TRANSFORMING MATHEMATICS CLASSROOM INTO LABORATORY

A Drive for Quality Elementary Education in Mathematics

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Abstract: *The efficiency and potency of an educational system consecutively lies upon its teachers. Teaching becomes a fulfilling journey that gives an incredible opportunity to mould the impending future of a society. It becomes quite necessary for a teacher to nurture the practice of self-appraisal, improve interactions; develop reflective strategies etc. to steer students towards healthy reflexive skills. Ironically, Mathematics is the basis for scientific, industrial and technological advancement of any country. Mathematics being a compulsory subject of study, access to quality mathematics education is every child's right as per RTE 2009. But it is very sad to note that the performance by the students are not up to the mark and student's general impression is that it is a dreadful subject. Hence, the main objective of the paper is to explore necessity of new pedagogy to connect abstract conjectural of mathematics into reality, through problem solving method, laboratory method, project method instead of the traditional method and to create a culture of thinking, inventing, tinkering and doing to promote enquiry based learning among teachers of Mathematics. National and International journals, project report, government documents, thesis, proceedings of seminar, conference, article of research work have been used as source of secondary information. Major findings suggested that class room teaching practice becomes more effective, if students are given the opportunity to explain or clarify their ideas. So in terms of pedagogy, the development of education now requires teaching strategies that emphasize student involvement in their learning, where focus is on knowledge construction rather knowledge transformation. Many researchers have shown that learning strategy in classroom can be very effective in encouraging student interaction and consequently enhanced students' achievement. Also, previous learning experience, previous poor performances in mathematics result in anxiety (Ho et al., 2000). In the classroom there are four main issues in the teaching and learning of mathematics such as (i) teaching methods, (ii) resources and teaching aids, (iii) language of the learner and (iv) the culture of the learner (NCERT). To ensure students are actively engaged, it is proposed that teachers should adhere to the strategies to (i) Create a safe environment where students feel comfortable, (ii) Establish clear procedures and routines, (iii) Provide both challenge and support, (iv) Use carefully assigned and well-managed cooperative groups, (v) Make frequent real life connections those are relevant to students, (vi) Present activities where students produce and share products. These could be achieved if teachers are provided the opportunities to make classroom in potential laboratory including modern IC i.e., an additional collaborative efforts – institutional and analytical – are needed in order to add a new dynamic to improve the quality of teaching learning in mathematics at elementary level.*

Index Terms - Elementary Education, Mathematics education, Mathematics achievement, Mathematical anxiety, Mathematics laboratory, Professional development, Quality education.

1. INTRODUCTION

Education is not only a device of strengthening efficiency but is also a powerful instrument of widening and boosting democratic association and upgrading the overall quality of individual and societal life. The Constitution of India is firm to providing to all children, opportunities for developing their potentialities and maximizing their learning in their areas of interest. Elementary Education comprising primary (Class I–V) and upper primary (Class VI–VIII) forms the foundation of the education pyramid. Unless this foundation is strengthened, it will not be feasible to achieve the goal of universal access to quality education for all. The Right of Children to Free and Compulsory Education (RTE) Act, 2009, became operative on 1 April 2010. . The Quality of Education is at present in the focus in all programmes relating to elementary education in general and mathematics education in particular.

Mathematics is a form of reasoning. Thinking mathematically consists of thinking in a logical manner, formulating and testing conjectures, making sense of things, and forming and justifying judgments, inferences, and conclusions. We demonstrate mathematical behaviour when we recognize and describe patterns, construct physical and conceptual models of phenomena, create symbol systems to help us represent, manipulate, and reflect on ideas, and invent procedures to solve problems (Battista, 1999).

Any improvement in Education System must start with improvement of the Teachers already in the classroom; this topic is one of real urgency. For this purpose, reforms in education system from time to time can force teachers to keep pace with change and to review and renew their own knowledge, skills and vision of good teaching,([Beaty,1998]). In this process, the role of teachers needs to be the subject and object of reforms. Teaching experience itself leads to professional growth if a teacher examines his or her teaching systematically,[Glatthorn,1995]. Formal experiences such as attending workshops, professional meetings, mentoring etc. and informal experiences such as reading professional publications, watching television documentaries related to an academic discipline, etc. can provide teachers the parameters of assessment, [Ganser, 2ooo].

