparation and professional development of teachers has been recognised the world over with the realisation that the teacher' conceptions and attitudes play an important role in the teaching learning process. This is reflected in Sowder's (2007) comment that " recognition of the need to change the way in which mathematics is taught and learned is international in scope". In India, the importance of the teacher was recognised by the Education Commission as early as 1964-66 which observed that "of all the factors that influence quality of education... the quality, competence and character of teachers is undoubtedly the most significant". Research evidence from other countries indicates that professional preparation of teachers is significantly related to students' achievement (National Mathematics Advisory Panel, 2008). Moreover, the recent reports of the international TEDS-M study indicate that rigorous maths instruction in schools and demanding university teacher preparation programs in countries like Taiwan and Singapore accounts for their teachers having better knowledge of mathematics and its teaching. (Tatto et al., 2012).

In this article, we will discuss the need for the preparation of mathematics teachers in India, the institutional arrangements that exist, the context that guides the priorities, efforts that have been made, the challenges that continue to limit gains, and possible ways forward. The discussion will largely focus on the mathematics teachers at the school level. There is recognition of the need for some kind of specialised training and preparation of teachers at the tertiary level of education beyond the regular university education. However, virtually no institutions or models exist to directly address the need for better mathematics education at the tertiary level, beyond the periodic "refresher courses" that undergraduate teachers are required to attend, which largely focus on enriching teachers'

knowledge of the subject rather than on issues of teaching or learning[1] (See Chapter 7, this volume).

In India efforts have been on continuously over the decades to expand access to schooling for a rapidly growing population. As a consequence, the teacher education system has also expanded vastly but unevenly with some states still having inadequate infrastructure to train teachers. Of around 5.3 million "regular" teachers (i.e. excluding "para teachers") at the elementary level, roughly 80% have a teacher training qualification (Mehta, 2011). The pre service training is typically for elementary school for two years, and for secondary school for one year (often amounting only to 6-7 months of instruction). The curriculum and instruction time available do not provide enough opportunity for the student teachers to reflect on their experiences and prepare them to face the ground realities of teaching in a school (National Council of Teacher Education [NCTE], 2009). This adds to the pressure to provide in service education to more than 5.5 million teachers at the elementary level alone at regular intervals while teacher education institutes grapple with "lack of resources, infrastructure, training materials and professional expertise" (Walia, 2004). There is a need to recruit even more teachers as around 30 million children are still estimated to be out of school.

Recent years have seen the launching of a vigorous effort to universalise elementary education through strong legislation. The pressure created by the Right to Education (RTE) Act implemented in 2010, has led to the realisation that in some parts of the country, vastly many more teachers are needed than are employed at present, and the institutional infrastructure for teacher education in these regions needs to be rapidly expanded. This has created a situation where attention is focused on the urgent importance of teacher preparation. At the same time, the sheer magnitude of effort needed increases the pressure for short-term, patch-up measures which may weaken the system of teacher preparation in the long run. There is also a blurring of the distinction between in service and pre service teacher education. In several states, teachers without specialised teacher qualifications already teach in schools, but are now required by the RTE Act to obtain a diploma or degree in education within a specified time period. While this puts additional pressure on the system, it also creates sites where teacher students interact intensively with practicising teachers in an academic setting.

Besides the RTE Act, the other major contextual factor is the new National Curriculum Framework (National Council for Educational Research and Training [NCERT], 2005), abbreviated henceforth as "NCF 2005". The NCF 2005 advocates a shift away from a textbook centred rote learning approach, to one that emphasises the link between school

[1] Building on the success of the decades long MTTS programme (See Venkataraman, Sholapurkar & Sarma, this volume) the Pedagogical Training for Mathematics Teachers (PTMT) programme has been launched in 2012 under the MTTS umbrella. It is aimed at providing a national platform for teachers at the Undergraduate level to improve teaching methods and share pedagogical insights.

learning and life outside school. It stresses that the knowledge that students bring to the classroom from their life outside, and the diversity of ability and ways of thinking within the classroom are resources for teaching and learning and not hindrances. Specifically with regard to mathematics, it gives precedence to the goal of mathematical thinking or mathematisation, rather than "knowing mathematics" as a set of rules and facts. Clarity of thought, pursuing assumptions to logical conclusions, the ability to handle abstractions, problem solving are what are considered central to mathematics and worthwhile aims of mathematics teaching and learning (NCERT, 2006a).

Although ideas such as child-centred learning are not new, NCF 2005 has been effective in changing the discourse on education in a system-wide manner. Teachers are now more open to the idea that their teaching approach needs to undergo fundamental change. However, there is very little clarity about what this change really amounts to in terms of classroom teaching and learning, and schools and teachers look for help as they try to interpret the message of the new curriculum framework. In terms of implementation of NCF 2005, besides a significant change in the textbooks, administrators of major school systems have tried to implement reform measures through directives and circulars. However, it is widely acknowledged that in order to support change in classroom teaching there has to be system-wide preparation involving not only teachers, but also other stakeholders like administrators, principals, education officers as well as parents. This situation creates a potential for change as well as a challenge by way of designing in service teacher professional development that addresses teachers' needs to comprehend the vision of teaching and learning as articulated in the NCF.

Policy perspectives relevant to mathematics Teacher education

Vision of mathematics and its teaching

While the importance of mathematics as a subject for the elementary school has been felt for a long time in Indian education, the issues of why mathematics and of what mathematics to teach have been contentious. The Nai Talim, Gandhiji's influential perspective document on education, emphasised language and mathematics as the basic core of the school program (Sykes, 1988). In independent India, the report of the landmark Education Commission of 1964-66 (also known as the Kothari Commission) emphasised mathematics as essential for national development since education in science and engineering was dependent on mathematics. The commission thus made mathematics compulsory up to Grade 10. It recognised that teaching through lectures was prevalent in most science and mathematics classrooms and recommended emphasis on developing understanding of basic principles rather than "mechanical teaching of mathematical computations" (Government of India [GOI], 1966, Ch. 8, Sec. 8.66). Recognising the

importance of subject knowledge the commission recommended "20%" of teacher training time to be devoted to developing adequate knowledge of subject matter and for relating it to methods and materials of teaching (GOI, 1966, Ch. 4, Sec. 4.14). For secondary teachers this was to be done in collaboration with university departments.

The National policy on Education (GOI, 1986), which was the major landmark document after the Kothari commission, and its subsequent revisions also emphasised mathematics but the focus in these was to develop the capability of using mathematics in daily life and in applications in other areas. The understanding of mathematics teaching for improving its everyday application and the capability to handle mathematical aspects in other subjects of study were the core concerns in National Curriculum Framework for School education (NCERT, 2000), which also emphasised the need to develop capability of doing mathematical calculations.

The NCF 2005 made a break from this and emphasised developing the capability to abstract, use and understand logical forms, grasp ideas and discover, create as well as appreciate patterns. The idea of mathematisation and giving learners the space to discover the way mathematics functions was an important change in the NCF 2005 formulation. It also urged focus on developing concepts and learners' own ways of solving problems and building new algorithms rather than remembering short cuts and efficient ways to calculate.

