Pedagogical Innovation can make Primary Mathematics Adaptable

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Abstract

Mathematics is considered to be the most difficult subject to study. General perception is that mathematics is not made for all, whereas, the reality is that basic mathematics is not difficult for anyone. In fact, mathematics is required in every aspect of our life and learning basic mathematics is one of the emergent requirements of the modern era. Fear from mathematics or say 'math anxiety' is a bigger problem for a teacher rather to tackle a student who is bad in mathematics. We have tried to examine the situation and provided certain steps which a teacher may adopt so as to overcome the problem. In our view, with some changes in the teaching techniques, with use of certain devices and systemic improvement the scenario can be changed. We highlight the problems being faced in teaching of mathematics, especially in teaching of primary mathematics, and provide solutions to overcome these problems. It must be an endeavour of every teacher to present mathematics in the plate of every child with proper garnishing of supporting devices so as to make it adaptable for all.

INTRODUCTION

Mathematics is often considered as the most difficult subject to study. It is a common belief that some special skill or aptitude is required to learn mathematics. Such presumptions may be true to some extent, but not acceptable in toto. Due to some inherent skills or zeal someone may excel in the field of mathematics.

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This, however, does not imply that others cannot do mathematics at all. Just like the fact that a few among us are good players, few others are good dancers or writers or actors or teachers etc.; some of us may be good or excellent in mathematics. All of us may not excel in the field of mathematics. But, there are no reasons to keep ourselves at a distance from the perception that mathematics 'it is a difficult subject', which is still prevalent in the society. Basic mathematics is not difficult to learn. There may be a possibility that some persons may learn mathematics with less effort but others may require more efforts or some special efforts just like the fact that some of the children start talking their mother tongue earlier as compared to the others. The parents start making some extra or special efforts to make their child talking their mother tongue. Same happens with mathematics also. In the present scenario, the mathematics has become as important as the mother tongue and the basic knowledge of mathematics is required in almost all spheres of life. From purchasing grocery from a local store to launching a satellite, mathematics is required everywhere. Life cannot be imagined without mathematics. Therefore, it becomes necessary to make learning of mathematics children friendly and to find out the reason as to why most of the children still keep mathematics at a stone's throw and have a fear from learning mathematics.

We are living in a time of revolutionary, extraordinary and accelerating change, in which, the need to understand and use Mathematics in everyday life is continuously and rapidly increasing. Basic knowledge of Mathematics has become an essential requirement for smooth functioning in day to day life. Imparting mathematics education has become an important task because it, if performed properly, may result in popularisation of mathematics among the people and 'mathematically educated' people may make any country strong and advance. Mathematics education at primary level plays a pivotal role, because it has the privilege to lay the foundation over which the entire building of mathematical concepts and procedures is erected. Mathematical education at elementary stage is aimed at preparing the children for the challenges they face in the life. Mathematics Knowledge and Skills refers to the conceptual understanding of numbers, their relationships, combinations, and operations. Mathematics also includes shapes and their structure; reasoning; measurement; classification; and patterns. Math skills during the early years help children to connect ideas, develop logical and abstract thinking, and to question, analyse, and understand the world around them. Math knowledge, interest, and skills are basic to children's success in school and in later life. Early math skills are highly predictive of later

academic achievement – not only in the field of mathematics but in multiple subject areas.

There is broad consensus among the policy makers, curriculum planners, school administrators and the business and industry leaders that mathematics is an important element of the school curriculum. The objective of mathematics education in school is to bring clarity of thoughts among the pupils so that they can think mathematically and pursue their assumptions to logical conclusions. There are many ways of thinking and the kind of thinking one learns in mathematics is an ability to handle abstractions and an approach to problem solving.

