# AN INSIGHT OF THE MATHEMATICS EDUCATION IN INDIA: OBSERVATIONS FROM CLASSROOMS

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**Abstract**

This paper provides an insight on mathematics education in India focusing on primary schools, high schools and colleges. The study also focuses on observation on mathematics classrooms of schools in the Mumbai region, schools in Jodphur and a college in Rajasthan. It also provides snapshots of mathematics classes in the primary and secondary levels that reflect the implementation of the National Curriculum Framework in India. Teachers' pedagogical approach and students learning approach are discussed. One of the interesting observations was that the classrooms were teacher-centred that valued drill and practice skills. A brief description of the selection and objectives of the Indian Institute of Technology (IIT) is also provided. Teacher-preparation programmes are also discussed. Nevertheless, despite India having a centralized school system, it still has difficulty serving the needs of all students especially in the rural areas.

## Introduction

The current educational system in India comprises primary education, secondary education, senior secondary education and higher education. In the primary level, pupils have to go through eight years of schooling. The secondary level is a two years education followed by another 2 years in the higher secondary education (Heitzman & Worden, 1995). Therefore pupils undergo 12 years of schooling. Generally, students in India follow the 10+2+3 system with the first ten years of general education, followed by two years of pre-college preparation and the final 3 years with degree programmes.

In this report, there are several qualifications to make. Firstly, the educational system in India is very large and diverse that any general characterization is impossible to be made for a paper of this length. With that in mind, the authors have decided to concentrate on three cities namely Mumbai, Jodhpur and Rajasthan. The simplification also includes providing snapshots of the schools involved instead of a detailed case study. This paper is organized into three main sections. The first section describes how Mathematics is taught in two secondary schools at different educational levels in Mumbai. The second section provides a brief understanding of teacher education from the trainee teachers' perspective and also snapshots of a primary school in Jodhpur. The third section discusses the system of higher education, focusing mainly on the Indian Institute of Technology (IIT) in Rajasthan.

## School System in Mumbai

We first begin with some general information on the Mumbai school system. The greater metropolitan area of Mumbai has approximately 18 million residents. By 1999, there were about two thousand primary schools in the area with over one million students. Juneja (2001) reported that many of the children work and do not attend school. With, almost half of the population living either in the slums or do not have a living shelter.

The schools we visited are among the top schools in Mumbai. The two secondary schools that we visited in Mumbai were Kendriya Vidyalaya IIT Powai and Atomic Central School-1. Both schools were set up to provide quality education for the children of the employees of the India Institute of Technology and the Department of Atomic Energy respectively. They are considered to be among the best schools in the region. This is due to the location, trained teachers, proper facilities for students, and educated parents. Many other schools in the rural areas do not have these facilities and sufficient teachers (Rahman, 2010).

***School 1***

The first school we visited was the Kendriya Vidyalaya, Indian Institute of Technology Powai (KV IIT, Powai) in Mumbai. This school is situated within the premier technology institute of IIT. It was established on 15$^{th}$ June 1964. KV IIT consists of elementary and secondary schools from Grades 1 till 12. This school currently has about 2000 students and 80 teachers. All the teachers are trained and we were surprised to know that the majority of their teachers had at least a Masters degree in their discipline or in education.

The lesson we observed was on surface area and volume and was taught by a teacher with 20 years of experience. Students in the class are about 14 years old. She began the lesson by asking one of the students to read one problem from the test book. The question is “Find the lateral or curved surface area of a closed cylindrical petrol storage that is 4.2 m in diameter and 4.5 m in height”. Then, she wrote down all the important information such as the diameter and the height of the object. Discussing with the class by asking different kinds of questions, the teacher gave the students some time to solve the problem on their own. She then moved around while looking at the students’ work. Using a cylindrical model to illustrate the second question on volume, the teacher asked questions on how to go about solving the problem based on the information given. The teaching approach used was rather didactic. The teacher demonstrated a worked example on the whiteboard and then got the students to work on other problems in the textbook

