Technology and Teaching Mathematics, An Indian Perspective

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Abstract: Education system in India is "10 + 2 + 3" model, and it is very examination-oriented. Education is a state matter and there are in all 28 states and 7 union territories. There is little scope for innovation and use of technology in regular teaching. In the second part of the paper, I will discuss the role of technology in teaching and a methodology of supplementing regular teaching to make the subject matter more lively and stimulating. In the third part, I will discuss my personal experiences of conducting math lab sessions for middle school students (age 13-14) and for senior secondary students (age 16-17). The last two parts of the talk will have multimedia presentations.

1. Indian Education System

The system of education in India is "10 + 2 + 3" model. Education is a state matter and there are in all 26 states. Each state has its own Education Board which is responsible for all matters relating to school education in that state. For more details, see *Rajput (2004).*

Indian education system is very examination-oriented. The "examination mentality" has had a strong negative influence on everything connected with education in India: textbooks, style of teaching, and teacher preparation. There is little scope for innovation and use of technology in regular teaching.

2. On the role of technology and teaching mathematics

Math education is in the midst of a change driven by technological developments.
What is technology? Historically, for math education point of view, it can be summarized as

Slate $\longrightarrow$ **Slide rule** $\longrightarrow$ **Software**

From oral education to engraving on clay tablets/stones, from writing on palm leaves to invention of ink/paper and printing, to digital media, are all various phases of evolution of technology.

In the present scenario, technology in math education can be viewed as: Hand held calculators on one hand and multimedia workstations on the other. Digital class rooms on one hand and

virtual class rooms on the other. Course distribution over the internet, ICT. Then there are CAS, for example: Maple, Mathematica, Mupad, Drive, and dynamic geometry softwares like GSP, Cabri, and so on. All these help to compute and simulate. Then, there are course management tools and evaluation tools.

Aspects of technology use

Technology is entering many facets of math teaching and learning. Technology is a valuable tool in the teaching and learning of mathematics, for it has the ability to empower mathematics students as well as mathematics instructors. The use of technology is prompted, in some cases, by the methods that can help a teacher to do some jobs easily and in a better way. In others, it is motivated by the belief and effort to impart instructions in a way that will help to achieve the learning goals of students.

Integration of technology in education can also be because of non-academic reasons: to build the profile of a school/college.

Positive aspects of technology use

Technology adds new components to teaching and learning of mathematics by providing:

- Tools for visualizations/ illustrations.
- Tools to do tedious computations in less time.
- Tools to recognize pattern in a problem.
- Helps to formulate conjunctures.
- Tools to develop problem solving skills.

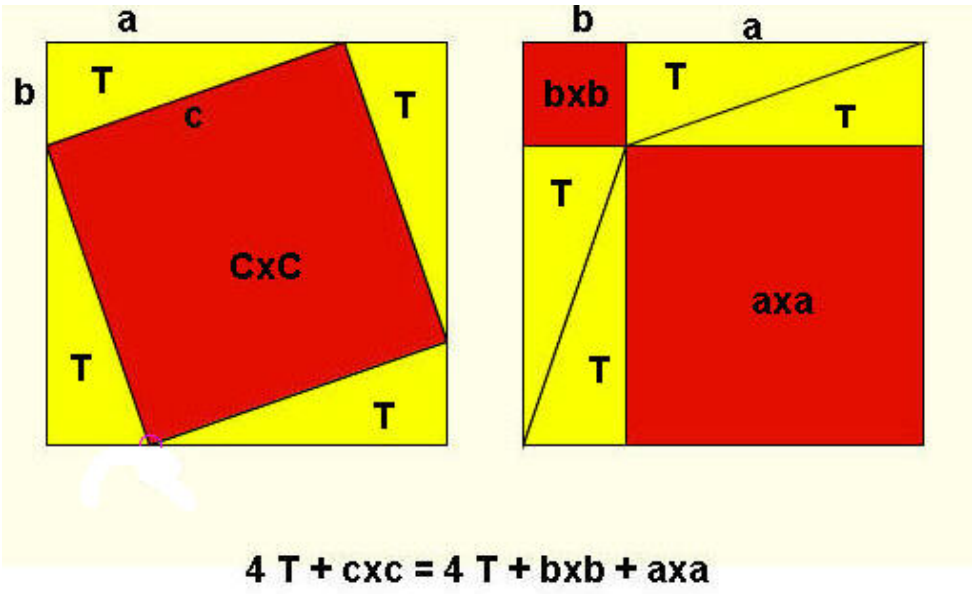
Technology Enhanced Learning, Visualizations

