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## Introducing the unknown and the unknowns in teachers professional development

*By S. Sreekanth, 31st August, 2017*

This was an Urdu medium government Higher Primary School in a district in Karnataka. I attended a Class VII Mathematics period which went on for around an hour, amidst the constant drum-beating from the Ganesh pandal, which was located right outside the school wall. The teacher was introducing Algebra to the students.

She started with the question “What is Algebra?” and she herself answered the question “It is a way to find out the known from unknown in Mathematics”. She repeated it and got the students also to repeat this as is usual in many schools. Teachers often speak in a certain tone indicating clearly to children that she expects them to repeat after her. She briefly touched upon the history by saying this was a technique that comes from Al-Jabr who is an Arabic mathematician. Subsequently she briefly says that in certain situations we do not know the numerical value of something so denote that by “x” or any alphabet from a to z. She tried to give an example, how many children are in this class. The answer 12 came and so she had to modify it to say that if I don’t know how many students are there then I would say x students. Then she says why this is useful. She asks a student her age. “12”. Of then if we have to find out how old you were 5 years back, then we can use this. Immediate answer comes saying 7 years. She writes the expression on board  $12 - 5 = x$ , then says now  $x = 7$ . That’s how it works.

She then goes onto introduce many words and their meanings in this context. Terms are x or 3t or 5 etc. Expressions are  $3x+4$  or  $2t +3s$ . Depending on number of terms, an expression can be called monomial, binomial, trinomial or polynomial. Equations are when we equate expressions. Coefficients mean 3 is coefficient of x in  $3x$  and x is coefficient of 3 in  $3x$ . This part of the class was just her taking these terms one by one and explaining what it is and moving on.

She then made them do an exercise of separating terms from an expression. Matters like  $3x-5$ , will be separated as  $3x$  and  $-5$ , and that we need to pay attention to the sign of the term as to whether it is + or -. She also made them add terms like  $3x + 5x$  to form  $8x$  etc.

By chance one of the co-visitors with me, took a mock class in the same class few hours later. He saw Algebra written on the board and so gave them an equation to solve something like,  $5x + 3 = 3x + 7$ . Children weren’t yet introduced to equation solving and they had no prior exposure to algebra. So they tended to add  $5x + 3$  and write it as  $8x$ . But then my co-visitor realized that Algebra was just introduced and so he moved on to something else.

These are some of the thoughts that came to mind on watching this class in action.

First is on the history of Algebra. “al-Jabr” was actually part of the name of the book from which the word Algebra came. Author was none other than al-Khwarizmi. The history of Algebra is of course quite complex, as it can go back to Babylonia, Greece, China and India. Though it does find a clear articulation in al-Khwarizmi’s work, sufficiently enough for the area itself to get its name from the name of his book. I got curious and took a look at the chapter in the state textbook. It had a boxed item on the history, which mentioned first the Indian mathematicians and how it was there in India as Beejaganitha. Subsequently there was reference to François Viète and modern algebra. Not having any reference to al-Khwarizmi and the Arab mathematicians was quite striking. In sharp contrast,

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the teacher only referred to the Arab author, even if she got the name a little mixed up. But of course the history is a lot more than getting the names right. The history of how an idea (like Algebra) emerges, particularly, what are the human, practical, relevant or aesthetic issues, problems or needs that these respond to are never given much importance in my experience of sitting in such classes. The problem which we could pose to ourselves, to which this method comes as an answer is often not the priority in introducing a new idea. The idea anyways has an independent existence, being a chapter in the textbook, and so it is introduced not so much because it has human relevance, but because it has to be done and done with. I was left with the distinct feeling that the history of how different civilizations faced particular issues, whether in sea navigation or in predicting the weather for agriculture or for making perfect structures with religious or cultural significance, could have enlivened such a classroom a lot.

The approach used also reminded me of a particular issue pointed out by Prof. Rohit Dhankar in one of his papers titled “The Teaching and Learning of Mathematics” written some 25 years ago.