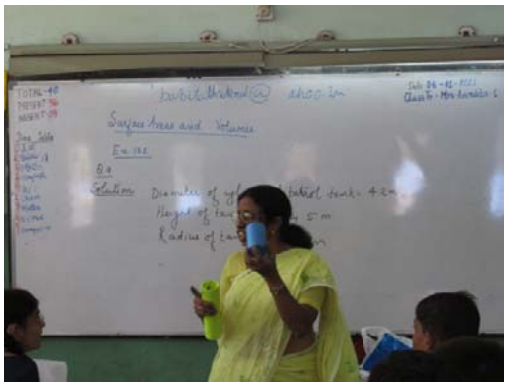
She further explained the connection between the capacity of the cylindrical tank to the volume. Going back to the first question, the teacher showed two different sizes of the cylindrical object. A student was called upon to present his solution on the whiteboard while the teacher walked around to check on other students’ work. The student drew a cylindrical figure on the board to help others visualize the cylindrical object. The teacher then went through the solutions with the whole class. This lesson exemplifies the teacher-centred approach in the lesson. The teacher tried to incorporate discussion technique by asking some questions and to explain the main ideas. Using questions from the text book, the teacher solved them as an example and then assigned some questions for the students to attempt. For these students, this is a typical mathematical classroom pedagogy. Throughout the entire lesson, students had little opportunity to discuss the solutions with each other.

A Standard 7 mathematics lesson on 3-Dimensional Solids and Nets was also observed. The lesson was more vibrant than the previous class as students were given the opportunity to draw and cut out the nets of the solids from a piece of paper.

*A student being called upon to respond to question posed by the teacher*

*The teacher went round to check on the students' work while a student was asked to present his solution on the whiteboard*

*A student showing the model of a pyramid*



*The teacher using a manipulative to explain the volume and surface area of a cylinder*

***School 2***

The Atomic Energy Central School consists of both the primary and secondary levels. It is housed within an atomic research centre with scientists working at the different institutions. With an enrolment of 1173 students, it can be considered as one of the better schools since most of the students are from the educated families' background of professors and researchers.

The next lesson comes from an urban sixth grade classroom learning algebra. In this class, the teacher started the lesson by questioning their understanding of the terms variable and constant. Instead of providing the students with the examples, she probed them to give her a few. One student said "two multiply x is 2x". The teacher wrote it down on the board. To elicit the next example, the teacher asked "Imagine that your age now is $y$ years? What is your age after 2 years?" One student answered "Is it $y + 2$?" The teacher explained that after 2 years is like "2 more years and more" means "addition". Next the teacher explained the difference between the number of terms with the terms "monomial", "binomial" and "trinomial". She wrote a few examples on the board and asked how many terms were there in the expression. This time almost the whole class answered. She then asked the students to repeat after the meaning of the terms once again. The teacher was using the repetition method to help students memorize the meaning of the algebraic terms. Using the same technique, the teacher also explained the difference between "like terms" and "unlike terms".

Students were then introduced to addition and subtraction of algebraic terms. She gave a few examples before proceeding to showing the steps involved in solving them. To test whether the students understood the operations, one student was asked for his answer and he gave a wrong answer. The teacher did not tell him that he was wrong but instead asked him to check whether the term was “like terms”. This helped the student to identify his mistake and he mentioned the correct answers. Finally, the teacher wrote five questions on the board. Students were expected to copy the questions and solve them. Later the class discussed the answers to these five questions.

At the end of the lesson, the teacher asked the students the number of correct answers that they have obtained. The students raised their hands for the number of correct solutions. One student raised his hand to indicate that he only obtained one correct solution. The teacher requested him to see her after class for clarification. That ended the lesson.

Overall, this lesson was very traditional based which began with the teachers’ explanation, followed by examples and finally with exercises given. Nonetheless, the teacher tried to stimulate discussion with her students by asking mostly closed-ended questions to elicit responses. She also tried her best to ask probing questions to test her students’ understanding. It was very traditional based but the students seemed to have enjoyed it. What looked interesting was also the students’ behaviour in the classroom. They were very engaged and motivated to learn Mathematics even though in the opinion of the researcher the teacher did not fully maximize their potential during this lesson. The researcher, on the other hand faced little difficulty engaging them in a rich mathematical discussion.

*A student explains her answer to the rest of the class*

*Group photograph with the school principal*

*Students raising their hands to answer the teacher's question*

*A student being called to respond to a question posed by the teacher*

The next lesson observed was a Standard 10 lesson on Probability. In this lesson, the teacher tried to make a distinction between experimental and classical probability and she used the tossing of coins and drawing cards from a deck of poker cards to illustrate the concepts of probability/chance. The approach to the lesson was rather lecture style, in which the teacher did most of the talking and the students only responded when they were called by the teacher.

*Teacher using a deck of poker cards to illustrate the concept of "chance"*

**Discussion**

Both the Kendriya Vidyalaya IIT Powai and Atomic Central School-1 adopt the National Curriculum Framework that was prescribed by the National Council of Educational Research and Training (NCERT). Students in these schools used the same textbooks which were developed for the National Curriculum Framework. The use of scientific calculators would only be introduced in Standard 11 and 12 and graphing calculators would not be introduced within the curriculum at all. Nevertheless, the teachers shared that the students were quick in picking up the skills in operating a calculator.

