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Researches on Curriculum and Teaching: Mathematics

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INTRODUCTION

India has a rich Mathematical heritage. An Instrument was actually used for drawing circles in the Indus valley as early as 2500 BC (Mackey 1938). Several significant contributions to the world of mathematics have been made during the last two million, for example, by Aryabhata I (475 AD), Brahma Gupta (7th Century), Mahavira (850 AD), Bhaskara II (1150 AD), Madhava (14th Century), Ramanujan (1887–1920).

There is hardly any discipline of study without the numbers. The Education Commission (1964-66) recommended mathematics as a compulsory subject for all school students. Thus, mathematics enjoys a unique status in a school curriculum. The National Policy on Education (NPE-1986) also emphasises that mathematics should be visualised as the vehicle to train a child to think, reason, analyse and articulate logically, apart from being a specific subject it should be treated as concomitant to any subject involving analysis and reasoning. And yet many school students find difficulty with learning of mathematics and fail in mathematics. A major reason for the failure is that the teachers quite often pay no attention to the basic concepts. The object is to develop the skill and methods of solving questions with cramped up formulae.

The *National Curriculum Framework for School Education–2000* (NCFSE–2000) reiterates importance of mathematics education as visualised in NPE–1986. According to NCFSE–2000, one of the basic aims of teaching mathematics in schools is to inculcate the skills of quantification of experiences around the learners who in turn carryout experiments with numbers and forms of geometry; frame hypothesis and verify them; generalise the findings with proof; make decisions applying mathematics; develop precision, rational and analytical thinking, reasoning, competence to solve problems, positive attitudes and aesthetic sense. A major distinction suggestion of the curriculum is that of setting up of mathematics laboratories in the existing science laboratories and converting the existing science laboratories into science-cum-mathematics laboratories.

There is a huge gap between prescription and practice of a mathematical curriculum. Most of the time of the classrooms of mathematics is preoccupied with routine teaching and not much time is devoted to learning of mathematics. Hardly a student asks questions in a mathematics classroom, implying that the learning rarely takes place in the classrooms. The teacher education colleges in India prepare the mathematics teachers at secondary level and unfortunately, some of the teacher education colleges don't have teacher educators who studied mathematics as a subject at degree level or have experience of teaching mathematics at school level. Many of the mathematics teachers do not

distinguish between teaching of mathematics and teaching of say, history. Many of them at secondary level do not understand mathematics well, as is evident from the fact that more than 90% in in-service programmes conducted for teachers at Regional Institute of Education, Bhopal and Mysore during 1998-2000 did not answer correctly questions like the following:

i) Why is it that the product of two negative numbers is positive?
ii) What is the number after ½?
iii) Why cannot addition replace multiplication?

Researchers in mathematics education at higher level are almost negligible. Vision 2020 for School of Mathematics, Tata Institute of Fundamental Research (TIFR) (Paranjape, 1995) also states "The job of teaching and exposition is one area where TIFR has not contributed much as yet. One of the disturbing aspects of mathematics education in India and also the rest of the world is that of the lack of mathematical sophistication in the education provided to non-mathematicians. Most of the mathematics taught to non-mathematicians centres around the developments of the previous century". Miyan (1991) in his report on the *Fourth Survey of Research in Education* made a concluding remark- "The quality of researches in mathematics education in India leaves much to be desired...What is needed is a proper selection of problems, specially in the area of methods of teaching and measuring multidimensional outcomes among students as a result of teaching exercise". With respect to research findings in mathematics education in India, Kapoor (1997) commented "Quality of research is good, but quantity is poor". He further remarked that in mathematics education both research and development should go together and it was time that the utilisation of research should be considered as important as research. He listed as many as 28 topics of mathematics education in which research is needed. The present review shows that very few of these have been studied during this period.

REVIEW OF RESEARCHES IN MATHEMATICS EDUCATION (1993-2000)

The present trend report is based on 63 Research Studies conducted in India during 1993-2000 of which 12 are degree-oriented studies. It is gratifying to note that 51 of these 63 are non-degree studies. The studies have been classified into the following four categories:

(a) Achievement in mathematics and its correlates.
(b) Teaching-learning factors related to mathematics.
(c) Errors committed and difficulties faced by learners in learning mathematics.
(d) Teacher training packages and teaching-learning materials.