Visualizations can be developed manually (sometimes) or with the help of technology tools provided by calculators/computers and software. They play an important role in learning and teaching of mathematics, see *Guzman (2002).* These can also be used to make the learning process non-routine: interactive and explorative. We discuss this idea in details with two examples. The process is divided into following steps:

- Explore / Experiment
- Observe / Conjuncture
- Convince / Prove
- Extrapolate / Extend

First example

This example is taken from the middle school level mathematics: Pythagoras theorem. One of the standard visual proofs of this theorem is as given below:

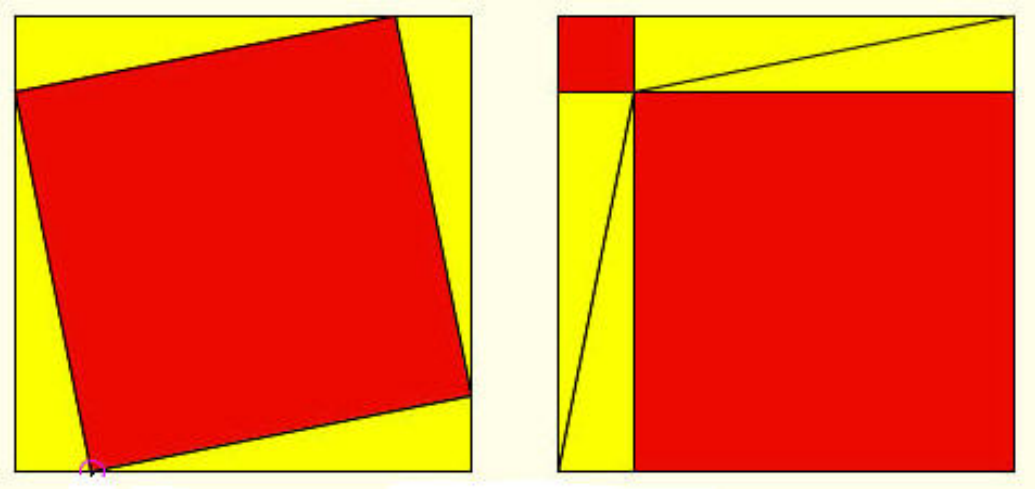


Instead of showing the above proof, students can be made to explore and discover it as follows:

1. **Exploration:**

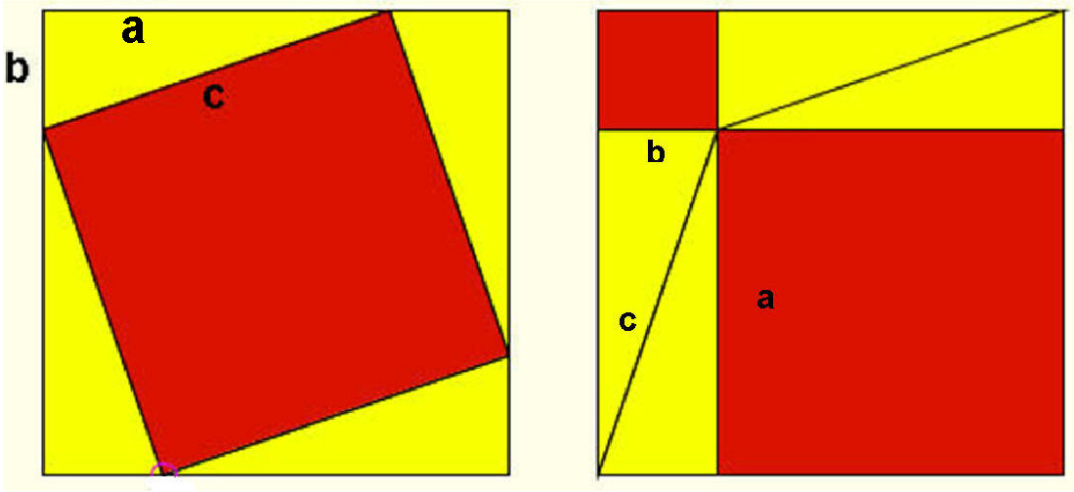
Students are shown an animation in which a red square is inscribed inside a yellow square, as shown in picture 1 below. And picture 2 shows a rearrangement of picture 1.