Recommendations about teacher education in various documents

Recognising the importance of teachers in improving the quality of education, the Kothari commission (1964-66) recommended "securing a sufficient supply of high quality recruits to the teaching profession" by increasing the status of teachers, "providing them with the best possible professional preparation" and "creating satisfactory conditions of work" (GOI, 1966, Ch 3, Sec 3.01). To improve teacher education in the country the commission recommended professionalisation of teacher education and urged that isolation of teacher education institutes from university life, from schools and from one another be removed. It recommended reorganisation of teacher education programmes at all levels, including the reorientation of subject knowledge and improvement in methods of teaching and evaluation. It recognised problems in teacher preparation programmes like set pattern and rigid techniques for practice teaching done for a few isolated lessons, which was unsupervised or ill supervised. Therefore it recommended that student teachers should be oriented in the first phase to teaching and working of schools through observations and teaching individuals and groups before teaching the whole class. In the second phase, student teachers should be involved in "block teaching" (teaching continuously) for a period of 2 to 6 weeks. It recommended increasing the duration of teacher education programmes at primary and secondary levels from 1 to 2 years to allow deep study of fundamental concepts in the subject matter.

The Kothari Commission recognised the need for the continuing professional education of teachers and called for "the organisation of a large scale, systematic and coordinated programme of in service education, so that every teacher would be able to receive at least two or three months of in service education in every five years of service" (GOI, 1966, Ch 4, para 4.56). It recommended that continuing in service education be based on research inputs.

The National Commission on Teachers (GOI, 1983- 85) advocated a 4-year integrated course after 12th grade that combined a university degree in a subject with a teacher qualification, having at least 4 weeks of internship in the fourth year. For sharing human and material resources for in service professional development of teachers, it recommended establishing school complexes, which would include schools within the radius of 5-10 miles having 1-2 higher secondary schools, 6-7 middle schools and 30-35 primary schools. The commission advocated that desirable competencies of the teacher for recruitment should be on the basis of practical research. While acknowledging the woeful inadequacy of in service education, the commission recommended that classroom and practical needs of teachers should be identified by surveys and studies. The programs should be announced well in advance and feedback from schools and teachers should be taken after in service courses. Resource persons for teacher professional development were recommended to be from diverse backgrounds – university professors, people from industry and agriculture and practising teachers and supervisors. The in service course should be in the workshop mode where materials are developed which teachers take with them for use in classrooms. The commission noted that what teachers need most "is a change in the climate of schools, an atmosphere conducive to educational research and enquiry".

The New Education Policy of 1986 recommended a rapid expansion of the infrastructure for education of teachers at the elementary level through the setting up of institutions at the district and block levels, which would deal with both pre service and in service teacher education (GOI, 1986a). NPE 1986 attempted to break the separation between pre and in service teacher education by considering both as phases of a continuous process thus acknowledging the need for career long professional development of teachers. It recommended that mathematics teaching should be focused on analysis and reasoning and enable use of technological devices for analysing cause effect through interplay of variables (GOI, 1986a, para 8.17)

The Acharya Ramamurthy committee in 1990 (GOI, 1990) emphasised the role of actual field experience during internship to foster professional growth of teachers. The Committee explicitly stated that "in service and refresher courses should be related to the specific needs of the teachers. in service education should take due care of the future needs of teacher growth; evaluation and follow up should be part of the scheme" (as cited

in NCERT, 2006c, pp. 4) It recommended adoption of "internship model" by having brief theoretical orientation followed by 3-5 year supervised teaching under mentors.

The Yashpal committee report titled "Learning without burden" (GOI, 1993), which had a major impact on the revision of the school curriculum, recommended restructuring of the course content of teacher education to serve the changing needs of school education and making teacher education more practice oriented. The National curriculum framework 2005, which attempted to implement the recommendations of the "Learning without burden" report in a systemic manner, acknowledged the problems in teacher preparation as teachers are prepared for disseminating information rather than fostering reasoning in mathematics. While the teacher education infrastructure has indeed expanded vastly, issues of poor quality and low relevance of teacher preparation remain. Further, teacher education institutions have tended to focus more on pre service education leading to the neglect of in service education.

The National Focus Group on teacher education (NCERT, 2006c) remarked on the inadequacy of teacher education and how despite various recommendations of commissions they have remain unchanged in terms of their "substance, experience offered and modalities adopted" (p.3). It recommended "recognising the active 'agency' in institutionalising the process of school curriculum renewal" by creating "reflective practitioners" (p.25). The position paper by National focus group on teaching of Mathematics (NCERT, 2006b) recognised the problem of inadequate teacher preparation leading to primary teachers reproducing techniques experienced in their schooling, the pedagogy adopted rarely "resonating with findings of child psychology" and inability to link formal mathematics with experiential learning. On the other hand due to curriculum revision secondary teachers are faced with content in which they are not confident and thus unable to make connection within and across mathematics while relying on notes/guides available in the market. The Focus Group recommends that professional development have a specific focus on mathematics as opposed to 'generic' teacher training. Recommendation is also done for generation of large number of freely available resources and networking among teachers as well as with college teachers and research mathematicians to enhance their pedagogic competence.

A renewed attempt to address the problems of pre service and in service teacher education is made by the new National Curriculum Framework for Teacher Education (abbreviated hence forth as 'NCFTE') (NCTE, 2009). While reiterating and elaborating on earlier recommendations in pre service teacher education, the NCFTE also puts forth several principles that need to govern the design of in service teacher education programs. These include,

- designing programs with clarity about aims and strategies for achieving these aims

- allowing teachers to relate the content of the program to their experiences and also to find opportunities to reflect on their experiences
- need to respect the professional identity and knowledge of a teacher and to work with and from it (NCTE, pp. 66-67)

Most pre and in service programmes view teachers as mere agents of the state, and as implementers of curricular and reform directives. Hence they do not directly address the teacher's own conceptions of teaching, learning and mathematics gained from her own experience. Thus revisions in pre service teacher education curricula and in service modules tend, over the years to acquire "add-ons" while not aiming to address teachers' beliefs and attitudes at a fundamental level.

Pre service teacher education

Nearly all schools in India require students to study mathematics as a compulsory subject upto Class 10. The primary school mathematics teacher in India would typically have completed 12 years of school, while a secondary mathematics teacher may be a graduate or post-graduate of mathematics or science. Although the National commission of Teachers (GOI, 1983-1985) recommended twelve years of initial schooling as basic qualification for entry into elementary teacher education programs, its large scale acceptance was achieved only into the late 1990's (Rajput & Walia, 2001). The most recent figures compiled for all types of schools (private, government and government aided) indicate that roughly 19% of regular primary teachers have completed only 10 years of school (Mehta, 2011). However, nearly 46% of primary teachers (Grades 1 to 5) have a university Bachelor's or Master's degree, while for elementary teachers as a whole (Grades 1 to 8), the figure is nearly 57%.

The preparation to become a certified primary teacher requires a two year Diploma in Education (D.Ed.) programme following 12 years of school, and for a secondary teacher, undergoing a one year Bachelor of Education (B.Ed.) programme following a University degree. However, for the country taken as a whole, roughly 22% of primary teachers have a B.Ed. qualification, which is higher than the requirement of a diploma, while 20% of primary and elementary teachers have no teacher qualification (Mehta, 2011). It is only recently that a sharper distinction has been introduced between elementary and secondary teaching qualification, with the RTE Act stipulating that only D.Ed. and not B.Ed. is a qualification to become a primary teacher. NCFTE (2009) has recognised that elementary education and early childhood education have been neglected as "distinct areas of knowledge with their own distinct concerns, concepts and methodological perspectives (NCTE, 2009, p. 10).

The eligibility for getting admission in a regular course of B.Ed is 50% marks in the

university Bachelor's degree, while it is 55% for doing it through Correspondence. The duration of the regular course is one year while it is 2 to 4 years when done through correspondence. The Master of education programmes are for one year after B.Ed. and serve as preparation for becoming a teacher educator and researcher in the field of education. Bachelor of education and Master of education are conducted in either colleges affiliated to the university or by departments of education of the concerned university.