2. SIGNIFICANCE OF THE STUDY

Mathematics gives students the language through which they can interpret, analyse, describe, make predictions, and solve problems in everyday life. It allows them to participate in a wide range of mathematical experiences and relationships both in school and in daily living. All students need higher level math and reasoning skills to be successful in today's technological society. Mathematics anxiety has a negative relationship with mathematics performance and achievement (Green, 1990; Hembree, 1990; Mevarech, Silber & Fine, 1991; Norwood, 1994; Wigfield & Meece, 1988) , though it has also been found that a degree of cognitive anxiety (worry or concern) may motivate student to try harder. It is when this worry or concern becomes too strong that it may interfere with performance (Ho, Senturk, Lam, Zimmer, Hong, & Okamoto, 2000; Wigfield & Meece, 1988). A major negative consequence of mathematics anxiety is mathematics avoidance (Hembree, 1990) [6].

In the present day students have to know not only the basic reading and arithmetic skills, but also skills that will acknowledge them to face a world that is continually changing. The teachers must be competent to think critically, to analyze, and to make inferences. "Are we sure that our students are getting these?" What are the skills that young people need to be successful in this rapidly changing world and what competencies do teachers need, in turn, to effectively teach those skills to their students? The question that arises from this is, of course, what teacher preparation programs are needed to prepare graduates who are ready to teach well in a 21st century classroom. This question is, however, yet tough to answer with available comparative substantiation.

Traditionally mathematics is often taught in an abstract mathematical world, using formalism first, removed from authentic contexts, and discouraging to the students that do not see its relevance – for example, students are taught the techniques of arithmetic, then given lots of arithmetic computations to complete; or they are shown how to solve particular types of equations, then given lots of similar equations to solve. On the contrary, in the 21st century, students require to have an comprehensive understanding of the fundamental ideas of mathematics, they need to be able to transform a new condition or problem they face into a form that renders the relevance of mathematics, make the problem open to mathematical treatment, identify and use the relevant mathematical knowledge to solve the problem, and then evaluate the solution in the original problem context. This paper takes an attempt to go through the process of teaching learning creating realistic situation in the classroom.

3. OBJECTIVES

This paper aims to

(i) Find the objectives of teaching mathematics at elementary level.

(ii) Analyses the cause of under achievement in mathematics and emphasizing of quality mathematics in elementary education.

(iii) Thrusts on the necessity of the new pedagogy of constructivist approach through problem solving method, laboratory method, project method instead of the traditional method

4. METHODOLOGY

National and International journals, project report, government documents, thesis, proceedings of seminar / conference, article of research work have been used as source of secondary information.

5. FINDINGS

5.1 Aims of mathematics at elementary education

Mathematics education refers to specialized discipline that sits between mathematics on the one hand, and a range of other disciplines (such as psychology, human development, sociology, philosophy, epistemology, pedagogy, curriculum studies, policy studies and science) from which it draws underpinning research findings and concepts etc. 250 researchers across 60 institutions worldwide who categorized 21st-century skills internationally into four broad categories:

***Ways of thinking*.** Creativity, critical thinking, problem-solving, decision-making and learning

***Ways of working*.** Communication and collaboration

Tools for working: Information and communications technology (ICT) and information literacy

Skills for living in the world: Citizenship, life and career, and personal and social responsibility (Schleicher & Ed., 2012)

Mathematics, according to National Education Policy 1986, 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 a concomitant to any subject involving analysis and reasoning.

Mathematics education is to enable students to:

(i) Acquire the necessary Mathematical concepts and skills for everyday life, and for continuous learning in Mathematics and related disciplines.

(ii) Develop the necessary process skills for the acquisition and application of Mathematical concepts and skills.

(iii) Develop the Mathematical thinking and problem solving skills and apply these skills to formulate and solve problems.

(iv) Produce imaginative and creative work arising from Mathematical ideas and develop positive attitudes towards Mathematics.

According to NCF-2005, the main goal of mathematics education in schools is the mathematization of the child's thought processes. There are two aims of school mathematics – the narrow aim and higher aim.

The narrow aim of school mathematics is to develop 'useful' capabilities, particularly those relating to numeracy-numbers, number operations, measurements, decimal and percentage. The higher aim is to develop the child's resources to think and reason mathematically, to pursue assumptions to their logical conclusions and to handle abstractions.
These aims could be achieved through the use of innovative Mathematics teaching strategies instead of the conventional approach.