According to the National Council of Teachers of Mathematics (NCTM), the school mathematics is based on the six principles (NCTM) – Equity, Curriculum, Teaching, Technology, Learning and Assessment. Excellence in mathematics education requires equity. All students, regardless of their personal characteristics, backgrounds or physical challenges, can learn mathematics when they have access to high-quality mathematics instruction. Equity does not mean that every student should receive identical instruction. Rather, it demands that reasonable and appropriate accommodations be made and appropriately challenging content be included to promote access and attainment for all students. A curriculum is more than a collection of activities; it must be coherent, focused on important mathematics, and well articulated across the grades. Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well. Students' understanding of mathematics, their ability to use it to solve problems, and their confidence in doing mathematics are all shaped by the teaching they encounter. Technology has become essential in teaching and learning modern days mathematics. It influences the mathematics that is taught and enhances students' learning. Students can develop deeper understanding of mathematics with the appropriate use of technology. Assessment is another important aspect of learning mathematics. Assessment should support the learning of important mathematics and furnish useful information to both teachers and students. Periodic assessments inform and guide teachers as they make instructional decisions.

Some People cannot do Mathematics : A Myth or Reality?

In our daily life we come across many people who say that 'I am not good at mathematics'; or 'Mathematics! it is not my cup of tea'. It is true that some people are better at mathematics than the others – just like some are better than others in singing, dancing, painting, running and playing a

particular game etc. It is also true that learning mathematics does not come as naturally as learning to speak and it requires some efforts and, of course, a considerable period of time.

However, the notion that 'some people just cannot do math' is a myth (Willingham, Daniel T. 2009-2010) Virtually, everyone is fully capable of understanding arithmetic procedures, algebra, geometry and probability deeply enough to allow application to the problems in our daily lives. Place 2-3 chocolates at one corner of a table and 5-6 chocolate at another corner. Then bring a child of less than 2 years near the table and tell him to grab one set of chocolate. You will notice that the child will go for the bigger one. Again take two pieces of sweets or chocolate such that one piece is slightly bigger than the other. Take both the pieces in your hands and offer one of them to a small child. Any child who likes sweets/chocolate will go for the bigger one. These examples show that basic concepts of mathematics are inherited among all of us. In fact, it is one's own perception that he/she can't do well in mathematics and such perceptions are often wrong. Role of a teacher is very important to cultivate the habit of doing and enjoying mathematics among the students and to realise them that of course they can do well in mathematics, in as much as they are able to do in other spheres of their lives.

Our country has great mathematicians. Bhaskar, Varahmihir, Aryabhatt, Narayan Pandit, Boddhayan, Ramanujan, Chandrashekhara and a large number of other Indian mathematicians of antiquity have done a lot which has placed India in a respectable position in the international mathematics. Our great mathematics heritage shows that genetically we are not inferior to any other community in the world. Then where is the problem that our children are having a fear from mathematics. Why we are not able to produce the quality children with a passion in mathematics as are being prepared at Finland, Japan and Hungary. As far as primary mathematics is concerned, we can show better results by using some innovative ideas in teaching so that each and every student can take part in the process of learning and start taking interest in mathematics. If at the primary stage a child starts thinking mathematically and takes interest in mathematics, he/she would be able to explore the vast kingdom of mathematics in the higher classes with great enthusiasm. A teacher plays a crucial role here in laying foundation stones of mathematics in the minds of the tiny touts.

Expectations from a Math Teacher

Question arises now as to what a teacher is required to do so as to make the mathematics interesting and understandable for the kids. What innovative ideas and techniques can be used to strengthen the concept and

knowledge of mathematics among the kids? We point out some of the pedagogical methods, which may help in making primary mathematics enjoyable and understandable among the kids.

'Learning by doing' is very effective methodology in teaching learning process as the experience gained through practical course remains permanently affixed in the minds of the children. Mathematics should not be taught like an abstract subject and instead each and every aspect must be explained with the help of practical exercise, pictures, stories and using audio visual tools so as to conceptualise the aspect. Once a concept is made in the mind of kids and gets picturise in their mind they would be able to recall it any time. This not only helps them in solving the related problems but also makes them able to correlate one aspect with others and he starts enjoying mathematics. Teachers are the single most important resource for developing students' mathematical abilities. By attending to the differing needs that derive from home environments, languages, capabilities, and perspectives, teachers allow students to develop a positive attitude to mathematics. A positive attitude raises comfort levels and gives students greater confidence in their capacity to learn and to make sense of mathematics.