D.Ed. Programmes typically require entrants to have completed 12 years of school, but only a very small proportion of students take up mathematics as a subject in the senior secondary school (Grades 11 and 12). The two year D.Ed. programme has besides the component of teaching methodology, a subject component including mathematics. Although most student teachers who join the D.Ed. programme have done mathematics upto Class 10, they have no confidence in their own ability to learn mathematics or to solve problems in mathematics on their own. The mathematics component in the D.Ed. Programmes, like in school, emphasises remembering known solutions to problems, and does not encourage a genuine engagement with the content. While recognising this NCFTE (NCTE, 2009) has recommended enhancement of entry qualification and duration of training making it equivalent to degree programme and bringing these isolated institutions under universities for their management. It must be noted that teacher and the teaching profession in India has a low social status and becoming a teacher is the last choice for most entrants into the population.

Among the graduates and post-graduates who complete the B.Ed. programme, the capability of even those who have studied mathematics at the University level is limited, since most University mathematics programmes do not give the learner any confidence in the subject, fostering a view of mathematics as a set of limited problems that have been already solved. The tasks that students learn to complete is not one of formulating and solving problems that cannot be solved by using known principles but of solving problems that can only be solved with a known trick. It is possible that this attitude to mathematics and learning, and their lack of confidence in mathematics leads them, as school or college teachers, to shun dialogue in the classrooms.

Teacher education institutions

Institutions in India that prepare teachers at all levels (pre-primary, primary and secondary) are run by the Government as well as by private bodies, with both types of institutions offering the same degree. Some programmes like the integrated 4 year B.Sc.Ed. (which combines a university degree with a secondary teacher qualification) are run only in a few Government institutions like the Regional Institutes of Education. An innovative 4-year integrated programme in Elementary Education (B.El.Ed.) is offered by the Delhi University through a few of its affiliated colleges. The integrated programmes however have not spread beyond a few institutions (Walia, 2004).

For pre service training, the National council of teacher education (NCTE), a statutory body of the central government, is responsible for planned and coordinated development of teacher education in the country. The NCTE lays down norms and standards for various teacher education courses, minimum qualifications for teacher educators, course content and duration and minimum qualification for entry of student teachers for various courses. It also grants recognition to institutions (government, government-aided and private) interested in undertaking such courses and has in built mechanisms to regulate and monitor their standards and quality. Financial support is provided by both state government as well as central government to different institutions.

In service training is provided by a large network of government owned teacher training institutions at various levels of hierarchy. The National Council of Educational Research and Training (NCERT) along with its six Regional Institutes of Education undertake design and implementation of in service programmes for both teachers and teacher educators. Along with advising and assisting the government of India in academic matters related to school education, the NCERT serves the function of supporting educational research and training in educational research methodology, developing school curricula, textbooks and other learning material, materials for teacher education, training of teachers, teacher educators and officers, publication and dissemination of research through journals, and programmes with different countries for exchange of educational materials and faculty members.

At the state level, the state councils of educational research and training (SCERT) prepare modules for and conduct teacher training for teachers and teacher educators. The colleges of teacher education and Institutes for advanced learning in Education (IASE) provide pre service (B.Ed) and in service training to secondary teachers and teacher educators, develop materials for teachers and conduct surveys and Research. The District Institutes of Education and Training (DIETs) provide in service and pre service education for elementary teachers.

Stage	Government	intake	private	intake
Pre-primary	16	746	219	14102
Elementary	757	49089	4831	298278
B. Ed.	224	20031	5731	609496
B.Ed. open university	24	13800	2700	16500
B. El. Ed.	-	-	13	545

Table 1: Teacher education institutions and their intake by category (Source: Rajan, 2012)

Teacher education curriculum and its revision

In the post independence era from the 1950's to the 1970's, pre service teacher education mainly emphasised theoretical aspects like discussing aims of mathematics education, inductive and deductive method, analytic and synthetic method, focus on Herbartian steps of preparation, and presentation and application for planning lessons (Chel, 2011). The mathematics method paper had a weightage of 10% of the total marks. The student teachers were expected to make charts and other teaching aids but there was no emphasis on relating mathematics to out of school experience or to other subjects.

The comprehensive curriculum framework for teacher education was released in 1978 which adopted a task oriented approach to teacher education viewing teaching as a series of concrete and hierarchically graded tasks. It had practical aspects of teaching as its focus as it suggested that student teachers should be put through a series of simulating, micro teaching situations before being pushed into actual classrooms. The weightage of the mathematical component was raised to 22.5%. The assessment of content was made by asking student teachers to solve problems from different content areas of school mathematics upto class 12. In the earlier syllabus there was no separate evaluation of mathematics content. However in 1990's there was criticism of this move as teachers and teacher educators felt that testing of content separately without integration with methods is redundant since teachers have already been tested for it in their undergraduate degree programme (Chel, 2011).

Following a major revision of the school curriculum, the "National Curriculum for Elementary and Secondary Education" (NCERT,1988) recommended integration of theoretical understanding with practical application and recommended more weightage to practical application, leading to a revision of the teacher education curriculum. A major watershed development in teacher education was the establishment of National council for Teacher Education (NCTE) as a statutory body in 1993. The NCTE brought out a "Curriculum Framework for Quality Teacher Education" in 1998, which was the first to provide stage specific guidelines for teacher education. It defined several areas of commitment, competence and performance to serve as guiding principles for teacher education programmes (NCTE, 1998). The competencies for teachers were established with a view to supporting the achievement of the Minimum levels of Learning for students in classrooms as laid down in a document on the "Minimum levels of learning" (GOI, 1990). It expected teachers to express learning outcomes in the form of constituent competencies and behaviours that indicated mastery learning. It was assumed that minimum levels of learning are to be achieved uniformly across students. There was focus on developing diagnostic tests and therefore construction of "Achievement test" was assigned additional weightage in the B.Ed. course. The questions in the achievement test were categorised as knowledge, skills, understanding and application. Remedial

teaching was recommended after diagnosis of mistakes through the test, but it was not clarified as to how remediation is to be done in order to help students learn.

In the 1998 teacher education curriculum, integration of content with methodology was introduced in the form of "pedagogical analysis of concepts" having weightage both in theory and practical papers. The purpose of pedagogical analysis was to make a student teacher "conversant with the objectives of teaching a unit, the entry behaviour of the pupils, the classroom management and evaluation strategies" and thus make him/her more "effective and confident in his/her interventions in the classroom" (NCTE, 1998). The total weightage of mathematics in the B.Ed. Curriculum was raised to 28.5% of the total marks.

The National Curriculum Framework for Teacher Education (NCTE, 2009) is the most recent attempt at a thorough overhaul of the teacher education curriculum. It contains many new proposals, but is yet to be implemented across universities in the country. It advocates teacher education to be open and flexible, emphasising dialogical exploration rather than didactic communication, diversity of social contexts and learning spaces as sources of inspiration, and teacher education based on reflective practice rather than on a fixed knowledge base (NCTE, 2009). Major revisions in curricular areas are recommended and attempts have been made to draw upon theoretical and empirical knowledge as well as student teachers' experiential knowledge. The attempt is to focus on the learner, develop teachers' understanding of self as well as the social context, critically examine disciplinary knowledge and develop professional skills and pedagogic approaches to address needs of learners. Each curricular area has a theory and related "field based units of study" (practicum) in which the student teacher is expected to undertake projects, field work, clinical interviews, observation and analysis and interpretation of qualitative data to generate knowledge and continually seek clarity of ideas. The teaching of the subject is now conceived as "pedagogic studies" under which linkages among learner, context, subject discipline and the pedagogical approach has to be established. The shift in view of what is considered as knowledge is evident through inclusion of a course like "knowledge as construction through experiences" as compared to the earlier focus on disciplinary content in textbooks as knowledge. Another important aspect is the emphasis on research related to student learning in different areas, studies on addressing learners' misconceptions and engagement with epistemological questions. These indicate an important shift in recognising centrality of the student and her learning in teacher education. The practicum course work includes "hands- on experience at developing curriculum and learning materials, designing appropriate activities.. and formulating questions to facilitate learning" (NCTE, 2009, p. 38).