Picture 1 **Picture 2**



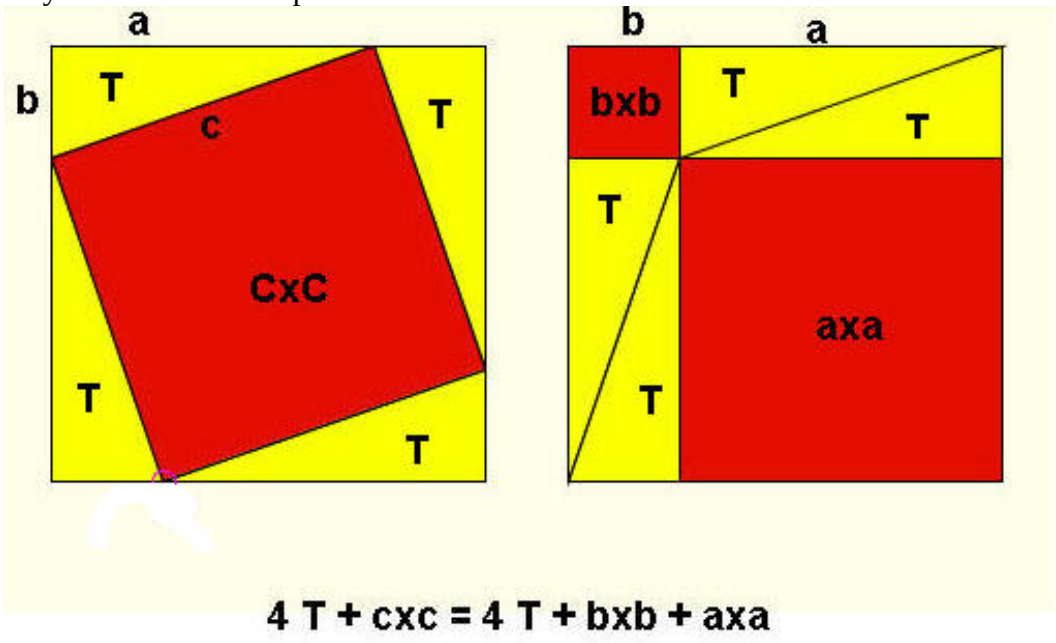
The students are asked to make some conjectures about the relations between the areas of various shapes inside the bigger square. Most probably no answers will be forthcoming. At this stage they are shown the following two pictures:

Picture 3 **Picture 4**



2. Conjecture:
Hopefully, some of the students will guess the relation $c^2 = a^2 + b^2$.

3. Convince/Prove:
Finally they should be able to prove the result as follows:



Second example

The second example is from secondary level: how the coefficients a, b and c affects the graph of a quadratic $y = ax^2 + bx + c$.

1. Exploration:
Analyze the effect of the change in the values of the coefficient a on the graph of the quadratic:

$y = ax^2 + bx + c.$ Students are shown animations how the graph changes with change in the values of the coefficient *a* and are asked to give their observations.

2. Observe/Conjecture:

The, graph bends away from x-axis when a is positive, and for a negative the graph bends towards x-axis. The graph is a straight line for $a = 0.$ It always passes through the point $(0, c),$ whatever is the value of $a.$

3. Convince/Prove:

Students should try to justify the claims that for both b and c are fixed, why does the shape of the graph of $y = ax^2 + bx + c,$ depends upon the sign of $a.$ Further, the graph is a straight line $y = bx + c,$ if and only if $a = 0.$ Further, why does the graph always passes through the point $(0, c),$ whatever be the value of $a.$

1. Exploration:

Analyze the effect of the coefficient b alone on the graph of the quadratic: $y = ax^2 + bx + c.$

Students are shown animations how the graph changes with change in the values of the coefficient b alone, and are asked to give their observations.

2. Observe/Conjecture:

The 'tip' of the graph traces a path similar to that of the given quadratic with shape upside down, i.e., it is also a quadratic with coefficient of second degree term has sign opposite to the given quadratic.

3. Convince/Prove:

The student verifies analytically that the point (h, k) , corresponding to the 'tip' of the graph satisfies the equation $k = -ah^2 + c,$ as observed.

1. Exploration:

Analyze the effect of the coefficient c alone on the graph of the quadratic: $y = ax^2 + bx + c.$

Students are shown animations how the graph changes with change in the values of the coefficient c alone, and are asked to give their observations.