Young children are drawn to things that are colourful and interactive. A teacher should make full use of such instinct to push math related games to them. Use of graphics, computer and internet may be useful in this regard. Many times we know that our child needs cereals, vegetables, fruits etc for the purpose of nutrition. However, the child does not like the taste and keeps away from the nutritious food. Then what we do, do we start him giving lessons on the importance of nutritious food or their requirement for the body? No, because the child is not mature enough to understand all these things and such lessons will not serve the ultimate purpose. We simply start preparing food according to his taste ensuring that he gets all the essential nutrients and try to develop her taste buds towards the food which is good for health. With the passage of time he starts adapting the taste of the food and the purpose is served. Same happens in case of mathematics. Mathematics is not a preferred subject for most of the children, yet it is a 'must required' and 'nutritious' from the point of view of developing logical and scientific approach. Therefore, basic mathematics is required to be made adaptable for all. Like an apt mother, who uses various recipes to provide the nutritious food for her kids, it is the duty of a teacher to devise and use the colours, information technology, manipulative, pictures, games, cartoons etc., towards which the children are normally get attracted and start taking interest, to make mathematics adaptable for them. A teacher must use various devices and

techniques to make her presentation attractive just like garnishing is done to present the food in better manner.

Nobody likes to do things that they think they are not good at. If our child has always done badly in math questions, especially problem sums, then it is natural for him to dislike math. It is the duty of a teacher to determine when and where the child started to perform badly. This is very crucial because it indicates that the child may not have conceptualise certain concepts well, which might be affecting his/her ability to understand deeper mathematical concepts. Once the teacher finds the points where the child is experiencing difficulty, the child should be allowed to attempt very easy question for the concept. Every success builds the confidence of the child and plants an important thought in her mind 9that I can now solve questions that I couldn't before. It is now time to give reward to the child for each success to motivate him to climb further. For e.g., If a child could not understand the concept of Place Values, he may have difficulty while solving big addition or subtraction problems.

Innovative teaching aids and projects of math's laboratory plays a vital role in the conceptualisation process as recommended by NCF 2005 also. For this purpose a classroom can be made a resource room. Multi-purpose sets of materials collected and made by the teacher can be kept in the classrooms which can be used for various mathematical explorations and tests. Some materials which may be very useful in multiple ways include:

- Bag of counters/bottle caps/tamarind seeds and small baskets
- Abacus or UTH sets: Unit, tens and hundred cubes and about 200 additional unit cube blocks
- Mala-moti sets, mala-moti cards
- Basic geometrical shapes: triangle, square, rectangle etc.
- 1-100 number card
- Small cards/tokens with numerals from 0-200, and in multiple sets
- Flash cards or erasable cards and marker pens for writing numbers, small problems, shapes, names, for use in sorting based items
- Match-sticks in large numbers
- 3-D shapes in various sizes
- Cloth pieces and cloth bags, string, pins, chalk etc.

The NCF 2005 emphasises that children's experience of school education must be linked with the life outside the school, to make the learning experience joyful. With this perception in mind, several opportunities may be provided to students to construct their systematic knowledge by engaging them in activities, experiment, projects, field visits, discussion with peers and teachers, group work, enquiring, listening, thinking etc. The examples provided during the teaching must be related with the family and social background of the child. To illustrate our assertion, we give an example:

Example 1

Suppose while teaching mathematics in some village, a teacher gives a problem to the students – 'if 8 pizzas are to be divided among Ram, Shyam, Sohan and Mohan so that each of them get equal share then how many pizza will one get?'

This may be a good example to illustrate the process of division. However, the main point here is that the children who are being taught should be familiar with pizza. Pizza has become a routine part of our eatery in the urban area but it is not so easily available to the rural children. The point we want to argue here is that if this example is given to rural children who have never seen pizza, their maximum attention will be towards the pizza and they will hardly pay any attention to the aspect of division for which the example was formulated. Such examples are, therefore, not purposive or fruitful. Instead these create more complexities and, therefore, needs to be avoided. Finally the conclusion we draw here is that the mathematics teaching must be supported by examples and examples must be essentially from the domain of daily activities of the child.