The duration the internship has been increased to minimum of 6-10 weeks for the two year programme and 15-20 weeks for the 4 year programme to allow sustained engagement

with learners. The school internship is expected to provide opportunities for reflection on one's own beliefs and practices while trying out unconventional pedagogies.

A look at some B. Ed. syllabi across country

A look at various B.Ed. syllabi in Universities across the country (Pune, Gujarat, Rohtak, Mumbai, Indraprastha-Delhi, Tamil Nadu) indicates that there are differences in terms of emphasis on content. The B.Ed. syllabus typically consists of theory courses dealing with philosophical and sociological aspects of education, with psychology in relation to education, school administration and management. In some syllabi courses on educational technology or educational innovation are included. The student is typically expected to choose one elective course from among courses such as environmental education, guidance and counselling and mental health. The student has to choose two subject specific method courses. All these courses include a theory portion for which most universities allot 50% marks and some having as much as 70 % marks (Gujarat, Rohtak). The theoretical component of the mathematics methods course would comprise from 5% to 14% of the total marks alloted for B.Ed. Within the mathematics method course the content of mathematics is discussed only in the context of analyzing textbooks of various grades. The practical component of B. Ed course dealing with mathematics comprises of around 30 to 48% of the the total marks alloted. The major portion of practical marks are allotted to practice teaching including micro and macro lesson teaching. Other component of practical includes lesson plans, practical records and construction of achievement test for students. Thus the total mathematical component of the B. Ed courses ranged from 31 to 55% of the total marks. Besides practical work related to subject, other practical work like school based and community based activities which include case studies of students, psychological experiments, etc., are included in almost all universities.

The mathematics method course has broadly three foci. The first comprises the nature of mathematics, its aims, its connections to other subjects and contributions of great mathematicians. The second focus is on specific methods and maxims of teaching like "inductive–deductive method", which in a few universities include "models of teaching" like advanced organiser model, concept attainment model, etc. Out of school activities for mathematics as well as development of math clubs, math laboratory design have also been included in some syllabi. The third focus is on content enrichment for which some universities prescribe study from school textbooks, while others expect students to formulate specific methodologies for teaching a particular topic and in some rare cases ask student teachers critically analyse school textbooks. To assess content some universities (for e.g., Mumbai university) have a "content enrichment" component where in students are expected to do self study of the subject they have chosen for the special methods course. Tests are conducted internally by colleges based on the syllabus of state board for Grades 9 to 12. This reflects a concern for building proficiency in mathematics at that

level. But focus on school textbooks for developing understanding of content might make it difficult for student teachers to go beyond textbooks while teaching. As a teacher one needs to have proficiency of developing problems to enable student learning which does not have its place in the teacher education curriculum. Also the kind of mathematics that is needed for teaching of mathematics is different from what is typically learnt in school as identified by several researchers (for example, Ball, Thames and Phelps, 2011).

Pedagogical content analysis, which includes identification of concepts, listing behavioural outcomes, listing activities and experiences and listing evaluation techniques, is included in 3 of the 6 syllabi. However it is not clear how it leads to construction of knowledge that is useful in classroom teaching since there is no indication of students teaching a topic after doing pedagogical content analysis and getting some insight about student learning.

What has not changed over the years (since perhaps the 1950's) in the B.Ed. syllabus is discussion of aims and objectives of mathematics education, maxims of teaching, methods of teaching like "inductive, deductive, analysis, synthesis" methods, techniques of teaching like "oral work, drill work, brain storming, self study" and preparation of teaching aids like charts, models and lately "power point presentations". Most of these topics adopt a view of teaching without considering students thinking thereby preparing teachers for transmitting information in different ways (NCERT, 2006b). Clearly the teaching of methods is unlikely to effect a change in the way mathematics is taught in classrooms and developing students' understanding and reasoning in mathematics as envisioned in NCF 2005, even though though there is a substantial component of practice teaching.

Most B.Ed. syllabi devote about 20 hrs for Micro teaching, 10 hours for integrated lesson, 15 hours for preparing 2 simulated lessons and around 150 hours for preparing 10 practice lessons for each of the 2 semesters in the B. Ed course).

What is lacking in the syllabi is a perspective of teaching that makes the child the centre, and views her conceptions and sense making process as an important part of the teaching and thus the teacher preparation process. In contrast, teaching is fragmented into its components which are dealt separately with a hope that this will impact teaching in classrooms. Its not clear if the B.Ed. programme allows opportunity for students to think critically about their own mathematics learning, teaching practices prevalent in schools, curriculum and textbooks.

The NCFTE 2009 in its radical departure from earlier teacher education curricula has recognised the importance of developing an understanding of the learner, and classroom based teaching and research work as important tools to such understanding. The proposed syllabus for B.Ed. based on NCFTE 2009 has incorporated many interesting features. The pedagogy for teacher education has been proposed to include "focused reading and reflection, observation-documentation-analysis, seminars, case studies and school based

practicals and workshops" besides lecture-demonstration. The assessment of student teachers has been recommended to include reflective journals, products like lesson plans and observation of student teachers in various contexts of teacher education. The school based experience has been aimed at preparing teachers for "understanding and developing meaningful learning sequences appropriate to the specificity of different levels of learning and also mobilize appropriate learning resources for them". Pedagogical analysis of content now includes content analysis, identification of various content categories and skills, task analysis with reference to learning objectives, student capabilities and learning approaches, learning resources, possible assessment modes, visualising learning situations, organising learning sequences and contextualising learning. The integration between theoretical and practical aspects of teaching has been proposed through designing learning situations which allow teachers to scaffold learning, clarify fallacies and misconceptions, and reconstruct meaning that teacher has to facilitate in classroom. Comparative textbook analysis has also been proposed.

Practice teaching in the teacher education curriculum

Over the years people have realised that pre service teacher education is too theoretically oriented and efforts have been made in several teacher education curricula to make it more practically oriented by increasing the weightage assigned to practical aspects of teaching (NCTE 1998; NCFTE, 2009). In the 1998 curriculum practice teaching was advocated for about 40 lessons, i.e., 20 lessons each for the two subjects chosen for specialisation in B. Ed program. However NCFTE 2009 listed the following as major drawbacks of the current model of practice teaching.

- Treatment of school curriculum and textbooks as 'given'
- Fastidious planning of lessons in standardized formats with a view to fulfil ritual of delivering required number of lessons
- Repeated practice of isolated lessons being considered as sufficient for professional development
- No opportunity for student teachers to "examine their own biases and beliefs and reflect on their own experiences as part of classroom discourse and enquiry"
- Theory courses having no clear connections established to practical work and ground realities
- The evaluation protocol is too theoretical and excessively quantitative.

In light of the above problems in pre service education NCFTE 2009 has recommended "School internship" through 'partnership model' where trainees develop new materials that function as resource for regular teachers. The duration is to be a continuous period

of 4 days a week for 12-20 weeks after observing classroom for one week. Sustained engagement with schools is visualised through teachers participating in all school activities, conducting classroom research and developing learning resources. Recognising the importance of practice teaching the framework views it as both an "evaluation tool for effective teacher education as well as its critical quality indicator" (NCTE, 2009, p. 41).