2. Observe/Conjecture:

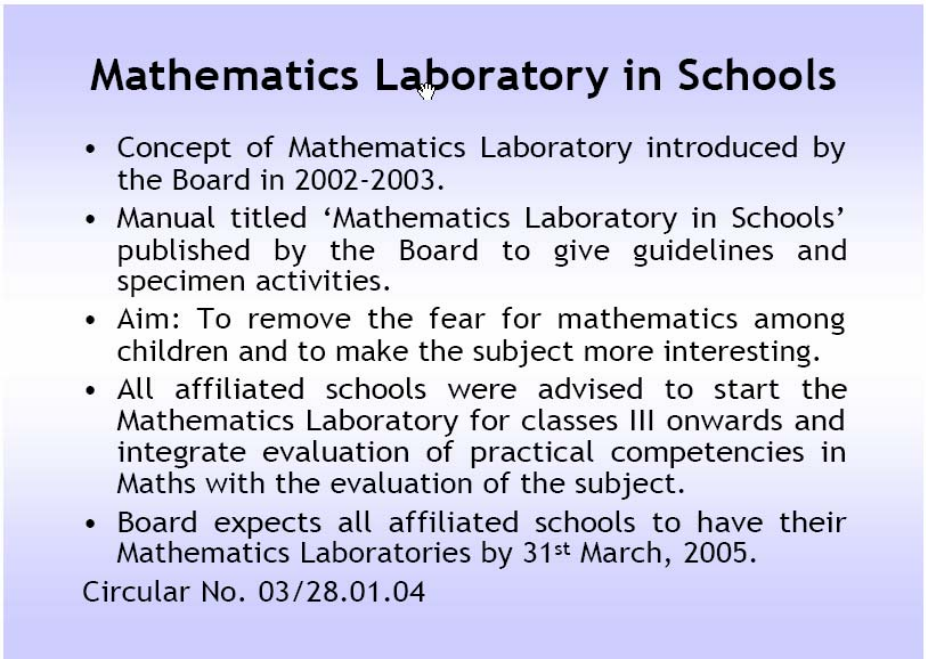
The tip (h, k) moves along a vertical line.

3. Convince/Prove:

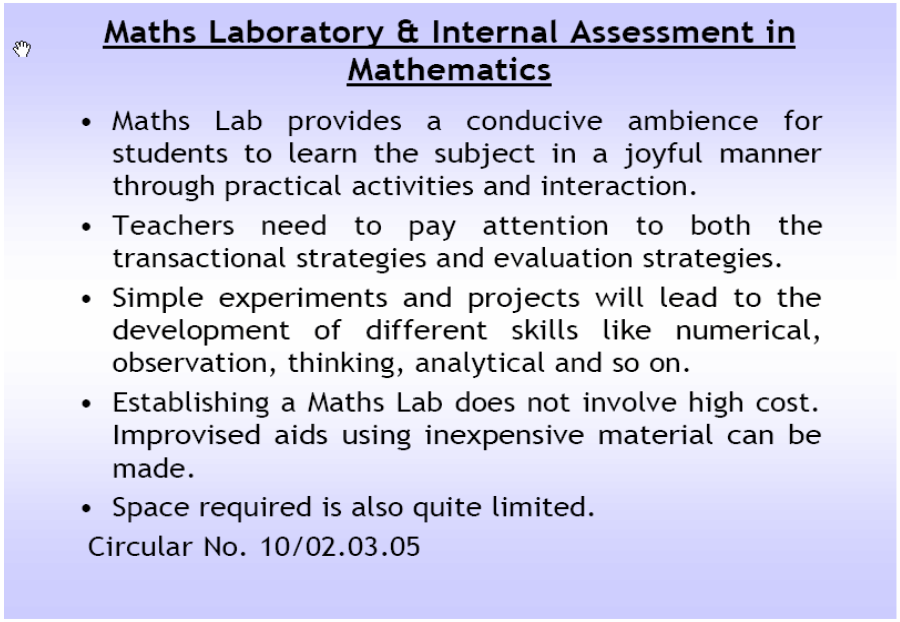
Students verify analytically that the tip (h, k) moves along a vertical line, as observed, with $k = c - ah^2.$

3. On conducting math labs

In March 2004, the "Central Board for Secondary Education" issued a directive to all the schools afflicted to it:



In March 2005 came out with some conclusions about math labs:



To help teachers of local schools to implement this, two math labs were designed.

Recipe for a math lab

- Select a topic from the curriculum
- Revise the basic concepts related to the topic
- Design some hands-on activities and give an example of the activity you want them to do.
- Activity should involve observations, analysis of observations based on the concepts revised, conclusion based on the observations and their justifications.
- Give a short quiz to test the assimilation of the concepts.

Math Lab on the concept of Areas

This lab was conducted for middle school (age 14-16 years) students (186) on the concepts of perimeter and areas. I give below an outline of the workshop:

The concepts of **rectilinear figures: t**riangle, rectangle, square, parallelogram and rhombus were revised. Computations of areas of these figures were demonstrated with flash animations.
Non rectilinear figures were introduced and the problems involved in finding the perimeter and area of a circle were discussed. With the help of animations, the computations of these were demonstrated. Students were asked to do some hands-on activities and a short quiz was given. Historical background of defining and determining pi was also demonstrated.

