# A Study on the Effectiveness of ICT Mediated Performance Based Learning Material (PBLM) on Achievement in Mathematics

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# Abstract

This pretest–posttest equivalent groups experimental study compared a procedure that is the ICT mediated performance based learning material(PBLM) for helping a section of ninth class students to be better able to improve the achievement in non-standardized summative assessment conducted by school than a control group of ninth class students. We predicted ICT mediated PBLM would improve the achievement and facilitate both the gender equally. A variety of mutually overlapping constructivist strategy like reciprocal teaching in flipped classroom, cognitive apprenticeship or inquiry learning or dialogue and instructional conversations or problem based learning in flipped classroom set up were used to help students learn a semester class 9 mathematics content of CBSE, India; as no single strategy would have done justice to learn such a diverse variety of content. There was at least some sort of activity designed; for example, making the objects to understand, physically measuring the quantity involved like volume, surface area with real example from surrounding; creating simple art forms to develop acquaintance with the concept; as part of their assessment students were provided with small cylinders, cubes, cuboids etc. from their daily life to calculate their volume or surface area etc.; this process of feeling mathematics probably justifies the nomenclature performance based learning mathematics; this was an attempt to make mathematical process more important than product. ICT mediation was designed to accelerate the whole process efficiently. The achievement of students in their last summative assessment conducted by school (that is achievement in class 8 annual summative assessment) was taken as pretest scores of both the groups. The mean pretest score of the control group ($M$ = 55.5,$SD$ = 22.1) was significantly higher than the mean pretest score of the experimental group($M$ =33.2, $SD$= 21.9). Comparing the estimated marginal means using ANCOVA showed that the more score was gained on ICT mediated treatment given to experimental group (mean=50.4) compared to conventional treatment given to control group (mean=29.4). The results indicated students in the experimental ICT mediated group ($M$ = 39.7, $SD$ = 24.4) scored better in posttest than did the students in the control group ($M$ = 40, $SD$ = 28.6). These results suggest ICT mediated interaction has significant impact on improving the achievement in mathematics.There was no significant difference on the mean test scores of girls and boys in any of the pretest and posttest; which indicated gender had no effect on achievement in mathematics at class 9 level and ICT mediated PBLM facilitated both the gender equally for improvement in achievement.

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# Content

## Introduction

In the context of universalisation of education, the first question to ask is, what mathematics can be offered in eight years of schooling that will stand every child in good stead rather than be a preparation for higher secondary education alone(NCF 2005, p.43)? NCF 2005 advocates constructivist pedagogy. Developing children's abilities for mathematisation is the main goal of mathematics education (NCF 2005, p. 41). We have to admit that the present day teaching of mathematics is not up to satisfaction (James, 2005). In addition, Mayer and Wittrock (1996) note that field studies of problem solving in real situations show that people often fail to apply the mathematical problem-solving approaches they learn in school to actual problems encountered in the grocery store or home(Woolfolk, 2004, p. 371). The higher aim is to develop the child's resources to think and reason mathematically, to pursue assumptions to their logical conclusion and to handle abstraction. It includes a way of doing things, and the ability and the attitude to formulate and solve problems (NCF 2005, p. 61). Several attempts have been done among experts and educators to make connections between abstract mathematical ideas and the everyday material world. Almost all sorts of simple everyday materials offer great scope for a variety of interesting and mathematically rich activities. Connecting mathematical concepts includes linking new ideas to relate ideas learned previously, helping students to see mathematics as a unified body of knowledge whose concepts build upon each other. Major emphasis should be given to ideas and concepts across mathematical content areas that help students see that mathematics is a web of closely connected ideas (George, 2007). External representations of mathematical concepts, for example, manipulatives, are indispensable in mathematics education (Carbonneau,Marley,&Selig,2013; National Council of Teachers of Mathematics [NCTM], 2000).

In the form of educational reform after the introduction of vision document National Curriculum Framework 2005, CBSE and some State Boards in India introduced Continuous Comprehensive Evaluation (CCE) pattern. Rather than helping in the construction of knowledge most of the present strategies practiced under CCE are mere repetition of traditional lecture method based pedagogy. There seems to be some sort of complicated relationship between the acts of introducing CCE to improve quality in our classrooms and RTE Act 2009 in India. Though there was an attempt to bring the constructivist pedagogy