(a) Achievement in Mathematics and its correlates

The correlates of mathematics achievements studied include sex, socio-economic status (SES), rural-urban locale, abilities of teaching, numerical, problem-solving, arithmetical, verbal reasoning and comprehension, attitude towards and perception of mathematics, intelligence, creativity, personality, mathematical aptitude, anxiety, self-concept, study habits, adjustment problems, school factors, home factors, remedial measures, peer group and achievement motivation.

There are seven studies, which have attempted to study sex as one of the correlates of mathematical achievement. Two studies have found boys performing better than girls (Hota,1995; and Muhkerjee, 1997), 2 have found girls doing better than boys (Paria, 1996; Pal and Natarajan, 1997), while 3 did not find any difference between boys and girls (Wangu and Thomas, 1995; and Chakrabarti, 2000; Nagalakshmi,1996) in terms of their problem-solving abilities. In this study, Hota (1995), found that the field independent boys were better in arithmetic reasoning measures while, field independent girls were better in verbal reasoning measures.

The SES is yet another variable which attracts educational researchers. Patel (1997) has found that socio-economic level of parents had a large impact on the achievement, the lower the socio- economic level, the lower was the achievement. Nagalakshmi (1996) found in her study that SES facilitated problem-solving ability, while Srinivasan (1999) did not find any such relation.

There are five studies, which have attempted to understand the role of rural-urban locale as a correlate of mathematics achievement. Three of these studies have demonstrated the superior performance of urban students (Nagalakshmi, 1996; Pal and Natarajan,1997; and Mondal, 1999), one study by Chakrabarti (1999), found the superior performance of both rural and urban in different contexts, while Srinivasan (1999), has found no significant difference between rural and urban students in his study.

There are 5 studies on abilities that are correlated to mathematical achievement. Rangappa (1993), has found that higher the level of reading ability, higher the level of achievement in mathematics. The other study conducted by Gourikuttyamma, (1993), also has found higher ability to be highly correlated to higher levels of mathematics achievement. Lalithabai's (1993) study highlighted the role of numerical ability especially the abstract reasoning factor, in higher level of achievement in mathematics. Sood (1999) found that the problem-solving ability correlated significantly with mathematical achievement of students. Chakrabarti (2000), found that the comprehension ability increases with age, and in order to foster comprehension ability frequent use of Comprehension type test is necessary. It is distinctly clear from the above studies that different abilities i.e., reading ability, numerical ability, problem-solving ability, arithmetic reasoning and verbal reasoning abilities, and comprehension abilities are directly related to higher performance in mathematics.

Researchers have also attempted to study 'Attitude' as an important correlate of mathematical achievement. Srinivasan (1999), in his study has found that, the attitude of students towards study of mathematics had the highest correlation with mathematics achievement. A similar finding has been obtained by Singh, *et.al.*, (1994); Sumangala (1995), Wangu, and Thomas(1995), and Thampuratty and Devi (1994). Attempting to study the causes of under-achievement, Panchalingappa (1995), has found poor attitude towards mathematics is a cause for underachievement. It is evident from the above studies that, attitude does play a very important role in mathematics achievement.

Basavayya (1995), has attempted to study the student's perceptions of mathematics among Class IX students and found that, there was a positive correlation between perception and achievement in mathematics. But, a majority of students were not happy with existing facilities for teaching of mathematics. From the above study findings, it can be implied that there is a need to develop love and a positive favourable attitude towards mathematics among students at different levels. A conducive environment is equally necessary for teaching-learning mathematics. This needs to become the professional responsibility of teachers at large.

While studying Intelligence as a variable, Sumungala (1995); Srivastava (1993), and Patel (1997) have found that higher the level of intelligence, higher will be the achievement in mathematics.

Among the individual factors, issues and correlates such as creativity, problem-solving, study habits, personality, peer group, liking, mathematics aptitude, self-concept, achievement motivation, and anxiety are studied.

On creativity, Thampuratty and Devi (1994), has found that creativity as whole had a substantial significant correlation with high achievement in mathematics, while, Sood (1999) has found only fluency was found to be significantly correlated with mathematical achievement of students of residential schools and significant differences were found between the residential and non-residential school students. Singh (2000) in his study of mathematical creative thinking among adolescents has found that quality and

quantity of mathematical creative thinking were significantly related to each other.