Feedback from students:

- Did the workshop help you in revising the concepts about Areas of figures?

YES	NO
183	3

- Were the activities interesting?

YES	NO
172	14

- How were the quiz questions?

GOOD	EASY	DIFFICULT

125	45	16

- How was the workshop?

VERY GOOD	GOOD	OK
129	43	04

- Would you like to attend more such workshops?

VERY MUCH	YES	NO
109	69	08

Math Lab on the concept of derivatives

Another Math Lab for senior secondary (age group 17-18) students (77) of K.V. I.I.T. Bombay School was conducted on the topic of derivatives and applications.

Feedback from students:

The way lab was conducted	**Contents of the lab**	**Would you like to have more such labs?**
Very interesting (46.15%)	Difficult (6.41%)	Very much (41.02%)
Interesting (42.30%)	Moderate (78.20%)	Yes (52.56%)
OK (11.53%)	Easy (15.38%)	No (6.41%)

- **Some general comments:**

1. Activities were new and interesting. Concepts are much clearer now.
2. It cleared my fundas. Would like to attend more.
3. We need such labs in Integration also.

4. Actually such labs are really good, but I need to be intelligent enough to grasp things!
5. It was time consuming, but still interesting.
6. Boring!!
7. gre8!
8. Sir, please conduct these types of labs more often.
9. This is something that I had not done before, helped me to understand graphs.
10. This kind of labs should be conducted for chemistry also.
11. Excellent, just a bit slow.
12. Cool! Expecting more such in future.
13. Amazing mental exercise! Too good, making concepts crystal clear.
14. I really liked it from the down of my heart.
15. A new look at calculus, amazing! Thanks a lot!
16. (Thank you Sir)^2 .
17. This comment by one of the students sums it all:

4. Conclusions

Negative aspects of Technology use

One of the biggest drawbacks of technology is that it needs resources: both financial as well academic. Given that schools/colleges have limited resources, there are difficult choices to make on how to invest the resources. Also, sometimes technology gives a false sense of accomplishment to deceive the school/college and community.

For teachers, using technology increases workload to learn technology. Also it puts pressure on them since they have to change their teaching approach. In their enthusiasm, teacher may lose perspective and aim of instruction. For students, learning to use technology itself may be time consuming and frustrating. *Galbraith (2002)* states that "Results suggest, teaching demands are increased rather than decreased by the use of technology, that attitudes to mathematics and to computers occupy different dimensions, and that students adopt different preferences in the way they utilize available resources"

Using technology can lead to an easy way of getting answers for students. This can lead to weakened conceptual understanding and basic skills.

Technology is not versatile and its functions are limited. After all it is the product of human mind. Technology by itself cannot promote learning. *Olsen (1999)* discusses one of the most extensive examples of technology used to provide automated instruction: Virginia Tech's Mathematics Emporium, a 58 000 square foot (1.5-acre) computer classroom. That seems to suggest that many feel "mathematics is something primarily to be delivered and consumed". Finally, more often than not, technology needs a facilitator.

Questions:

Some of the questions one would like to ask are:

- Is the use of technology required for learning in general, or for learning mathematics in particular?
- Is there evidence that students learn mathematics better with any technology or with a specific technology?
- Is it worth spending on technology when there is a shortage of resources, both financial and academic?
- Can technology compensate for the lack of qualified instructors?
- Should the use of CAS and other software be following prior understanding of mathematical concepts and procedures, or as a means for the development of such understanding.

Some answers:

- Technology is not a universal tool and an omnipotent aid that can always help.
- Technology often provides convincing demonstration of ideas, helps to conjuncture, but does not replace 'proof'. Nor does constructing a proof rules out the use of technology. This distinction must be emphasized and the importance of both must be appreciated.
- Technology can neither replace live class room teaching nor can it compensate lack of qualified teacher. In terms of valid reasons, from a learning standpoint, there actually is no conclusive evidence that specific technology can improve students' learning of mathematics when implemented properly.
- Learning does not take place in the technology.
- Learning takes place in the interaction between motivated faculty and motivated students. Whenever possible, technology can be used to provide such environments.
- Used properly, technology can help the teacher to impart instructions in a more effective way that will enhance students understanding and motivate them to learn.

Instead of making
Kids love mathematics,
Let us create mathematics
That kids will love.

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