Innovations in pre service teacher education

The four year integrated course of Bachelor of Elementary Education (B.El.Ed.) is an innovative programme introduced over a decade ago in the Delhi University. It is aimed at preparing teachers for the elementary level of school in contrast to B.Ed. Programmes, which typically focus on the middle and secondary school level. However, it includes more relevant and useful courses for preparing teachers for teaching mathematics as compared to the B.Ed. curriculum. The course outline on "Core Mathematics" in the B.El.Ed. curriculum indicates that "various concepts and operations will be reconstructed through activities and problems, using concrete materials as often from the kitchen as from mathematical kits, to arrive at solutions or conduct investigations. This would be followed by reflective discussions on the concepts, solutions, results and the methods used" (Maulana Azad Centre for Elementary and Social Education [MACESE], 2001). The course includes study of concepts like number and measurement, space and shape, algebra and number patterns.

Another course in "Logico-mathematics education" includes the following: understanding the nature of children's logico-mathematics thinking through exposure to theories by Piaget, Vygotsky and Dienes; language and mathematics; critical study of pedagogical constructs like zone of proximal development, drill, memorization and algorithmization; research on children's learning in specific areas and content specific pedagogy for numbers, fractions using ready made kits. The course on "pedagogy of mathematics" deals with "helping children develop a mathematical view of the world; initiating student's investigations and independent activity and problem solving strategies" (MACESE, 2001).

Here we see a more wholistic view of teaching as compared to the B.Ed. syllabi discussed earlier where different aspects of teaching were dealt with separately and then student teachers were expected to incorporate them in their classroom teaching. The 'aggregation' view of teaching in the B.Ed. syllabi assumes that any method, teaching aid can be useful in teaching any concept. There is no scope of exploring how a particular teaching aid helps in concept formation. Understanding this might contribute more towards building knowledge for teaching of mathematics rather than knowing how to make different teaching aids without consideration of content in the teaching learning process. Unlike some B.Ed. syllabi which include "drill work" in techniques of teaching, the B.El.Ed. syllabus is progressive in giving an opportunity to engage student teachers in critical

study of practices like drill but also concepts that have propensity for being used as buzz words like "zone of proximal development". Further, the course attempts to connect teacher education with research in education making efforts to bridge the gap between research and practice. As compared to the B.Ed. syllabus this course keeps the child at the centre of the teaching-learning process and assumes a view of teaching which encourages construction of knowledge through investigations and using students' ideas and strategies in teaching.

Realising the need for focus on content knowledge in teacher education

The typical educational experiences of a teacher in school or university do not prepare her or him to engage with mathematics, to struggle to find a solution to a problem, to examine a concept from different points of view, to make connections, to reason and provide justifications, all of which are stressed by the new curriculum framework (NCERT, 2006b). In a typical B.Ed. programme, the focus is almost entirely on pedagogical technique, and content is assumed to have been mastered earlier. The fact that such education leads to a grossly inadequate preparation of the mathematics teacher with regard to her understanding of mathematics is well recognized (Ravindra, 2011).

The Teacher Eligibility Test (TET), now made an essential qualification by the Right to Education act to secure a teaching job in any school, acknowledges the importance of content knowledge. There are different tests for primary and middle school level aspiring teachers having 150 multiple choice questions. Out of the 150 questions in the primary level test, 30 questions are devoted to Mathematics, of which 15 questions are based on the content in the school textbooks and the remaining 15 on pedagogical issues like error analysis and related aspects of teaching and learning, and "understanding children's reasoning and thinking patterns and strategies for making meaning and learning". For the elementary level mathematics teachers (Grades 6 to 8), again 30 questions are devoted to mathematics, of which 20 are devoted to content and 10 to pedagogical issues. (A similar pattern is followed for science.) Teachers need to get 60% correct answers to pass the test. The recent results show an extremely low pass percentage of 5.5% for primary teachers and 6.5% for middle school teachers. The Human resource development minister ascribed it to the mushrooming of private teacher education institutions (12689 private institutions as compared to 1178 government teacher training institutes), whose quality of teacher preparation may be poor. (Teacher tests results...Kapil Sibal, 2012).

These results are consistent with the findings of other studies such as Banerji & Kingdon (2010), Ravindra (2007), Dewan (2009), which have revealed the unsatisfactory status of knowledge of mathematics of regular school teachers. This state is a reflection of teachers' own education which valued only rote memorization of procedures on the one hand and lacked opportunities to re-learn mathematics in a meaningful way during professional education and during the course of their career on the other hand.

With the change in school curriculum following the National Curriculum Framework 2005, the demand for better understanding of the content and alternative pedagogy has increased. Teachers in elementary and middle grades not only have to make their students fluent in computational mathematics but also address *process* goals in the learning of mathematics, such as reasoning, using multiple ways to solve problems, justifying their solution, making generalizations and conjectures, analyzing the mathematical work of others, etc. (NCERT, 2006b). However there have been few teacher education programs in India, which have focused on the skills and knowledge required to facilitate this kind of teaching. Research studies of teachers' knowledge in other countries have identified pedagogical content knowledge (PCK) as a specialized form of knowledge required for teaching of mathematics and subject matter knowledge (SMK) as a coherent, connected and deep understanding of mathematics (Shulman, 1986; Ma, 1999). Although PCK and SMK are widely acknowledged now as essential components of teachers' knowledge, the preparation of content, and pedagogy revolving around content, is rarely the central focus of any phase of teacher education in India. Teacher education needs to provide opportunities for deepening teachers' knowledge of mathematics and of pedagogy revolving around mathematical practices.

While the teacher education policy documents and the curricula of some innovative programmes acknowledge the importance of content knowledge, actual policy measures suggest the opposite. With the passing of the Right to Education Act, and the consequent pressure to universalize elementary education, most states are faced with a shortage of teachers. This situation has led to multiple cadres of teachers and the appointment of *para-teachers* without the requisite teacher qualification (Govinda and Josephine, 2004). This policy measure reiterates the assumption that a primary teacher does not need to know mathematics beyond the level that he/she is going to teach. Thus there are very low expectations by policy makers regarding the level of content knowledge required of a primary teacher.

In service professional development of mathematics teachers

As emphasised in the policy documents, the central and state governments in India have made efforts to include in service Teacher Professional Development (TPD) as an integral part of the school education system. According to a recent report (Mehta, 2011), 35% of all elementary school teachers in India received in service training in the year 2007-08. However, in service programmes do not follow a well thought out structure and there is no regulatory mechanism that ensures the relevance, quality and suitability of the training provided. In India, workshops are an important component of TPD programs on which maximum time, effort and resources of the state are spent. TPD workshops are often organized in an ad hoc manner on the basis of expediency, sometimes driven by the need

to utilize funds (MHRD, 2009, p. 2. Also pp. 15-16). There is no clear consensus about what needs to be done in these workshops and how it is to be done. The vision underlying most of these programs restrict teachers' agency to implementing a new textbook, a pre-designed pedagogy or a prescribed assessment technique. TPD programs however need to have a broader vision of what the needs of a teacher as a developing professional are, and must address issues of knowledge, beliefs, attitudes and practices in a comprehensive manner, rather than in the narrow context of a particular reform.