Researchers have also studied 'personality' as a correlate of mathematical achievement. Sood (1999) has attempted to study different personality factors as facilitators of mathematical achievement and found that out of 16 factors only seven personality factors correlated significantly. They included, scizothymia-cyclothymia, lower-higher mental capacity, submissiveness-dominance, desurgency-surgency, threctia-parmia, artlessness-shrewdness, and conservatism-radicalism. Hota, (1995), studied the field-dependence and independence as related to mathematical achievement among high school students and found that field-independent boys were better in arithmetic reasoning measures whereas, field-independent girls were found to be better in verbal reasoning measures.

There has been an attempt to study the relationship between mathematical aptitude and achievement in mathematics. Sumangala (1995), has studied 750 students of Class IX in Kerala and found all the components of mathematics aptitude, i.e., numerical ability, numerical reasoning, ability to use symbols, spatial ability, and abstract reasoning abilities, to be significantly correlated to achievement in mathematics. This implies that those who possess these aptitudes are quite likely to do well in mathematics. Perhaps this can be used as a good indicator for nurturing the mathematically talented students. Srinivasan (1999), in his study on Tamilnadu students has found that along with learning environment and attitude, academic achievement motivation has contributed to the tune of 30% of the variance to the mathematics achievement. Panchalingappa (1995) in his study on underachievement in mathematics has found that the low achievement-motivation has contributed to the under-achievement in mathematics. Attempting to find out the relationship between mathematical aptitude and socio-familial variables among secondary school pupils, Raju (1996) studies among 700 students of Kerala and found that there was a positive significant correlation between mathematical aptitude and socio-economic status. However, there was no significant relationship between facility environment index and mathematical aptitude.

Different types of anxiety studied include general anxiety, test anxiety, and examination anxiety. Patel (1996a), in his study found that, there was an effect of anxiety on the achievement in mathematics. While, Panchalingappa (1995), has found that higher general anxiety and examination anxiety are the causes of underachievement in mathematics, Patel (1997) found that low test anxiety group showed better performance in mathematics than the high test anxiety group. It is desirable that anxiety is minimised and self-concept is enhanced.

While studying some psychological variables, Sumangala (1995), has studied the role of self-concept too and found it to be an important correlate.

Among some of the learner factors that are important for high achievement, study habit is one. The studies conducted by Patel (1997), and Panchalingappa (1995) clearly indicate that study habits and academic achievement are directly related. Patel (1997) studied and compared students who different on different problems they have covering areas, viz, health, monetary, personal, social, religious-cum-sex, and educational. He has found that the under-achievers had more problems as compared to high achievers in all the six areas. Thus, the psychological tranquility is to be maintained by the learners with the active support and guidance of teachers and family members in order to facilitate higher achievement in mathematics.

Panchalingappa (1995), has studied the adjustmental problems among underachievers and found that lack of educational adjustment is an important correlate of under-achievement. Patel (1997), has found in his study that, long absence from school was an important factor in under achievement in mathematics.

A few researchers have studied the important role that school factors and home factors play in the performance of a learner. Wangu and Thomas (1995), have attempted

to study "achievement in mathematics" among 300 high school students of tribal town of Aizawl. They have compared the performance of government schools, deficit schools and mission schools. It was found that, achievement of students from government schools did not vary from that of the students from deficit schools but the mission school students achieved better than both the other schools. Pal and Natarajan (1997) in their study on gender and the mathematical mystique have considered 'home support' as one of the variables and found that home support along with teacher support and liking of teaching influenced the perceptions and attitudes related to mathematics and all these factors interactively influenced the mathematics achievement for both boys and girls.

Most of the studies on achievement attempted to study various factors responsible for poor and under achievement. Merely identifying these factors are not sufficient, while it is desirable to suggest what can help them to achieve better. One such attempt is undertaken by Dhall, *et al.* (2000), where, it has been found that teaching of students of low achievement with remedial materials, prepared after diagnostic test increased their achievement. Such studies can strengthen the teaching processes and they are necessary. It is desirable that all teachers are sensitive to the needs of their learners. In order to be so, the background and the competence of teachers is also important. There has been an attempt by Sensarma (1997), to see whether the specialisation of mathematics teachers did effect the performance of students and found that at secondary level, it matters little.