In terms of the instructional approach, teachers in both schools were rather didactic in their lessons. There were very few opportunities for the students to investigate and discuss the mathematical concepts among themselves. All the classrooms in the two schools were

arranged in rows and columns which did not facilitate group work. In addition, the large enrolment of 40 students in each class proved to be a challenge for a teacher to manage class discussions or group activities.

Despite having to go through a traditional curriculum, students in both schools demonstrated positive attitude towards the learning of mathematics. In all the lessons that were observed, students paid attention in class and were very keen to learn. Teachers in the schools were well respected by the students and were often seen as the 'Guru', the main source of knowledge by the students. Many students in these schools were children of scientists and engineers and many of them aspire to be scientists, engineers and doctors like their parents. A casual conversation with the students and teachers led the authors to believe that social beliefs and parents' irrelevant expectations might be the key factors in shaping the students' aspirations and positive attitudes towards education. The authors had the impression that many of these students were trying to live up to their parents' or society's expectations rather than to follow their own dreams. They believe that by doing so they could ensure a better standard of living and secure a better future.

***School Visits in Jodhpur***

In Jodhpur, we visited the campus of the Global Indian International School which provided K-12 education. We had a discussion with a group of trainee teachers who were attending training workshops at the campus over the weekend. Here, more information about the teacher preparation were obtained. Approximately, 30% of the teachers in India are women and about 50% of the elementary teachers are graduates and more than 60% of the middle school teachers are graduates. Graduate teachers are required to go through 1 year of Bachelor in Education while non-graduate teachers have to go through 2 years of teacher preparation before they are certified to teach in the schools up to standard 10. Graduate teachers who wish to teach standards 11 and 12 are required to sit for the National Eligibility Test (NET) in addition to the Bachelor in Education. Teachers who wish to teach in the college are required to sit for the JRE (Junior Requirement Examination) but interestingly they are not required to have a Bachelor in Education. However, they must have a Master's degree in one discipline before they could sit for the JRE.

Even though calculators were only introduced in either Grade 11 or Grade 12, teachers shared that the students had no problem picking up the skills required to operate a scientific calculator. It was surprising to know that although the use of scientific calculator was introduced much later, students did not face much problem in mastering the usage of calculators. The authors hypothesized that one of the ways to ensure quality in the country's education was to prepare the teachers well through their comprehensive and structured teacher preparation program. All teachers who teach Standard 1 to 10 are required to obtain a Bachelor in Education and if they wish to teach Standards 11 and 12, they must pass the NET. This is to ensure that the teachers are equipped with both sound pedagogical and strong content knowledge, so that they could appropriately challenge students at high school level.

We also visited the Thar School in Osian which provided elementary education to children in the rural area. The Thar School was established in 2008 under the Thar Education and Development Society (TERDS) with the objective of providing quality education. One of the main objectives was "establishing a framework of creative learning process using processes, tools and technology in elementary education and then implementing and replicating this framework in the Schools of the Rajasthan, spreading the message of importance of literacy,

improving the teaching techniques, bringing in latest research in field of education to these schools, connecting these schools to the world's best teachers and labs" (TERDS 2010, p.1)

There were altogether 4 preparatory classes and one Standard 1, one Standard 2 and one Standard 3 classes. There were about 40 students in each class and each classroom has 2 rows of tables and benches. The students were mostly from families that engaged in farming and agriculture in the region. Although the medium of instruction is English in the school, teachers often had to use Hindi to explain English terms to the students as their language of communication was Hindi back home. There were far fewer girls in this school compared to the ones in Mumbai. In one of the classes that I observed, there were only 6 girls out of 43 students.

Teachers in the Thar School creatively used materials such as cardboards, strings and chalks to develop manipulative and materials for the teaching of Mathematics. The following photographs show some of the teaching materials developed by the teachers.


*These beads which were made out of chalks and strings were used to teach addition and subtraction*


*Teaching of place values using the numbers on the bus*


*Calculate and pick the bus with the correct bus number from the envelopes*

Although many teaching materials were being showcased in the classrooms, the author was not sure whether these manipulative were regularly used to engage the students. Given that there were so many students in one class, we would expect the teaching materials and manipulative to be well used and worn out. However, what was surprising was that the manipulative such as the counting beads looked rather new. Nevertheless, the ideas that the teachers had come up with were innovative and commendable.