Further, suppose the parents of a child earn their livelihood by ironing cloths. As usual happen among the child, after going back from school sits with his parents at the kiosk and sometimes help them in returning the cloths to the neighbours and get money from them. Without having much idea about the multiplication or division or subtraction such children are able to calculate the amount due or the amount to be returned etc. Suppose the child of this environment is introduced the concept of division, multiplication, addition or subtraction in the background of the professional skill inherited by him, it may be interesting and easier for him to learn.

ASSESSMENT IS IMPORTANT

Assessment is essentially a process of gathering information. In the assessment of learning, if marks alone are used they do not tell us much about what is being learnt or how. Even the child's statement 'I don't know' provides us valuable information, and we must not mark 'zero' for the question. In addition to telling us that the child does not know the answer, it does tell us that the child is confident and comfortable enough to say that he does not know.

Give a problem to the students and then watch for their response. Each child is to be observed separately as a separate entity and thereafter, required to be guided accordingly. One example follows :

Example 2

Suppose a classroom has 3 windows at one side wall of it, each window has two pans and each pan has 3 glass pieces. Suppose the students are given a problem to count total number of glasses on the basis of the information provided as above.

The problem may be addressed in different ways by different students.

Student I may first calculate the number of glasses in one pan 1 + 1 + 1 = 3. Then she may calculate the number of glasses in one window by either adding 3 + 3 = 6 or by multiplying 2 x 3 = 6. The he may find the total number of glasses by adding 6 three times or by multiplying 6 and 3.

Student II may first calculate the total number of pans by multiplying 2 and 3 to get 6 and then she may find the total number of glasses by multiplying 3 and 6 or by adding 6 three times.

Student III may draw picture of the pans of the window and then calculate the total number of glasses by counting them in the figure drawn by her.

Student IV can count the number of glasses just pointing his finger towards the wall and pans and write the correct answer.

There may be several other methods and several students in the class may not have attempted the question. The teacher is required to interact with every children explaining him all the possible methods and comparing them.

Before starting any topic or any presentation before the students, a teacher must always think over the following:

1. Is there some new way in which I can present this material in order to make it more meaningful and more interesting?

2. What activities, demonstrations, teaching aids, etc. would enrich the classroom presentation and divert the attention of students towards what is being taught to them?

3. How to conceptualise the subject matter to the students so that every student can follow something which is being taught and associate himself from learning?

Once the teacher discovers innovative ways to arouse interest and enthusiasm in the class, mathematics becomes interesting and adaptable.

The learning of mathematics requires three types of knowledge – factual, procedural and conceptual (Willingham, Daniel T. 2009-2010). Factual knowledge refers to the answers ready in the memory of simple problems of addition, subtraction, multiplication and division. For e.g., $1 + 1 = 2$, $2 \times 2 = 4$ etc. The answers are not calculated but retrieved from our memory. The procedural knowledge refers to the knowledge of the sequence of steps by which a problem is solved, whereas the conceptual knowledge is clear understanding of each step and the fact that why the step is required.

Of the three type of knowledge mentioned, the conceptual knowledge is the most difficult for the students. A teacher plays an important role in imparting the conceptual knowledge. In our country, the primary mathematics, which is the foundation of mathematics, is suffering from

various problems. As highlighted in the *National Curriculum Framework, 2005* and the Position Paper presented by the National Focus Group on Teaching of Mathematics (NCERT 2006) the following are the core areas of concern in primary mathematics:

i. A sense of fear and failure regarding mathematics among a majority of children,

ii. A curriculum that disappoints both a talented minority as well as the non-participating majority at the same time,

iii. Crude methods of assessment that encourage perception of mathematics as mechanical computation, and

iv. Lack of teacher preparation and support in the teaching of mathematics.

All these problems, except that related to the curriculum, can be addressed by using innovative pedagogy. A teacher who is committed can make changes with little efforts.

Role of a Teacher is Important

A teacher is required to respect the level of knowledge and the ability the children have, the background and the culture they are coming from and then try to create harmonious environment in the classroom which can help to increase the level of mathematics in each and every student. The teacher is an important tool which helps the student to improve his/her mathematical skills. She should prepare the lesson plan in such a way that it must contain something for everyone. At one place, the lesson plan must be prepared keeping in view the weakest student of the class, but the brightest student of the class must also get something interesting and challenging in it, otherwise he will remain cut off from what is going on in the class. Preparing a food tasty for a group is not enough, unless it is served properly and everyone in the group finds something of his or her interest in the menu. Likewise, the lesson plan may first be prepared carefully and the delivered properly so that every child must get something interesting in his or her plate. During the entire course, if the teacher is able to develop the taste buds of the child towards mathematics, the purpose is well served.