(b) Teaching-learning factors as related to Mathematics

There are around half a dozen studies, which have attempted to study the effectiveness of different teaching strategies based on certain models. Busama (1993) has studied the effect of simulation technique in teaching mathematics and found that it is more effective than traditional method of teaching mathematics. Attempting to study the effectiveness of Cognitive modelling on learning of mathematics, Balasubramanian (1999) has found it to be effective in enhancing achievement in mathematics at undergraduate level. Molia (1999) has studied the effectiveness of inductive thinking model of retentional indices in mathematics among Class VIII level and found it to be effective in improving the achievement in mathematics. Chel (1997) tried out 'seeing is believing' principles in teaching mathematics at the secondary level and found it to be more effective than the conventional methods. Teaching of mathematics through a module was tried out by Litty (1995) on Class VIII students. The findings of the study include the following. The module helped students to learn factorisation effectively. It also improved the cognitive ability to read, manipulate, convert, reason out, and relate the knowledge to novel situations to a large extent. It helped learners to understand better than merely manipulation and conversion skills. It also helped pupils in developing certain values like honesty and cooperation. In another attempt, Reddy and Ramar (1995) have attempted to study the effectiveness of multimedia modular approach as against traditional method in teaching mathematics to low achievers. The experiment proved that the multimedia modular approach did help the poor achievers in doing better in mathematics. Advocating the usefulness of usage of Angular method in improving Class VI school students' skill in simple addition, Sinha (1993) found that the angular method was more effective than traditional method. It also was helpful in developing favourable attitudes towards learning mathematics. Nanita (2000) found discovery method to be better than expository method of teaching mathematics.

Deshmukh, (1997) conducted an experiment in the use of educational technology for teaching mathematical concepts. This experiment was designed to develop alternative strategies and support activities, as well as instructional material to facilitate learning of the unit - 'Vulgar Fraction' for Class V students. The researcher concludes that the learner learns what the teacher does. As the

learning needs of pupils vary, a teacher needs alternative approaches. Learning through games gives joy and reduces stress. Swarnalekha (1997) has attempted to use joyful active learning in promotion of problem-solving ability among primary level students. It is found that remarkable improvements in the area of problem-solving area of mathematics learning were attained by paying attention to the language comprehension skills and other non-scholastic areas. It was found important to frame different activities to develop different skills like comprehension, judgement, analysis, synthesis, critical thinking, problem-understanding, finding analogy, checking equivalence in similar situations, which were finally linked with operationalisation of the basic problem-solving skills essential in mathematics. It was also found that the teachers who were given more opportunities to interact and share the experience showed positive approach towards joyful learning strategies as compared to their counterparts who showed total negative approach and believed that joyful learning practices were more said than done. Mathematics needs to be taught with full involvement and conviction. The beauty that is inherent in mathematics needs to be enjoyed by teachers and they need to enthuse learners to develop love towards mathematics, thereby teaching-learning mathematics becomes interesting.

Dash (1996) has attempted to study the effects of instructions using innovative self-learning activity sheets on the problem-solving behaviour of Class III children leading to mastery level performance. The remedial intervention in solving different types of problems on multiplication and division was found to be effective. The average performance of children after remedial instruction was significantly higher than the same before the instruction, while they took significantly less time to complete problems after remedial instructions as compared to before instructions. Interestingly, instructions through self-learning activity sheets using heuristic search strategies not only developed the problem-solving ability of Class III children but also increased the tendency of these children to be engaged more deeply in their general mathematical activities.

Goel (1996a) studied the mathematical language needs of students of Classes I and II for smooth transaction from concrete to abstract stages of comprehension of mathematics teaching. He found that the performance of students at representational level was better than their performance at abstract level. Students performed better at concrete level than at representational and abstract levels. The learning problems as related to arithmetic difficulties as identified included memory problems, reading problems, language problems, cardinality problems, symbol confusion, inability to group sets, ordinary problems, lack of concept of place values, inability to subtract, and lack of mastery of computational skills. Patel (1996b) has attempted to examine the affective behaviour of pupils through lesson idea in the subject of mathematics. He has found that the lesson idea programme in mathematics could influence the affective behaviour of the experimental group, while it did not have significant impact upon the behaviour of boys and girls.