5.2 Scenario of present students' achievement

Elementary education (class I-VIII) is a crucial stage for children as it prepares them for the world of work. It is very essential to provide good quality mathematics education available, accessible and affordable to all our children. To achieve this, there is a need to strengthen the secondary school education by providing opportunities to teachers for improving their professional capabilities/capacities. In majority of the schools, untrained teachers are handling secondary classes. Even the trained teachers are facing lot of challenges to handle classes at secondary stage of school education especially in science and mathematics. As a consequence of this the scenario of mathematics achievement in India remains to be improved from a long way to present situation. As for example, Thakore (1980) found that the students of class V did not have clear concept of fractions. They did not understand the place value of respective figures in decimal fractions. They did not understand addition, subtraction, multiplication and division of decimal fractions. In **TIMSS** (2003) study India ranked at 46 among 51 countries. Indian students' score was 392 versus average of 467 for the group. In the year 2014 in the National Achievement Survey (NAS) for class VIII in mathematics conducted by NCERT the average score of 33 states/ UTs was 245 out of 500 with SE of 0 .6. Also the mean value of result (out of 100) in mathematics found by them in the year 2012 is given below:

table 1: mean value of result in mathematics (out of 100) in 2012

Round	Grade III	Grade V	Grade VIII
Round I	58.25	47.45	39.17
Round II	61.88	49.88	42.17

5.3 Challenges to realizing the goals of Elementary Mathematics Education

Variables of the study contains dependent and independent variable. The study used pre-specified method for the selectio Elementary education forms the basis of mental development in a child, and equips him/her with the analytical skills, confidence and competencies which help pave the way for a successful future for him/her. Hence, it is imperative for nations to focus their attention on providing quality elementary education to their citizens, especially to the underprivileged sections of the society and empower the masses with a quality education that can enable them to break the shackles of poverty.

Despite the importance placed on mathematics, researchers (Odili, 1986; Salau, 1995; Amazigo, 2000; Agwagah, 2001; Betiku, 2001; Obioma, 2005; Maduabum and Odili, 2006; Okereke, 2006) had observed that stud-ents lack interest in the subject and perform poorly in it. Ukeje (1986) observed that mathematics is one of the most poorly taught, widely hated and abysmally under-stood subject in secondary school,

It has been found that written mathematics poses serious challenges for deprived children, even though they may have some competence in oral computations and problems situated in contexts meaningful to them. Class 6 children are not able to write three digit numbers, and many cannot perform subtraction or carry out division. A few who managed to solve it did so by inventing their own symbol system to distribute and add up each child's share. In another classroom trial it was observed that owing to poor training at primary grades, most class 6 students belonging to similar backgrounds had to be taught division afresh and they preferred the partial quotients method over the standard division algorithm (Khemani & Subramanian, 2012). The disconnect between these children's encounter with numbers and the demands of school mathematics is something that is well studied and reported (Nunes, Schliemann & Carraher, 1993; Lave & Wenger, 1991) and our experience with children from marginalized backgrounds resonates well with these studies. In general making sense of abstract number problems and algebraic expressions remains a major challenge for them as their training in mathematics has not enabled them to acquire these skills. Classroom interventions and close interactions with children show that most of them from lower socio-economic backgrounds have not learnt the use of the geometry kit. Angle measurement poses serious difficulty for many children. There are no suitable qualitative studies that focus on how children learn geometry and the challenges they face in different school situations, yet there is empirical evidence to believe that the content in geometry does not get transacted at all satisfactorily. A typical classroom transaction in mathematics could amount to the teacher working out a problem on the blackboard and the students copying with no comprehension. The upper primary classroom thus continues to alienate and remain effectively inaccessible for a large section of the socially marginalized student population and also for many from the urban middle classes (Subramanian, Umar & Verma, In Press). Teaching and learning of algebra and negative numbers remains a major challenge even in urban middle class settings. There has been some research exploring alternative approaches for the teaching of algebra by bridging the gap between arithmetic and algebra using 'terms' (Banerjee, Subramaniam, & Naik, 2008). In fact, mathematics educators concerned with social justice issues have engaged with similar questions (Ernest, n.d.; Gellert & Jablonka, 2007; Gates, 2001; Skovsmose, 2011; Greer, Mukhopadyay, Powell & Barber, 2009). Arguing that a narrow definition of mathematics guided by what mathematicians practice does not represent the multiplicity of mathematical practices in

varied cultural contexts, they call for a critical appraisal of the aims of teaching mathematicians' mathematics and ask how mathematics at the upper primary level could be redesigned to enable the learner to critically engage with the socioeconomic and cultural reality in which they are placed.

In the classroom there are four main issues in the teaching and learning of mathematics:

Teaching Methods

Studies carried out have shown that the teachers' method of mathematics teaching and his personality greatly accounted for the students' positive attitude towards mathematics and that, without interest and personal effort in learning mathematics by the students, they can hardly perform well in the subject. Students learn best when the teacher uses a wide range of teaching methods. (Fennema and J. Sherman [1995], W. J. Mckeachie and Y. Lin [1991], Yara (2009)). Bono (1991) in his study showed that girls would enjoy math, increase their time on math tasks, and have positive emotional reactions to math if math were taught in a cooperative setting.