NCFTE 2009 has now identified several principles related to content and pedagogic approach in in- service programs. It is recommended that spaces are provided to teachers for sharing their experiences in terms of content and pedagogy while providing autonomy in planning and teaching practices thus recognising professional identity of the teacher and building on it. The design of the program should thus be based on clear aims and vision of how they will be achieved while incorporating post programme support or extensive interactions over time with the same resource group for continuing professional development. Further, use of distance media, sabbatical for study and research, attending meeting and conference and development of professional foras, resource room and materials have been recommended.

In service TPD Initiatives

In Service teacher education at the level of the district is organized and provided largely by the District Institute of Education and Training (DIETs), with an overall co-ordination at the state level by the State Council of Educational Research and Training (SCERTs). Other institutes established by government like Institute of Advanced Study in Sducation (IASE), university department of educations are also involved in the effort. At the national level, the NCERT is involved in development programmes and resource material for TPD. For in service professional development of people working in colleges and universities several "Academic staff colleges" have been established (66) in several universtities which provide orientation as well as subject oriented refresher programmes.

There have been major initiatives in the in service training of teachers over the last few decades, in roughly two phases. The first phase began with two programmes initiated in the 1980s at the national level called Programme of mass orientation of School teachers (PMOST) and Special orientation of primary teachers (SOPT). The emphasis in these programmes was on methodology and how to teach in the classrooms, rather than on the content of mathematics. The SOPT also saw beginning of idea of Minimum Levels of Learning (MLL) in education, which was further reinforced by the report on MLL published by the Ministry of Human Resource Development in 1991 (GOI, 1986b). The document viewed learning as occurring in separate small chunks, each of which could be mastered separately by repeated practice. In the SOPT and subsequent MLL based programmes, teacher training was seen merely as a forum where teachers would be given

activities and materials that they could use in the classroom.

In a typical SOPT programme of 7 days, 3 sessions would be on mathematics. The training modules included detailed descriptions of what kind of activities could be done with children. The modules assumed that children have similar views and follow similar ways of learning and therefore suggested how an activity could proceed with a group of children. The emphasis was on activity and use of materials. The key words were hard spots, MLLs, competencies, assessment, diagnostic testing and remedy as well as activities, modules and demonstrations.

These efforts were followed in the second phase by the capacity building programmes under the District Primary Education Programme (DPEP) and similar projects supported by many multi-lateral partnerships. In service training in these programmes centered around "joyful learning" and presentation of activities to teachers. The orientations were marked by an attempt to introduce games and other interesting devices into classrooms without necessarily looking at the nature of the concepts to be transacted or the nature of mathematics. The activities that were developed involved a lot of movement, play, singing and use of materials but there was little thought about how this could be related to conceptual development in mathematics. The time spent in mathematical thinking on these tasks was much smaller than the total time required for the activity and most of the effort was spent on ensuring that children had fun. The pattern of training in the DPEP continues to influence newer initiatives such as the Sarva Shiksha Abhiyaan (Education for all mission) and the Rashtriya Madhyamik Shiksha Abhiyaan (National secondary school mission). Thus a continuing influence of these programmes has been the emphasis on technique or activity and a reduced emphasis on mathematical understanding or thinking.

Some in service initiatives have introduced important elements that have a significance for teacher professional development. The Shiksha Karmi (Education worker) initiative of the 1990s in the state of Rajasthan emphasised the autonomy of the teacher in its in service programmes, and developed a critique of the top-down "transmissionist" model of in service training (Sharma & Ramachandran, 2010). The main features of the programme involved selecting local youths to act as teachers in dysfunctional schools while they get continuous and intensive training through out the year and are supported by village education commitees. The "Shikshak Samaksha" (Teachers' empowerment) project in Madhya pradesh involved teachers meeting once a month in the resource centres to discuss their problems, experiences and suggestions to make their teaching interesting. The teachers were provided regular academic support (Mohanty, 1994). Andhra Pradesh Primary Education project (APPEP) included the use of demonstration lessons given to group of children to illustrate new pedagogic techniques and making the classroom interesting by displaying and organising children's work. Teachers planned

and generated activities for teaching at the teacher centres established at sub-district level in 23 districts (Mohanty, 1994). So the major departure in these innovations is providing regular academic support and discussion of teachers' experiences in the classroom. The influence of these and similar initiatives have led the new National Curriculum Framework for Teacher Education to stress the need to respect the professional identity and knowledge of a teacher and to work with and from it (NCFTE, 2009, pp. 66-67).

The Project in Science and Mathematics (PRISM) initiated in year 2000 involved collaboration of Homi Bhabha Centre for science Education with the Bombay Municipal Corporation. The objective was to strengthen teachers' understanding of fundamental principles, creating an environment in the classroom for students to ask questions and helping teachers and students to go beyond the textbook. HBCSE members worked directly with 50 resource teachers for a year to develop their capacities to train the larger group of teachers working in about 250 schools. There was focus on developing conceptual understanding through discussing usefulness of teaching aids (for e.g., bundles of matchsticks of 10 or 100 for place value concepts and operations). Activities were done with teachers to challenge the belief that all mathematics problems have only one correct answer by asking teachers to formulate open-ended questions. The approach adopted for the resource teachers included planning of lessons followed by one teacher teaching students while other colleagues observed the lesson, in a manner similar to Japanese "lesson study". The lesson would be followed by intensive discussion focused on the teaching as well as student responses and thinking, followed by planning for subsequent lessons."Model lessons" by HBCSE team members, problem solving, observing simulated teaching and teaching in schools of participant teachers was part of the program (Burte, 2005).

The "Prashika" experiment in primary education was an innovative programme launched by Eklavya, a leading voluntary organization working in the area of elementary education for many decades. This programme included a teacher education component, for which the description "orientation programme" was used instead of "teacher training". The word "orientation" reflected the Prashika standpoint that teacher education cannot be completed in a 20 day contact period programme, which serves only as an initiation into engaging with teaching, trying out things and "learning from experiences" (Agnihotri, Khanna & Shukla, 1994, p.127). Thus the teacher development was conceived as "gradual, ongoing, interactive and collaborative process of change" (Agnihotri et al., 1994, p.122). The major objectives of the programme were to

- Create an awareness of the learning process and bring about attitudinal changes.
- Cultivate skill and confidence
- Help teachers acquire knowledge

- Develop those operational skills that are needed to put curriculum in practice
- Help teachers in a sense to become their own informal researchers (Agnihotri et al., p. 126).

The Prashika approach focused on building teachers' understanding of the child, curricular understanding for creating appropriate activities and enhancing creativity of the teacher by overcoming inhibitions and enagaging in activities like drawing, singing and role play. The expectation was that the teacher will function as a "partial source of information and knowledge" while being able to "plan a multiplicity of activities, observe carefully their implementation and analyse the feedback to modify and change the activities" (Agnihotri et al., 1994, p. 120). The pedagogy adopted during teacher orientation emphasized establishing equality among resource persons and teachers by realizing that much can be learnt from teachers, flexible plans for the programme which could be modified based on the needs of the group and getting feedback from teachers, resource persons and observers for revising materials for classrooms and deciding teacher orientation agenda.

Recognising the limitations of teachers' knowledge of mathematics, Prashika placed emphasis on enhancing conceptual knowledge of teachers. "A large number of them know rules and formulas, but they are often incapable of handling questions like why and how a particular algorithm works" (Agnihotri et al., 1994, p. 135). One of the principles behind teacher orientation activities was to let teachers enjoy mathematics to ensure that at least some of it is taken up in the classroom. The vision of teaching mathematics involved using concrete materials at early stages and then moving to abstract concepts, opportunities for children to articulate their understanding, opportunities to make hypothesis and make their own problems, allowing expression and exploration of alternative procedures and attempt to understand *why* children make mistakes. Over the course of the engagement, teachers made important realisations like "reciting numbers upto 100 is not counting", students appear to understand and solve sums correctly in classroom when the topic is being done but not later and problems in developing functional understanding of concepts like place value even when student are able to understand their abstract nature (Agnihotri et al., ibid, p. 131).