There are some studies on the minimum levels of learning (MLLs) in mathematics. The MLLs are not teaching approaches, but they are only terminal essential requirements by all the learners at the end of every grade. Kothari (1997) has studied minimum levels of learning-based approach in teaching of mathematics among Class V students. It is a development and a tryout of an approach for attainment of MLLs. It was observed that the absence of methodical approach was one of the factors responsible for low achievement in mathematics. It was also found that the pupils had not learnt the basics in mathematics, as a result they could not do well and also developed negative attitudes towards mathematics. This indicates that mathematics could be learnt better if taught systematically. Pradhan (1996) has found that only 15.3% Class III children of Orissa attained MLLs in mathematics as against the desired level of 80%. Further, there

were perceptible differences between rural-urban, and tribal-non-tribal students.

There is a greater need of evolving sustainable remedial measures. In a separate attempt, Pal, *et.al.* (1996), have attempted to find out the effect of context, content, and construct on the acquisition of competencies by primary level students of Class IV studying in both rural and urban locales. They found that the rural students faced more difficulties in the acquisition of MLL competencies. MLLs competencies achieved were related to addition, division, and geometry. Structure of the content played an important role in understanding and performance. This was also influenced by the language used. Further, it was found that the attitudes towards mathematics and self-concept were significantly related to learning of mathematics.

Banerjee (1997) has attempted to study mathematical competencies of primary school pupils of Class IV in the use of numbers, computational ability and concrete problem-solving and calculative manipulation of sums and geometric ideas. In another attempt, Banerjee (2000) studied the mathematical competencies of primary school dropouts comparing the proportion of dropouts of girls was found to be significantly higher than that of boys in both rural and urban areas. Interestingly, it was found that the urban dropouts were significantly superior in their MLL competency than rural dropouts in both the genders. It was also revealed that though the dropouts left their studies prematurely, and not in touch with education system for a long time even then their mathematical achievement was quite encouraging. The main causes for dropping out were – poor economic condition, illiteracy of parents, lack of interest and motivation, boys helping families by earning outside and girls helping parents inside the house.

In a three year longitudinal study, Kaul, *et.al.* (1995) attempted to study the development of number readiness at the pre-primary stage and assessed the impact of the developed process-based readiness programme in the subsequent learning of mathematics in early primary stage. The study continued for three years. They found that, the cognitively-oriented intervention programme led to the development of the expected level of number readiness in the children. Further, in comparison to the control groups I and II the experimental group had consistently demonstrated a superior performance across the three grades for all the nine variables, excepting on the 'concept of money' for which the performance of control group II was found to be better in grade II. In comparison to the control group III, with the exception of some variables in grade I, the means of the experimental group was consistently higher for all nine variables in other three grades. This signifies broadly the usefulness of planned interventions in ensuring readiness.

(c) Errors committed and difficulties faced by learners while learning Mathematics

It is important to understand the learners and their learning styles so that a teacher can design some activities. As a prerequisite, it becomes necessary for a teacher to understand the difficulties of learners as well as the kinds of mistakes they do so.

Pal, *et.al.* (1997) have attempted to study different kinds of errors committed by primary school students related to the mathematical concepts based on the MLL competencies, as well as the causes of committing errors. It was found that most of the errors were due to a process of dualism, i.e., a different rule when zero involves as seen in case of place value, subtraction and multiplication. Major aspects of the response error were rooted in an alternative understandable pattern of rules. Errors were the result of incorrect induction from examples. Errors triggered due to inadequacy of language used in the definition, rules or procedure names.

On similar concerns at senior secondary level, Khichi (1998) has attempted to analyse the errors in mathematics committed by students of Rajasthan Board of Secondary Examination in the areas of set theory, trigonometry, complex numbers, coordinate

geometry, vectors, probability, matrices, curve tracing, differentia-bility, differentiation of a given function, application of differential coefficient, limit of a function, indefinite and definite integration, and application of integration besides computational errors using lower level concepts.

Paria (1999) has attempted to search the origin of errors committed by the higher secondary students in some selected topics. He found that the main errors identified were conceptual and computational and computational difficulty in the selected topics. Students faced difficulty in applying the laws of indices. The errors originated due to certain teacher and learner factors. The teachers were often unaware of the necessary and sufficient background knowledge of students before teaching a particular mathematical topic. Students often failed to remember formulae, key concepts and other relation of earlier topics. This ignorance prevented them from understanding the current topics properly. Sometimes, students were not conversant with or did not know the theory, basic principles and their operations. Moreover, they often made mistakes in applying them.