We now share, in the form of following example, an experience, the first author had during the course of teaching a class and making assessment:

Example 3

Suppose Kanika is said to write seven hundred two and the response she gives is 702. Then she is told to write seven hundred twelve and she writes it as 7012. Suppose another student Amit is told first to write seven hundred twelve and he writes it correctly as 712. However, when after writing 712 when he is told to write seven hundred two, he writes it as 72. Surprisingly, when he is told to read what he has written, he reads it

correctly as 'seventy two' and realises that he has written seven hundred two incorrectly. After realising his mistake, Amit may write seven hundred two as 7002.

The important point which is noticed here is that if the traditional method is used for assessment Kanika writes seven hundred two correctly whereas, she cannot write seven hundred twelve correctly whereas in case of Amit he can write seven hundred twelve correctly but is unable to write seven hundred two. However, if thorough and child centric assessment is done, it is found that both Kanika and Amit have not conceptualised the notion of place value of numbers and learning of place value is required to overcome the problem. In fact, the teacher may test their abilities to recognise the numbers like 678, 302, 320, 9005, 9025, 9154 etc. and it can be find out whether the children are able to recognise the numbers correctly, whether the problem is in recognition or it is in writing or in both. Necessary exercise may then follow accordingly.

Another important point we would like to mention here is that during the interaction between the teacher and the students, each and every child is required to be taken as single entity. The teacher must understand his or her individual depth of knowledge or understanding and the way of his/her thinking before imparting any new concept. To explain in better way, we cite an example.

Example 4

Suppose the following figure was shown to four students – Zakira, Arjun, Rashmi and Dhruv and they were asked to tell the faction of the shaded portion in it.
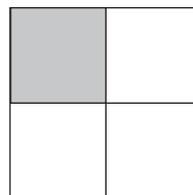
The answers given by Zakira, Rashmi and Dhruv are 1/4, 4/1 and 1/3 respectively, whereas Arjun has not given any response. The students are asked for the reasoning adopted by each of them for giving the answers. It is found that the Zakira has clear concept about the factions. Rashmi too knows the factions, however, she is little bit confused about writing it – whether it should be 1/4 or 4/1. Dhruv has written the answer as 1/3 because in his view 1 portion is shaded and 3 are not shaded. Arjun could not respond as he has no concept about fractions.

The important point we would like to mention here is that even if the final responses given by Rashmi, Dhruv and Arjun are incorrect, all of them require to be taught in different manner to clarify their concepts. Rashmi is required to be taught the fraction x/y like 'x out of y' or 'x parts out of total y parts' followed by other similar picture problems. Dhruv may be explained like that before shading

the portion, there were 4 equal portions and out of these 4 portions 1 has been shaded. Therefore, in terms of fractions it is written as 1 out of 4 or 1/4. As far as Arjun is concerned, he is required to be taught the concept of fractions afresh. Thus the assessment gives us feedback about the level of understanding or knowledge what a particular child possesses and provides us a direction to teach the child further. As per the traditional method Rashmi, Dhruv and Arjun all are on the same footing, as all of them have answered incorrectly. However, as elaborated above, the assessment shows us that Rashmi and Dhruv are not completely incorrect. They need to remove slight doubts in conceptualisation of the notion of fractions.