*“...mathematicians have developed systems of notations which pack a lot of information together, maintain the clarity and precision of the system and allow accurate manipulation of concepts. This they achieve by creating symbols for everything including the rules of manipulation. And do it so successfully that one can carry on the routine manipulations automatically, so much so that a mathematician can afford to let go of the concepts attached to symbols, perform his operations only on the symbols and still follow all the rules correctly and decipher the meaning contained in a string of symbols at any stage he likes.*

*Thus a formal language is developed which can express the mathematical structures in remarkably regular patterns. But this achievement of mathematics can also turn against the understanding of mathematics. The whole structure has regular patterns; the symbolized rules are easy to remember and apply; the children are good at memorizing. While on the other hand organizing experiences and undertaking conceptual analysis are difficult tasks; often unpleasant, demanding concentration and discipline, and building of concepts may consume time. Therefore a teacher who teaches mathematics as a system of meaningless symbols that is mechanically manipulated can achieve ‘good’ results in terms of marks obtained and still may spend little time and energy.*

*And that is how mathematics is being taught in most schools today. This approach works well initially. Then volume of things to be rote learnt increase, becomes too much to handle, the child loses the track of meaning. Further learning stops and the child gets frustrated.*

*On the other hand, the learner who keeps track of meaning through adequate conceptual structures and practices operations to the point of being automatic can keep his mind free from the routine and pay more concentrated attention to the new things he is learning now. And therefore learns faster.”*

In short that how while introducing say Algebra

- how the unknown comes about in real life (E.g. we haven’t got a chance to count the number of people in a bus and hence it is unknown) and

- also how along with additional information, we can form an expression (E.g. 3 people got down in one stop and then we got to count the people remaining in the bus and it was say 10; hence the expression  $x-3=10$ ) and how we can then solve such an equation.

These represent the concept. The  $x$ 's and  $3x+5$ 's represent the symbols. The manipulation of the symbols can be very much picked up if one learns the basic rules, without the concept being kept in mind at all stages.

In this example, this was the very first class on Algebra and so is it too much to expect? Maybe not, as it is at the beginning stage that the basic issue of the "unknown" should become clear. Later after introducing many other concepts and also doing many mechanical tasks – "meaningless symbols that are mechanically manipulated" as Rohit calls it - then to come back to unknown would be less productive of understanding than being clear about it right away. Interestingly this lack of clarity on what is it that we denote as  $x$  also led to the confusion of doing a mathematical operation without a meaning i.e.  $5x+3$  becoming  $8x$  later. Here again having such a misconception can be treated as fine as it is the very first class. However the issue is that given the syllabus and the time-table, this is unlikely to be easily revisited. However this particular misconception itself may get corrected when the teacher sees the student in a later class making this mistake. She may then say that you can only add the coefficients of  $5x$  and  $3x$ , not if the terms are  $5x$  and  $3$ . However this again is just what is called "procedural" understanding. The concept may still not be clear. The concept begins with how  $x$  comes about, and how  $5x$  comes about and the matter is understood or missed right there.

To be fair, we have to also locate the teacher more appropriately. The details of her context became clear in the later conversations with her and the situation is quite typical of teachers and head teachers. She is a very committed person, who is quite in charge of the things at the school playing the role of the head teacher. She comes on time, is seldom absent and does all her duties as required of her. The students are mostly children of migrant labour from other states and so are often away for 2-3 months at a stretch, losing many school days. The teachers of the school have to do extra for the students to catch-up when they return. The students are confident, articulate and enthusiastic. The overall feeling one gets in the school is quite pleasant.

However as people who visit these schools often may know, such things don't always translate to learning levels of student. But there's more to the teacher's context. She has to handle almost all subjects due to lack of subject teachers – Urdu, Mathematics, Science etc. She also has to handle all the administrative work of the school – Mid-Day Meal register, school data in the Student Tracking System (which she fills online on her smartphone late at night), many other registers including that the cluster resource person bringing in every once in a while. In fact the CRP brought one such form in front of us.