Attempting to study the arithmetic difficulties among primary grade children, Goel (1996) studied Classes I to IV in Banasthali Vidyapeeth. He found that the total number of errors committed by children in different grades varied significantly. Areas of difficulty differed as the complexity increased grade wise. Difficulties were mainly due to incorrect conceptualisations, inability to master basic facts and the use of incorrect operation while solving the problem. The nature of errors committed by low and high achievers were found to be different. Among low achievers, number problems, errors of basic fact, algorithms and incorrect operation were found more, while, high achievers committed relatively less errors.

Bhatia, (1998) undertook a study and found the following. A large percentage of students were found to be deficient in their performance on criterion tests. The poor performance was attributed to their lack of poor understanding and application skills. Around 15 types of common errors have been identified. It was also discovered that students were not aware of the use of numeration table, which was a must for understanding of place value concept, changing fraction into decimals, etc.

Goel (1996b) has attempted to identify the learning problems of students of UKG and standard I, and also suggested remedial measures for their improvement. On studying the patterns of responses, it was inferred that the performance of students at representational level was far better than their performance at abstract level. Further, the performance of students at the concrete level was found better than their performance for the corresponding items at representational level and abstract level. As apart of remedial measures the researcher has suggested that the actual manipulation of concrete objects is essential for alteration of mental structures and development of concepts.

Using meta-cognitive approach Subramaniam and Singh, (1996) have attempted to offer remedial measures to students who commit mistakes among Grades II and III. They have found that the students committed six types of mistakes in addition, eight types of mistakes in multiplication, and six types of mistakes in division. It was found that the poor concept of carrying over, poor concept of zero, poor concept of multiplication, introvert behaviour, lack of writing skills, etc., were observed as possible causes of mistakes committed by students. While giving reasons for poor performance of students, teachers opined that the different factors that are responsible include; home environment, SES, physical facilities in the school, extra work load of teachers, lack of interest, motivation and discipline among students, large class size, and such.

(d) Teacher Training Packages and Teaching-learning Materials (TLMs)

There is some attention by researchers on issues related curricular concerns covering Teaching-learning Material (TLM).

Shivaprasanna (1993), has attempted to study the problems of mathematics teachers in Bangalore city in teaching mathematics at secondary level. He found that the three main areas of problems of teachers are personal, administrative and students. The mathematics teachers' workload needs to be reduced. Special classrooms with audio-visual facilities are required. Last periods will have to be avoided in timetable to teach mathematics. Understanding of mathematics depends upon the ability of learners and time taken to teach. Sufficient drill work is necessary and good coverage of content for the examination is necessary.

Kumar (1996), studied 200 primary school teachers from 30 schools and found that less than 20% of the teachers held positive attitude towards mathematics. Among them, male teachers and teachers working in private schools out number their counterparts. Developing positive attitude becomes the responsibility of teacher training institutions, and it has an implication for quality teacher training programmes.

Gupta (1996) while assessing teachers' performance in mathematics and reading test, compared the performance in mathematics of the trained and untrained teachers.

Teacher training packages have also attracted the attention of some researchers. Raghavan (1997) developed a training package for teachers based on the identification of teaching-learning difficulties in mathematics in Class I of Tamilnadu schools. The study was aimed at identifying the hard spots in mathematics for Class I students so that intervention could be planned to overcome the deficiencies. Accordingly, the training programme was planned and provided and it was found that the training programme could reduce hard spots substantially as could be seen from the noticeable improvement in the performance of students. Basavayya, and Patanik (1997) developed a training package in mathematics for primary teacher educators based on the assessment of difficulties of students and problems of teachers. It covered the objectives, guidelines for trainers, schedule for organising 5 days programme, different activities to teach different competencies in Class I mathematics, apart from some brief write-ups about evaluation, diagnostic tests, multigrade teaching, MLLs, and remedial teaching.

There are very few studies in the area of TLMs and teachers' handbook. Prakash, *et.al.* (1996) have attempted to identify local specific materials for Grades I, II, and III in language, mathematics and environmental studies to nurture perceptual abilities including observation, measurement, and drawing inferences in order to make teaching-learning process effective. The researchers have identified various local specific materials in two sample districts of Raisen and Osmanabad.