Resources and teaching aids

Students learn best by doing things: constructing, touching, moving, and investigating. There are many ways of using cheap and available resources in the classroom so that students can learn by doing.

Language of the learner

- Language is as important as mathematics in the mathematics classroom. In addition, learning in a second language causes special difficulties. The most influence (Mestre, 1988) refers to proficiency with the symbolic language of mathematics (such as > or <).
- The another way in which language proficiency influence problem solving ability (Mestre, 1998; Sibaya et al., 1996) relates to the extent to which a student can translate a problem stated in general Bengali into a mathematical expressions or expression(which was found for the item number 35).

Culture of the learner

Students do all sorts of maths at home and in their communities. This is often very different from the maths they do in school. Examples should be taken from all over the surroundings of the world of students. Helping students to make that link will improve their mathematics.

5.4. Causes behind underachievement in mathematics

There are many possible reasons as to why students fail in mathematics. But most of the reasons are related to curriculum and methods of teaching rather than the students' lack of capacity to learn (Carnine, 1991; Jones, Wilson, and Bhaswani, 1997). Airasian and Walsh (1997) argue that the existing mode of teaching of mathematics in schools has not fulfilled the needs of the vast majority of our students, and that not nearly enough instructional stress is put on the higher order skills. Traditional method of teaching makes the learner to memorize information, conduct well organized experiments and perform mathematical calculations using a specific algorithm and makes them submissive and rule-bound. The traditional teacher as information giver and the textbook guided classroom have failed to bring about the desired outcomes of producing thinking students (Young and Collin, 2003). A much heralded alternative is to change the focus of the classroom from teacher dominated to student-centred using a Constructivist Approach.

Causes of weaknesses may be due to the reasons that are given below:

- The student's 'previous knowledge' is not clear.
- The students do not have appropriate acquaintance with the method of the problem.
- The students do not have adequate comprehension to identify mathematical logic behind the method.
- The students may be short of sufficient realization for conversion verbal statement to mathematical statement.
- The students may be deficient in an adequate amount of practices to crack accurate answer.
- The students do not have ample proficiency recognize geometrical figure and associated properties.
- Mathematical anxiety influenced the achievement in mathematics. These thought includes belief system, feelings of inadequacy and fear of failure, poor test preparation and ineffective study methods The same result was found by Ho et al.,(2000) and Perry,(2004).
- Socioeconomic background of the students: It was found that a significant relationship existed between economic factors and attitude towards mathematics in respect of rural boys and girls.
- The pupils' perspective: The pupils perspective is very important and anything that affects a students' ability or desire to attend school regularly and pay more attention in various curricular activities could be associated with achievement.

Therefore, from the above discussion it can be assembled the fundamental understanding of these issues around the following four problems which all the educators including the author believe to be the core areas of concern (source NCERT):

1. A sense of fear and failure regarding mathematics among a majority of children,
2. A curriculum that disappoints both a talented minority as well as the non-participating majority at the same time,
3. Crude methods of assessment that encourage perception of mathematics as mechanical computation, and

4. Lack of teacher preparation and support in the teaching of mathematics. Previous learning experience: Previous poor performances in mathematics result in anxiety (Ho et al., 2000).

5.5 Constructive Approach and Interventions in the classroom for mathematics teachers

Mathematics teaching is a complex and demanding process. The complexity is successfully resolved by unfolding continually new techniques or strategies for math teaching and learning suitable to the contemporary context. That way we get a process which has to take place harmoniously within several frameworks. That educational systems the world over acknowledge the importance of the teacher is often evident by the resources spent on teacher capacity building. However, the issues often have been about building an effective model and mechanism that would develop and enhance the teachers' capacity and provide them avenues for professional development. Recent studies have identified the need for improved classroom practices in teaching mathematics as a condition for improving K-12 pupil achievement in mathematics (Ball, Hill, &Bass, 2005; Ma, 1999; National Mathematics Advisory Panel, 2008; Stigler & Hiebert, 1999).To improve classroom practices, pre-service methods classes should focus not just on teaching general methods of instruction, but should engage pre-service teachers in learning how to successfully teach subject matter content using highly specific strategies that are specialized to that discipline (Shulman,1987).

There are some measures for intervening in the class room for teachers:

1. Screen all students to identify those at risk for potential mathematics difficulties and provide interventions to students identified as at risk.

2. Instructional materials for students receiving interventions should focus intensely on in-depth treatment of whole numbers in kindergarten through grade 5 and on rational numbers in grades 4 to grade 8.