practices into our Indian school classrooms, it seems to fail miserably as it is evident from the media outcry of school administrators, parents, educationists and other stake holders. As it is becoming increasingly evident from the views of eminent educationists from NCERT that the form of CCE adopted by CBSE lacks the spirit of constructivist pedagogy; rather it can be said that CBSE has adopted a mechanical version of CCE which suits their monitoring strategy. The present practices under CCE are mere ritualistic in nature than constructivist. In midst of all these changes CBSE gave up its decade long tryst with CCE to retract back to its old pattern of assessment from 2017; as the popular belief in India in last couple of years is that our earlier pattern of evaluation was better than the present. To get rid of this anomaly NCERT came up with its vision document ' Learning Outcomes at Elementary Stage, 2017' to translate the ideals of constructivist pedagogy into the reality of our classrooms. Learning Outcomes are assessment standards indicating the expected levels of learning that children should achieve for that class. These outcomes can be used as check points to assess learning at different points of time(Learning Outcomes at Elementary Stages, NCERT, 2017). Prof. H.K. Senapaty, Director, NCERT in NAVONMESH 2017 held in New Delhi categorically put that there was a strong need for transition from learning objective to learning indicator to learning outcome. Learning outcomes are the consequences of the constructivist pedagogy. This is the reflection of transition from behaviorist pedagogy to constructivist pedagogy. He also emphasized on the need to give up age old behaviorist pedagogy in favor of progressive constructivist. The learning outcomes clearly marks the switching over to constructivist pedagogy from the behaviorist. Here I describe ICT mediated performance based learning as a constructivist strategy to include a variety practices like reciprocal learning, cognitive apprenticeship, inquiry and problem-based learning, and dialogue and instructional conversations using projector, laptop and smart phone with access to internet. As the researcher has taken up a variety of topics from class 9 mathematics text book of CBSE to be delivered over a period of four months as treatment, so no single approach is found suitable to deliver such a wide variety of concepts using constructivist pedagogy. In fact, this research is one semester long intervention designed to test the effectiveness of this model. One example of practice is:

Children needs to be skilled enough to carry out instant gross estimation to calculate the quantity of cement, sand and small pebbles required to make 10 foot X 10 foot concrete roofing for their new house. The teacher asks them what is the volume formula to calculate the volume of cuboids?; length x breadth x height; What is the approximate thickness of

concrete roofing? No response or a variety of responses to conclude with teacher's mediation ½ foot or six inches; they take a real look at the breadth of a brick brought to the class to understand what six inches look alike; The class together calculate the volume like 10 x 10 x ½ = 50 cubic foot; what is the ratio in which concrete mixture is made; any of you has ever seen the preparation of concrete mixture? The whole class discusses to agree that cement : sand : stone chips = 1:1:2; can you tell now how much of each material needed to prepare 50 cubic foot concrete mixture for our 10 foot X 10 foot room? Classroom dialogue goes like half (two parts) that is 25 cubic foot sand, and 12.5 cubic foot each cement and stone chips are needed to make concrete roofing over our 10 foot X 10 foot room; teacher shows them to 1 cubic foot container and asks them what is the weight of 1 cubic foot of cement; have you seen cement bags brought for construction work? What is the weight of each bag and what is its approximate cost? Class comes to the conclusion that each cement bag weighs 50 kg; teacher asks the students how can they determine what is the weight of one cubic foot of cement? The class concludes one way is to fill one cubic foot container with cement and weigh it; too much cement is needed right now; I do not have that much cement; can I find the weight of one cubic foot of cement from the weight of a small quantity of cement? Is there any other way? The class discusses to conclude that there are 30.48 X 30.48 X 30.48 cubic cm = 28.3 liter in a cubic foot; so finding the weight of 1 liter of cement and multiplying it 28.3 one gets the weight of one cubic foot of cement. Teacher instructs two students to fill 1 liter bottle with cement and weigh? (or Density 1440 kg / cubic meter ; 1 cubic meter = 1000 liter ); 1.440 kg per liter, 1cubic foot = 28.3 liter; 1 cement bag = 35 liters; 1.44 x 28.3 = 40.752 kg per cubic foot; 12.5 cubic foot = 12.5 x 40.752 kg = 509.4 kg ; number of cement bags = 509/ 50 = 10.18 bags (10 bags); cost = Rs 400 per bag x 10 = 4000 Rs; cost of one cf of sand = Rs. 50(actual market rate); cost of 12.5 foot sand = 12.5 x Rs. 60 = Rs. 750, cost of 25 foot stone chips = 25 x Rs. 40 = Rs. 1000. So, the total cost towards cement, sand and stone chips for roofing of 10 foot X 10 foot = Rs. 5750.