On teacher's handbook there is an attempt by Nalage (1997) who has compared the effectiveness of teaching done with and without the help of teacher's handbook for mathematics for Class III. It was found that teaching of mathematics became more effective when it was done with the help of teacher's handbook. It gave a new direction to the teaching of mathematics. It also motivated teachers to prepare novel teaching aids. It helped better in explaining difficult concepts, and facilitated a better participation of pupils in teaching-learning process.

Atre and Parasnis (1997) did a critical evaluation of the mathematics teacher's handbook for Class IV. As a part of their study, they also were interested in knowing what percentage of mathematics teachers knew about the existence of teacher's handbook. They found in their study that, around 70% of the teachers were unaware of the existence of teacher's handbook for Class IV. Examination of handbook indicated that annual planning suggested in the handbook was found useful to teachers.

Number of Studies and their Concerns – Level wise

The following table indicates Researches at different levels: Pre-school, Elementary, Secondary, Senior secondary, and Higher education.

Sl. No.	*Level*	*No. of studies*	*Substantive concerns studied*
1.	Pre-Primary	1	Process-based readiness programme for primary level
2.	Elementary	23 + 15 = 38	(Classes I-V) - Effects of instructional strategies - MLL competencies - Mathematical competencies of learners - Performance of pupils - Mathematical language needs of students - Abilities - Competencies - Arithmetic difficulties/Learning difficulties - Problem-solving ability - Learning problems - Teaching methods - Teaching performance - Use of educational technology in teaching - Teaching-learning materials - Teachers' handbook - Attitude of primary school teachers towards training - Training package for teachers/teacher-trainers - Remedial teaching (Classes VI-VIII) - Reading ability - Prediction of success - Underachievement- causes - Achievement correlates - Academic anxieties - Difficulties - Errors committed - Teaching strategies - Remedial materials
3.	Secondary	18	- Students' perception of mathematics - Attitude towards mathematics - Cognitive factor structures of different levels of achievement - Underachievement- causes - Psychological variables - Ability correlates - Achievement correlates - Anxiety - Mathematical aptitude - Errors - Mathematical creative thinking - Role of specialisation of teachers - Problems of mathematics teachers - Teaching strategies
4.	Senior secondary	2	- Correlates of achievement - Errors committed
5.	Higher Education	1	- Cognitive modelling on learning mathematics
6.	Mixed levels	3	- Gender bias - Achievement - Teaching-learning in rural and urban areas

CONCLUDING REMARKS

There has been a growth in researches in mathematics education at school level during 1993-2000 and many of the issues addressed in the research studies are the real problems of mathematics education. Most of the studies aim at finding correlates of mathematics achievement and relate to teaching methodologies for improving performance in mathematics.

Proofs, aesthetics, interdisciplinary activities (including applications) are fundamental components of Mathematics Education. There are no studies in these areas.

There has been a growing tendency to replace proofs by inductive arguments in mathematics at school level, contrary to nature of mathematics. For example, proof of the theorem : "The sum of the angles of a triangle in a plane is 180°" cannot be replaced by actual measurements of angles of a triangle since any measurement has an error associated with it. Inductive arguments can be used for motivational purposes. We need to enquire into the distortions that are taking place in the proofs.

While aesthetics is mainly derived from infinite collections (patterns) it is difficult to find examples of infinite collections (sets) from the real physical world. The natural numbers which are the first experience in mathematics is an example of an infinite set. Mathematics is full of infinite sets and so full of excitement. As observed by King (1992) 'One of the vastest areas of contemplative beauty is Mathematics. This alone is sufficient reason for study of mathematics'. Mathematics could be an excellent instrument to develop aesthetic education in schools to fulfill an urgent and unfulfilled demand of a school curriculum.

Though all the curricula of mathematics stress the need of applications of mathematics, the school students of mathematics are rarely motivated to apply mathematics to local situations. A research in the area at the interface of mathematics, computer sciences and applied sciences will definitely motivate students to understand mathematics and enhance usefulness of mathematics in furthering sciences. This will yield a strength to the idea of mathematics lab as envisaged by the NCFSE-2000.

What ultimately matters for mathematics education is a harmonious blend of historical, cultural, societal, psychological, aesthetical, philosophical and universal considerations of mathematics, and with this as a prerequisite there is a need for an investigation that provides an information about external, environmental variables that can be monitored to facilitate cognitive performance and cognitive change.

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