When there are no negative consequences for saying something, the real exploration of ideas begins. Sometimes, a really bright child gives a most wonderful answer, with all the 'ifs' and 'buts' covered. Tempting though it is, the teacher would do best to not acknowledge it as such right away - until the rest of the class is asked what they think. Otherwise no one is motivated to seek an answer of their own. And of course one should acknowledge the first answer after all have had their say.

In such a classroom environment, the teacher knows what children think. Why is it important for the teacher to know this? After all, curricula are designed, textbooks written and prescribed by someone else, often someone far removed from the actual teaching. But that is precisely why teachers, who are the last and most vital link in this long chain, should be aware of what worked and what failed. Who is better placed than a teacher to give feedback to the 'system'?

> *"Just because something doesn't do what you planned it to do doesn't mean its useless."*
>
> *- Thomas A. Edison*

This culture of the classroom reaps rewards far, far greater than just the discovery of what children's alternative ideas are. Children get truly actively engaged in the class. They know their ideas matter. They learn to resolve cognitive conflicts, to critically evaluate others' and their own answers.

And thus begins their journey towards the wonderful exploration of the world that is science.

Jyotsna Vijapurkar is on the faculty at the Homi Bhabha Centre for Science Education, TIFR. Her major project currently is curriculum design and transaction, based on intensive classroom research. She can be contacted at jvijapurkar@gmail.com.

From the real to the abstract

G.S. Jayadeva

I do not actually hate mathematics, but for a long time I believed that I hated the subject because of various reasons. The strongest reason was the very process in which maths was taught. Especially, the tyrant teacher and his stick made maths the most formidable subject. In retrospect, nearly forty years later, I understand that I certainly was capable of learning mathematics quite well. It was my bad luck that every other incident during my school days made me believe that I could never learn maths, including the deep sympathy shown by all my well-wishers.

What went wrong? The answer to that is actually quite simple. The numbers never represented any tangible object of perception, but were mere signs that floated in a lifeless void like disentangled pieces of a complex puzzle. There was no reason why they had to be put together, and even if they were, were as lifeless as before.

Being an ardent student of science, I realized the importance of maths later in my college days, but it was too late. If this would have been taught to me as something related to my day-to-day life experience, I probably would have learnt it.

With this experience in my mind, we are now trying to make maths a true learning experience of immense joy and fun for children in Deenabandhu school, Chamarajanagara. Lessons of maths are given in a guise of biology that offers vivid experience.

Different types of dicot seeds are planted in a glass jar so that children can observe the growth of roots and shoots simultaneously. Seeds of beans, peas, green gram, etc. are planted. Every day, children measure

(and keep a record of) the growth of roots and shoots. It is interesting to observe that the roots of some pulses grow much faster than their own shoot in the beginning, while, in about a week's time, the shoots overtake roots.

This process of observation and recording gives children an opportunity to learn the skill of measurement and of recording data accurately. They also learn to recognize patterns in a biological phenomenon and hence learn to predict results in a similar situation. Apart from this, we could draw a vital link to maths through this biology experiment. The growth of the roots and shoots, recorded as centimeters, are no doubt numbers. Yet these are not lifeless numbers, but represent a live phenomenon. Using these data, children developed a bar graph and a line graph. These graphs paved the way for a very active discussion among the children. There were no ready answers for many questions and we learnt that science is not always about the answers, but can also be built around questions that cannot be answered instantly in a classroom situation.

There was a question about the bar graph and the line graph. If a bar graph explains everything, why do we need a line graph? Children were allowed to discover it by themselves. One of them quickly recognized that while the bar graph gives an over all picture of the phenomenon, the line graph could throw light on variations that occurred during the period of observation. Thus, it was inferred that the curve graph reflected the *process* rather than just the *end result*.

Needless to say, the numbers in this experiment represented an unforgettable phenomenon. Hence, these 'living numbers' could be harnessed for more mathematical understanding. The same numbers were used to learn ratio. Ratio of the growth of roots and shoots could be derived from these numbers; here again, the meaning of the ratio comes in relation to a phenomenon and it is not just a play of lifeless numbers.

> *"A scientist in his laboratory is not only a technician. He is also a child placed before natural phenomena which impress him like a fairy tale."*
>
> *- Marie Curie*

Similar experiments were conducted to understand the concept of ratio. For example, children undertook an exercise of measurement of the length of the head and the body, of children of different age groups. The length of the head attains its maximum very early , say by six or eight years. However the body elongates until the age of 18 years. Even the school teachers were measured for the length of their head and body! In this experiment also, the numbers were not lifeless. At the same time, we debated as to why the head has developed to its maximum size at such an early age. How many neurons are there at birth? Do neurons increase in the life time of an individual?

This kind of scientific understanding of mathematics, at the primary school level, provides children a sound foundation to better understand higher, more complicated and abstract, mathematics and science at the later stages of their education.

G.S. Jayadeva founded the Deenabandhu Trust (http://www.deenabandhutrust.org) in 1992. They are presently working in association with the National Institute for Advanced Studies for improvement of primary education in Chamarajanagar district of Karnataka. He can be contacted at gsjaydev@rediffmail.com