Another well known voluntary educational organisation working with teachers, Digantar, offers a "Certificate course in foundations of education". The mathematics component of the course emphasises that teachers must be involved in "*doing* mathematics" to understand the nature of mathematics through emerging patterns and rules. In the contact sessions, teachers engage in problem solving followed by discussion on how general rules can be derived by comparing the approaches used by participants. Teachers are also involved in discussing theoretical aspects of mathematics teaching through discussing readings and papers (for e.g., absolutist and conceptual change view of mathematics

discussed in the writings of Paul Ernest). Teachers are also encouraged to speak about areas of mathematics where their understanding is weak. Other colleagues are urged to help their peers in overcoming these weaknesses. Group work and presentations by groups is central to the pedagogy adopted for teacher orientation (Digantar, 2008).

Recent initiatives by NCERT have focused on developing a range of resources useful for teacher training including the development of an "in service teacher professional development programme" having 5 day workshops every year for in service teachers and heads of schools. The Training package of the programme for mathematics includes mathematics kits, source book for assessment and ICT Kits (Pattanayak, 2009). NCERT has been promoting Mathematics laboratories for a number of years. The need for maths lab has been mentioned in the school curriculum frameworks (NCERT, 2000; NCERT, 2005). As a result, the Central Board of Secondary Education has introduced Maths lab as a part of the curriculum for secondary school. Maths Lab Manuals containing suggestions for various activities for different concepts and instructions on how to do them have been developed by NCERT. Some educationists have cautioned against the excessive promotion of the idea of a maths lab since it may foster an incorrect epistemology of mathematics (accepting verification in a few cases as a substitute for proof), and may encourage drawing a sharp distinction between classroom teaching and "activities" done in the lab (Dhankar, n.d.).

The Department of Education in Science and mathematics in the NCERT organises orientation programmes for teachers and master trainers (who teach teachers) to strengthen the teaching of Science and mathematics e.g. orientation on "activity based teaching" in mathematics. The draft of a textbook on pedagogy of mathematics has been prepared recently for use in teacher preparation in line with NCF 2005 recommendations for moving from content to process and "transformation of procedural level understanding to conceptual level understanding" (NCERT, 2011). It includes experimentation and activity with low cost materials and teaching of mathematics through games, puzzles and visuals along with curriculum construction in mathematics at various stages with examples. Enrichment material has been prepared in collaboration with practicing teachers at the higher secondary stage on themes like conceptual understanding, applications and misconceptions. A teacher training manual for class 1 and 2 teachers has also been developed by "Group arithmetic" cell established in NCERT for strengthening early mathematics development programmes (NCERT, ibid).

For the promotion of mathematics several programmes have been started at state levels like Metric Melas, Math festivals, Math forum, Math clubs and even Maths Marathon. At "Ganit Melas" (Math Fairs) alternative teaching learning materials, activities and methods of assessment are presented to participants, i.e., teachers and students. The development of self learning and interactive learning material by teachers have also been undertaken

by various states. (Pattanayak, 2009)

Teacher education through distance education

Looking at the high demand for trained teachers and the inadequate infrastructure to train teachers, distance education plays an important role in providing avenues for pre service teacher education as well as in service professional development. Many practicing teachers achieve certification after going through distance education programmes.

The Indira Gandhi National Open University, the leading open university in the country, has developed materials specific to mathematics for a certificate program on "Teaching of primary school mathematics". The course is a broad based course meant to encourage learning of mathematics and the appreciation that it is not merely abstract and unrelated to our experience. The course is taken by teachers, parents, Bachelor degree program students, and persons working in mathematics education in various capacities.

The course aims at making the learner of the course appreciate the difference between understanding and doing mathematics on the one hand and merely using algorithms on the other. It includes discussion on the. It engages with the understanding about the nature of mathematics and the purpose of learning it common among the general public. Key ideas about how children learn and applying these ideas to build engaging classrooms, materials and assessment systems is an important part of the discussion. The certificate course comprises of two parts, a basic and an advanced course.

The print material for the course has been developed by a team of authors from a range of institutions who have contributed to innovations in mathematics education (Indira Gandhi national Open university [IGNOU], 1996). The course material focuses on concepts considered difficult while giving detailed illustrations of various teaching strategies in the areas of numbers, fractions and measurement. It is unique in dealing with topics like statistics and probability. Other interesting topics include development of spatial abilities of children, multiplication and division by a fraction, importance of estimation in fractions, understanding of simple algorithms, mathematical logic and language of mathematics and engaging in constructing proofs and ways of doing it with children. The teacher is encouraged to make the "model of learning" in her mind explicit and engage in inquiry about how children learn and how classroom processes influence learning. The student teacher is urged to actually try the activities given as illustrations with children, develop a sensitivity towards how students learn, try out variety of interactive learner oreinted methods of communicating mathematics, critically evaluate one's method of teaching mathematics and alter it to suit the situation of the learner and thus develop arguments to support one's experience and understanding.

Informal feedback from the course participants suggests that they enjoy studying it and being confronted with a host of new ideas (Parvin Sinclair, personal communication,).

The many innovative elements in the course make its success critically dependent on the availability of good counsellors at the study centres. Many counsellors and evaluators for the courses also find much to learn from the programme. However, the efforts put by learners on the activities and project work do not generally meet expectations, especially where counsellors are few or are unavailable. The overall percentage of students passing the exams is about 25%. While most students pass the assignments, very few pass the project component, which usually takes longer and multiple attempts.

Research in Teacher education

The Kothari commission mentioned the lack of adequate research on "problems under Indian conditions" (GOI, 1966) and absence of high quality original books on pedagogy and educational science in modern Indian languages as two major weaknesses that constrained the professionalisation of education as a discipline.The quality of research in teacher education leaves much to be desired. The research undertaken is largely questionnaire or survey based within a quantitative paradigm. The experimental research undertaken is usually of the form where comparison of conventional teaching with innovative method is done and the innovative method is found to be significant in improving the achievement of students. The use of case studies and ethnographic studies are rare. Most research studies do not take care to operationalise terms used and interpretations of terms vary from study to study. The tools used in research are mostly adapted from research done in other countries and the background or rationale for tool use is not made explicit. There is also not much infrastructure support for carrying research in teacher education institutes. Walia (1999) found that out of 150 elementary teacher educators in her study sample, only 11 undertook research studies. Out of 77 secondary teacher educators only 22 % undertook sponsored research.

NCFTE 2009 observed that there is very little research on effectiveness of training programmes and research does not provide thorough understanding about the interventions reported. The research reported has been anecdotal and impressionistic and there has been reporting of even contradictory findings depending on who is doing the research.

The need for Professional development of teacher educators

As emphasised by NCFTE 2009, it is imperative to develop programs for professional development of teacher educators. In most teacher education colleges, the majority of teacher educators are not graduates in mathematics thus have limited content knowledge. Additionally, most teacher educators are recruited from among teachers of secondary schools and thus don't have experience in teaching of mathematics at the primary level (GOI, 1966) even though they may be educating primary teachers, as for example in the DIETs. NCFTE 2009 notes that the lack of professional preparation of teacher educators

is the weakest aspect of teacher education in the country.