Use of Representations

A teacher must be encouraged to create an environment where student can learn mathematics with understanding. True understanding occurs when students are able to use what they know and apply it to new situations (Perkins D. 1993). It is also important that the students must be provided sufficient opportunities to show their understanding to ensure that they are constructing knowledge upto the desired level. Research has established that to make the grasping and understanding easier, mathematical ideas can be represented with the help of external and internal representations (Putnam, R.T. et al. 1990). External representations include manipulatives, pictures, diagrams, spoken languages and written symbols (Lesh and Behr. 1987), whereas the internal representations include mental models and cognitive representations of the mathematical concept (Putnam, R.T. et al. 1990). A way to make easy to understand and conceptualise learning is using external representations in teaching. Research on learning with representations has shown that when learners are taught with an appropriate representation, their performance is enhanced. Recent research is focused on learning with more than one representation. Use of Multiple External Representations (MERs) is being considered an effective tool of learning (Ainsworth. 2006). For further reading on MERs we refer (Ainsworth. 2006) and (Ainsworth *et al.* 2002). The effectiveness of a representation depends on the information provided in the representation and the way it is presented. A representation may be in form of a multi-media system which can display pictures, text, animations, sound, equations and graphs etc. Computers, power point presentations on big screens, charts, 3 D shapes/structures etc maybe used as external representations. A teacher must carefully select the external representation or a combination of external representations keeping in view the topic to be delivered and the background and knowledge level

of the children to be taught. Case study can be done to analyse as to which representation(s) is best suited for the children in order to make the topic interesting and help the students to understand the same. It is commonly seen that the people who are not formally educated often use many modes of mental mathematics for measurement, estimations, calculations etc, are called *'folk algorithms'* (NCERT. 2006). If the children come from such families/environment, such *'folk algorithms'* may be used as representations to inspire and motivate the formal learning.

Math Phobia IS A BIG HURDLE

There is no doubt about the fact that mathematics makes some children very anxious. For many people 'math' is a scary four letter word. They do not like it at all, they have a strong feeling that they are not good at it and they simply want to stay away from it. People who feel tension, apprehension and fear of situations involving mathematics are said to have 'math anxiety'. Students with a high degree of math anxiety perform worse in mathematics from elementary school through college, relative to their less math anxious counterparts (Maloney and Beilock. 2012). Math anxiety is not confined to a particular group or a country, but it is a global phenomenon. Caution here is that math anxiety is not solely related to being bad at mathematics.

In fact, *'math anxiety'* is more than 'being bad in mathematics.' Someone may have been better in mathematics if he/she was not so anxious about mathematics. Study has shown that the kids with highest level of working memory or say most cognitive horsepower are most susceptible to math anxiety (Ramirez et al. 2013). Math anxiety depresses math performance because it eats up the working memory space. Therefore, the impact would be lesser for those having lesser working memory space. Due to fear for mathematics and subsequent degradation in performance, even a bright student can succumb to the math anxiety if not taken care of properly. The role of a teacher is very important to find out whether the child is suffering from math anxiety. The child needs to be first boost up by asking what he knows and appreciating him for that. Then he must to be introduced with the subject and then gradually but in slowly pace he must be taken to the depth of the topic keeping in view his adaptability and appetite. Research has shown that math anxiety is more strongly linked to poor performance when kids take a timed test (Faust et al. 1996). Therefore, initially, such timed test must be avoided and the kids may be given sufficient time to do the task. Further, careful and thorough assessment of the kid's response is also required to be done. He should be appreciated/rewarded for every correct step he thought/

expressed/ wrote. Initially, help may be extended to him/her by giving clues and by communicating with him/her.

Link Learning with Real-world Applications

The learning of mathematics becomes ultimate when it is connected to its practical and real-world applications. A teacher should develop real-world examples to explain any aspect or phenomenon. Mathematics is in the core of our day-to-day life and life without mathematics cannot be imagined. There are a number of examples around us which may be quoted as real-world application of mathematics.

Today mathematics is considered one of the most important subjects. Basic knowledge is required in every aspect of our life and everywhere there is a scope of use of lot of mathematics. The problem is that learning Mathematics is not in the schedule of most of the people and there is a fear of difficulty and failure. Teachers are the most effective tool to help the society to overcome the problem. While teaching mathematics, the students, particularly the kids are to be taken care of particularly of the aspect that there should be no fear of mathematics and he must enjoy doing mathematics. Mathematics must not be taught just as a subject, the focus must be on the aspect that it should improvise the logical and analytical ability of the child and be able to mathematise his thoughts. The teaching of mathematics must not be focused on merely solving problems given in the text book, but the Endeavour should be focused towards conceptualisation of the fundamentals and creation of a positive approach towards mathematics.

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