So her introduction to an important area within mathematics i.e. Algebra, with its own deep history spanning civilizations, the monumental development in mathematics that it achieves, the relevance and beauty of all this to the students who are taught, is all to be delivered within the context of many a worries, responsibilities and pressures.

This also made me reflect as to what is it that we can realistically hope to achieve through the Foundation's Teacher Professional Development strategy. We or the teacher has minimal influence on the systemic aspects like having separate teachers in each subject etc. in the short-term. Coming to her own knowledge, that can improve in terms of history, concepts, how to introduce a topic, how to prevent or address misconceptions etc. The current level of motivation and care for the students

that she has despite the constraints, needs to continue. Given all this, a lot more can of course be done to engage with her on her own role as teacher and a head teacher, the role of education in this school, in the community and larger society and the larger story that she is an important part of.

So it is not surprising that when she or someone like her comes for a workshop or a discussion, they will be preoccupied with many things: wondering if she should go deep into one subject when she has to teach many, what is the practical implication of this larger idea being shared to her classroom teaching, the extra effort this will take to say design a learning activity or TLM, how will she manage that etc.

This is a huge challenge for organisations like ours working in this area. One of the illustrative ideas that occurred was that if we consider a change in the approach of teacher engagements. Currently we say that the teacher needs at least these 3 things to teach well:

- A decent understanding of the content area she is teaching
- An understanding of the methods that work in the class and why they tend to work given how children think and what their background is
- A larger understanding of why say have Math at all in the curriculum, or why education, how it serves a larger social purpose etc.

These above matters then become the content of what we transact in our workshops, discussions etc. The expectation is that over time the teacher's understanding expands and motivation improves and she applies what she learns in our engagements in the classroom and school context. This extra bit of applying it is left to the teacher. After all how much can a civil society organization do?

In this context, as shared till now, if the gap between the idea shared in the teacher engagement and its classroom application is high, then the teacher has to do more work. For example if we share the history of Algebra, why Algebra, how it is useful, how it is applied etc, then suppose the teacher realizes the content better, it may still not tell her much about why the student may face a problem in understanding this concept. Suppose we also bring in the matter of how somethings remain "unknown" in a certain situation in a way that a child can understand it. Illustrate this with examples, methods, misconceptions child may form at this stage, ways to avoid that etc. Later we go into how such an unknown can be denoted with a symbol like  $x$ , how other information in the problem can then be used to find out what  $x$  is, this makes it much easier for the teacher. She still has to internalise this understanding, and then while dealing with this in class, design an activity which will create an appreciation of what "finding the known from unknown" actually means. This is not easy, but is still doable.

It is true that we cannot take up every area within Mathematics and similarly every area within all subjects in this manner. At some level what is done for say Algebra has to be seen as an example of how the teacher can learn, apply, design and teach better.

Maybe, along with current engagements, some innovations like having teachers shoot mobile-based videos of how they introduce topics in their class can be used as material in such a workshop to collectively watch, critique, develop an ability to critique and thus bring much more self-awareness into the act of teaching. However such a video will be only useful if she also interviews children too and understand what they have understood and including if they have formed misconceptions and if so why they think the misconception is the correct conception etc. Details matter.

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Another idea is what if we realise the significance of text material and lesson plan in the teaching-learning process and enable the teacher to be a script-writer of these. What I mean is when we do a session on Algebra with teachers, we focus on introducing the concept of algebra to teacher within the context of teaching the same to the child. That is not as a concept we are teaching the teacher, but as a concept the teacher has to teach the child. Which means we start with a poor textbook chapter and lesson plan, focus on teacher understanding why it is not a good one and let teacher redesign the text and lesson plan. We end the session with a somewhat better text and lesson plan. Even if not perfect, this could always keep our sessions within the problem context of the teacher and reduce the gap between idea and implementation. This is a somewhat lofty an idea in the current context, still well worth thinking about.

These, and such innovative ideas, maybe needed to break the routine and work towards having a truly reflective practitioner, which after all is the aim of teacher professional development.

*The author presently is working at Azim Premji Foundation and leads the Bengaluru District Institute.*

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