At present the qualification requirement for teacher educators for the elementary stage is B.Ed. and for the secondary stage is M.Ed. although PhD and M.Phil. carry a weightage. The M.Ed. program is taught as an extension to B.Ed with little preparation for taking on the role of teacher educator. There is no "practicum" requirement for M.Ed., that is, M.Ed. students are not required to teach teachers. However, teacher educators need to have knowledge about supporting learning of children as well as of adult teachers. Secondly, there is need for teacher educators at the elementary stage to be proficient in areas of science, social science, mathematics and languages along with understanding of young child. The B.Ed course may not address this need as it is focused on preparing teachers for the secondary level. The Kothari commission had felt the need to raise the required qualification for teacher educators for secondary teachers. It recommended a double masters degree along with study of teacher education as a special subject and recommended that a fair proportion (10%) of teacher educators should hold a PhD degree. NCFTE 2009 recommends that M.Ed. be developed as a program for preparation of teacher educators where stage specific specialisation can be done like early childhood, elementary or secondary teacher education. Further specialisation in fields like mathematics education can be offered in M.Ed.

The pedagogy adopted by teacher educators in most teacher education institutions is mostly lecture method (Walia, 2004; NCTE, 2009; Ravindra, 2007). After NCF 2005 there has been shift in thinking about pedagogies adopted in teacher education with NCFTE 2009 recommending teacher educators engaging teachers with learners in real contexts while reflecting on the larger socio- political context in which the learner as well as teacher herself is situated. This can be done by bringing experiences of teachers centre stage and allowing for reflection on, for e.g., their own position in society in terms of gender, caste, etc.

Teacher educators hardly get opportunities for their own professional development. With significant shifts in thinking about teaching and learning as espoused in NCF 2005, there is now urgent need to engage teacher educators in discussions around this new vision of teaching. There are also no institutes designated for professional development or preparation of teacher educators in India. In order to reform the teacher education system in India it is important to first undertake professional development of teacher educators themselves. For teacher educators there are demands to understand both how children learn and how teachers learn to be able to support development of reflective practitioners.

A new M.A. programme in elementary education was launched in 2006 at the Tata Institute of Social Sciences in Mumbai, in collaboration with four other leading institutions that have made innovative contributions in elementary education. This is one of the very few Master's level university programme in India focusing wholly on elementary education.

The course prepares students for key roles in educational innovation, including the role of teacher educators. A pedagogy of mathematics course is offered as an elective course in the programme. The course discusses contemporary pedagogical and learning issues in connection with the content of elementary mathematics and exposes students to key research contributions in the field of mathematics education. A strong emphasis on equity issues with readings drawn from across the world is a notable aspect of the course. Several students who completed their course also completed a field research component in mathematics education; a few of these studies have been presented at conferences on mathematics education in the country.

Conclusion

Revisiting the goals of teacher education

It is pertinent at this point to ask what the goals of pre or in service mathematics teacher education must be. Studies across several countries have emphasised the role of specialized knowledge for teaching, teachers' beliefs and attitudes in shaping classroom teaching, and the need for teacher development programmes to address these. Studies of teacher development and teacher change have emphasised the creation of communities of inquiry and building the professional identity of a teacher. These insights are reflected in the needs identified by teacher educators through long experience of working with teachers in India.

Several components of knowledge that is needed to teach mathematics remain so far inadequately addressed in the educational trajectory of teachers. An important need is strengthening teachers' knowledge of mathematics, which includes not only an understanding of the concepts involved but also an appreciation of the nature of the discipline and its specific nuances. A second aspect that teachers need to feel assured about is the need for children to learn mathematics – why should children learn mathematics and what mathematics should they learn. A third aspect that the teacher needs to know involves the learners: what strengths and experiences do they bring to the classroom and how do these shape their capability to learn? A fourth aspect is understanding how mathematics needs to be addressed and engaged with in the classroom keeping in mind the above.

Teachers' beliefs and attitudes are also crucial. They are related to the components of knowledge described above, but are also independently directed. These attitudes, which may arise from prejudices, include their notions about the nature of mathematics, about children, their background and learning capability, about classroom processes and about what the purpose of education including of mathematics education can be and should be. It is quite common for educators and administrators to believe that children from

disadvantaged socio-economic backgrounds are incapable of learning mathematics, either because of an inherent lack of ability or because they do not have the cultural preparation and attitude to learning. The teacher also needs to have confidence in her own ability to do mathematics in order to encourage students and to give space for their thinking. Thus both pre and in service teacher education needs to address these gaps that have been created by a poor education system.

Challenges

The first and foremost challenge is of the scarcity of institutions and qualified people, to address the needs of a huge population of teachers. While in many states, the situation is one of a shortage of qualified teachers, and of teacher education institutions, in some states there is an excess of qualified teachers. This is a consequence of the massive thrust in expanding teacher education following the Kothari Commission report in the late 1960s. However the expansion has been at the cost of creating a deep structural limitation that affects both pre and in service teacher education. Teacher education has been hived off as a professional stream outside mainstream university courses and disconnected from other knowledge intensive professional courses, resulting in a commercialisation of teacher education, which has been the main engine for expansion. This has led to an absurd view of 'teaching' as an activity divorced from what is being taught.

Further, teacher education, which was designed to draw on disciplines like psychology, sociology, history and philosophy, has become de-linked from the developments in these disciplines, as also from their dynamic interplay with the Indian socio-political cultural milieu. The separation of pedagogy from content on the one hand, and from the social sciences on the other, has had far-reaching consequences. It has resulted in the near irrelevance of teacher education to the practice of teaching, and to a diminished status of the teacher in the academic community. Other short term measures taken without hindsight or a long term vision, have resulted in a weak infrastructure for teacher education even where it exists.

Another challenge is the paucity of resources and materials available to teachers for their own growth. The diversity of languages in India is an issue to be tackled since what materials exist are mainly in the English language, and are inaccessible to the vast majority of teachers.

The way forward

The challenge of the divorce of pedagogy from mathematical thinking and content is one of the deep structural problems that needs to be addressed. As discussed earlier, some efforts in this direction have been made by integrated programmes that offer a University degree together with a teacher qualification such as the four year B.Sc.Ed. Programme launched by the NCERT. Another programme which has had an impact in Delhi is the

four year B.El.Ed. programme, which emphasises a better integration of the disciplinary foundations of education with pedagogy and intensive practical work in schools, but not so much the integration of pedagogy with subject matter. These intitiaves represent a trend of forging stronger links between University based disciplines and teacher education. A development with a far-reaching consequence would be if regular university degree programmes linked the learning of concepts to learning to teach it as well, demanding attention both from students and faculty to how concepts could be taught and learned. There is in general a need to build strong links between universities and knowledge creating institutions and the work of teaching at all levels. Similarly, in many parts of the country there exist active mathematics teachers' associations focusing on talent search and nurture, promoting problem solving and popularising mathematics. They have weak linkages to teacher education institutions, and to nation wide in service TPD initiatives. A platform for forging these links could be provided by teacher conferences on challenges in mathematics education and efforts to address them.

There is a need to reformulate pre service teacher education programs to address the issues discussed above including in particular, understanding of the cultural and social background of children, the social processes that they face in school, how their language and culture could be a resource for their learning, understanding the purpose of education for society and be aware of the expectations of students, the capabilities of all children and the strengths specific to the group, how children learn mathematics and what conceptual understanding of mathematics means. An integration of the communities involved in pre and in service teacher education would bring it closer to the practice of teaching and also take advantage of situations where pre service student teachers and in service teachers are enrolled in the same programme. A mode of teacher education that combines face to face contact with distance and school based teacher development also needs to be explored for its potential.

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