Like the two schools that we had visited in Mumbai, the teaching approach used in the Thar School was also teacher-centred. The teacher did most of the talking and assigned individual work during the lesson. The teachers seldom assigned homework for the students as most of the students were not be able to get help or assistance in their school work at home. Thus all assignments were completed in class.


*Practicing addition in class on the board*

*A student working on the problem sum*

***India Institute of Technology Rajasthan***

The India Institute of Technology Rajasthan (IIT-R) was set up to produce scientists and engineers so as to support the economic and social development of India. Not only does IIT-R seek to be one of the leading technical institutions in India but also in the world. In order to realise this vision, three centres of excellence were set up:

- Centre of Excellence for Energy (Solar)
- Centre of Excellence for Medicine & Health
- Centre of Excellence for Education

IIT-R shared that they were embarking on 2 major projects at these centres of excellence, developing a low-cost (USD$35) laptops which they hope to distribute in the rural areas in India and developing high-efficiency solar cells which will be used by the department of telecommunications to meet the electrical needs in the rural areas.

To get admission to this institution is highly competitive. Out of 9000 students who applied for the college, only two would be selected. About 25% of the successful candidates are females and this trend seems to be increasing over the years. Students at the institution shared that the curriculum for their first two years of undergraduate studies is a broad-based one. For example a computer science student will have to take up courses on Engineering, Mathematics, Arts and Social courses and Human Resource courses. They will only specialize in their third year.

Students were also given opportunities to work with their professors on major projects such as the development of the software and hardware design for the low-cost laptop project. They also shared that they were encouraged to participate in at least one internship programme at a local or overseas industrial factories during their 3 years undergraduate studies. IIT-R shared that the courses were conducted in the forms of lecture and tutorial. With regard to the different modes of assessment, students were given regular quizzes and the final examination consisted of a paper and pen test as well as on-the-field practical examination.

**Conclusion**

Students in India were often engaged in drill and practice, and the lessons observed were teacher-centred. There were very few opportunities for the students to explore Mathematics beyond the regular classroom. Nevertheless, the students were very attentive in class and greatly respected their teachers. Like many other East Asian countries (Bishop 1999 & Leung, 2001) students in India greatly value education and they are generally highly motivated to learn. Teachers shared that they faced little or no difficulties in motivating their students and they received very strong support from the parents especially in the urban areas. On the contrary, teachers from the rural area shared that one of the challenges teaching in the rural area was to involve the parents. Very often parents in the rural areas were not educated and they were less interested in their children's education compared to parents in the urban areas.

Although some of the teachers that we came across during the school visits were rather conservative in their teaching approaches, we also came across teachers who were open to new ideas and keen to learn from others and that is the type of teacher that is admirable. The making of a good mathematics teacher takes beyond the teacher preparation programme and equipping with sound content knowledge. It is a journey that requires learning from experience, personal reflection and interaction with fellow educators. Most importantly, teachers should possess the intellectual humility to learn from fellow colleagues and even from their students. Knowledge and skills in teaching mathematics is not finite. There are always new things for one to discover in a mathematics classroom!

**References:**

Banerji, R. (2000). Poverty and primary schooling: Field studies from Delhi and Mumbai. *Economic and Political Weekly, 35*(10), 495-802.

Bishop, A. (1999). *Values in Mathematics Education: Making Values Teaching Explicit in the Mathematics Classroom*. Retrieved on Nov 15, 2011 from http://www.aare.edu.au/99pap/bis99188.htm

District Information System for Education (DISE). (2008). *Analytic Tables*. Retrieved on April 30, 2011 from: http://www.dise.in/AR.htm

Heitzman, J. & Worden, R. L. (1995). *India: A Country Study*. Washington: GPO for the Library of Congress.

Juneja, N. (2001). *Primary education for all in the city of Mumbai, India: The challenge set by local actors*. Paris: International Institute for Educational Planning/ UNESCO.

Leung, F.K.S. (2001). In search of an East Asian identity in mathematics education. *Educational Studies in Mathematics*, *47*(1), 35-51.

NCERT. (2005). *National curriculum framework*. National Council of Educational Research and Training.

Raman, M. (2010). *High Achievement in Mathematics Education in India*: *A Report from Mumbai*. Journal of Mathematics Education at Teacher College. Fall-Winter 2010 International Issue. New York.

TERDS (2010). *Thar Education and Rural Development Society*. Retrieved on 15 July, 2011 from http://www.terds.org/wwd_education.htm