3. Instruction during the intervention should be explicit and systematic. This includes providing models of proficient problem solving, verbalization of thought processes, guided practice, corrective feedback, and frequent cumulative review.

4. Interventions should include instruction on solving word problems that is based on common underlying structures.

5. Intervention materials should include opportunities for students to work with visual representations of mathematical ideas and interventionists should be proficient in the use of visual representations of mathematical ideas.

6. Interventions at all grade levels should devote about 10 minutes in each session to building fluent retrieval of basic arithmetic facts.

7. Monitor the progress of students receiving supplemental instruction and other students who are at risk.

8. Include motivational strategies - Reinforce or praise students for their effort and for attending to and being engaged in the lesson.

9. Consider rewarding student accomplishments.

10. Allow students to chart their progress and to set goals for improvement.

5.6 Improving Classroom Practices

- One of the most critical needs is to ensure classroom sizes in which teachers can give adequate attention to the students and involve them in the daily lesson practice is an important request from students – which also means giving more time to **lab work, projects.**
- **Move around the classroom and interact** with students while they solve problems or read texts,
- **Speak clearly** and audibly.
- **Use media** beyond '*chalk and board*', OHPs and Power-points - classrooms can be equipped with charts, models, projectors and videos to make instruction more visual and tactile.
- **Give feedback to students** on their performance and how to improve it. Weak students (and others) say they rarely get constructive feedback; in some instances, they get no feedback at all. Besides making such feedback part of teachers' responsibilities, they need to be trained in how to provide it.
- **Be available** for formal and informal contact after class.

5.7 Professional Standard for teaching of Mathematics

table2: professional standard for teaching mathematics

Towards	**Away from**
Classroom as mathematical learning collection of individuals under the control of communities.	collection of individuals under the control of an adult
Mathematical tasks that engage students' repetitive drill and practice interest and intellect	repetitive drill and practice
Logical and mathematical evidence as verification	The teacher is the soul authority for right answer
Mathematical reasoning	Merely memorizing procedures
Providing opportunities for students to deepen their understanding of the mathematics being studied and its applications	Trying to cover too many topics in too little time at a superficial level
Promoting the investigation and growth of	Passive absorption of information as the teacher

mathematical ideas through classroom discourse	lectures
Conjecturing, inventing and problem solving	Stressing mechanistic answer finding
Using technology and other tools to practice mathematical investigations	Using only paper and pencil to do mathematics
Connecting mathematics , its ideas and applications and helping students seek connection to previous and developing knowledge	Presenting mathematics as a body of isolated concepts and procedures
Students working individually, in small groups and as a whole class	Students working individually at own desk in lined up in near rows.

[Adapted from NCTM *Professional Standard for Teaching Mathematics*, pp. 1-3

table3: best practices in use of teaching mathematics

Instructional elements	**Recommended practice**
Curriculum design	Ensure mathematics curriculum in challenging context
	Clearly identity skills, concepts and knowledge to be mastered
	Ensure that mathematics curriculum is vertically and horizontally articulated
Professional Development for Teachers	Provide professional development which focuses on, Knowing / understanding Standards Using standard as a basic for instructional planning Teaching using best practices Multiple approaches to assessment Develop / provide instructional support materials such as curriculum maps and pacing guides Establish mathematics leadership teams and provide mathematics coaches
Technology	Provide professional development on the use of instructional technology tools Provide student access to a variety of technology tools Integrate the use of technology across all mathematics curricula and courses.

[Source: The Alliance Education, Business and Community for Public School, 2006]

6. CONCLUSION

A responsive mathematics learning environment involves:

- meeting the social-emotional needs of all students, by ensuring:
  - respect for their developmental needs
  - support for risk-taking in learning mathematics
  - positive attitudes and beliefs about mathematics
  - collaboratively constructed class norms
- optimizing the physical set-up of the classroom by ensuring:
  - space for collaborative work
  - equitable access to a variety of tools, mathematics learning resources, concrete materials, technology and manipulatives
  - the display of student thinking that reflects the mathematics topics currently being taught

Planning a responsive mathematics learning environment requires:

- knowledge and capacity in the intentional teaching of mathematics
- communication skills to support an inquiry approach to the teaching and learning of mathematics
- knowledge of classroom dynamics, including ways to:
  - support students in transitions
  - recognize the diversity of the classroom as an asset to learning
  - honour the range of mathematics knowledge students bring to the classroom
  - build student engagement and respect student voice
  - – develop an open-to-learning stance among students

All these may be achieved through proper utilization of classroom intervention using it as laboratory itself.

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