This is researcher's belief that ICT mediation may encourage self regulation and time management in real class. Barry Zimmerman(2002) describes self regulation as the process we use to activate and sustain our thoughts, behaviors, and emotions in order to reach our goals. When the goals involve learning, we talk about self regulated learning (Woolfolk, 2004, p. 512). Self -regulated learners have a combination of academic learning skills and self -control that makes learning easier, so they are more motivated; in other words, they have

the skill and the will to learn (McCombs &Marzano, 1990; Murphy & Alexander, 2000, Woolfolk, 2004, p.512).

Constructivism has become an important aspect of educational reform. Constructivism as a philosophy is not new, but its application to modern education is still in the formative stages (Ward 2001). Schools that are using constructivist methods have met with some success, but those schools are rare. Constructivism is a theory of learning rather than a theory of teaching; therefore, it does not prescribe a particular set of teaching practices. This means that the teachers can use a number of methods of teaching and assessment that will fit in the rubric of constructivism – even certain, more didactic practices, such as lecturing, note taking, and textbooks (Colburn, 2000). Teachers practicing in school are either unaware of the constructivist practice or view this practice as too ideal. This is researcher's belief that ICT mediation with constructivist pedagogy will encourage its practice in classroom. The present intervention may be seen as a strategy towards achieving and strengthening the desired and appropriate learning outcomes in mathematics.

**Statement of the Problem:**

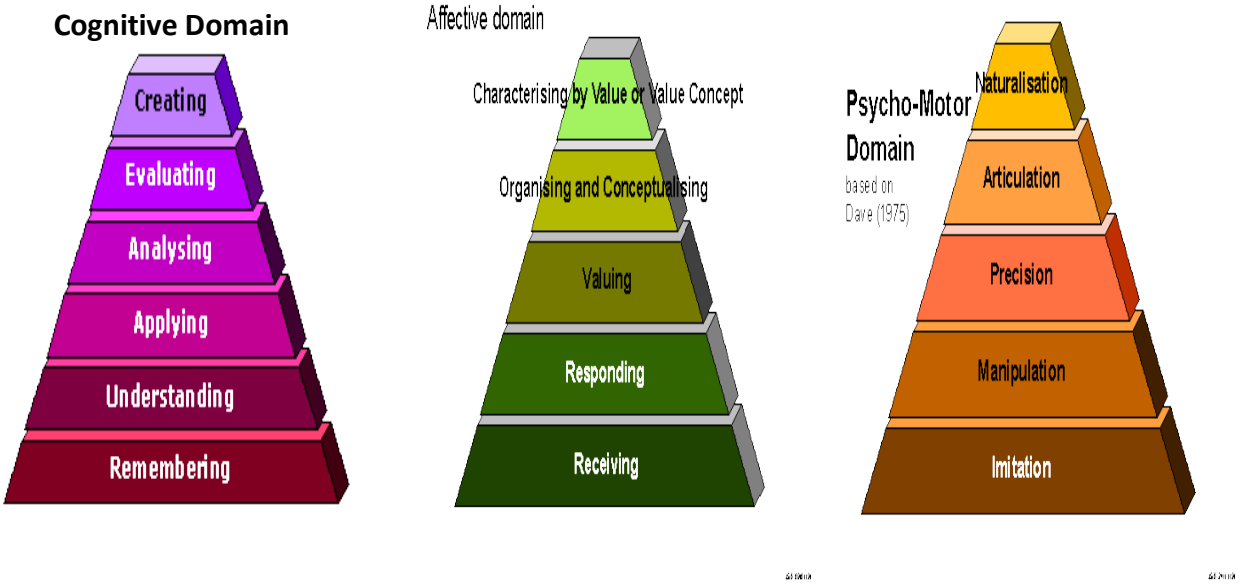
A Study on the Effectiveness of ICT Mediated Performance Based Learning Material (PBLM) on Achievement in Mathematics

**Need and Justification of the study in the contemporary societal context**

The present secondary school practice to teach mathematics in India concentrates on learning objective and learning indicator based product oriented behaviorist pedagogy with least emphasis on process. Efforts to include process or give importance to process along with product under behaviorist pedagogy seem to elude us for long. Looking at the sorrow state of affairs associated with learning mathematics there is an immediate need to put in place a learning practice(not teaching) compatible with the constructivist pedagogy which gives importance to the process skills instead of the product. The present summative assessment practice contains items mostly from knowledge and understanding level of cognitive domain. Comparatively less number of questions on application, analysis, and synthesis and evaluation level are found in summative assessment. The affective domain (receiving, responding, valuing, organizing and conceptualizing, characterizing by value or value concept) and psycho-motor domain (imitation, manipulation, precision, articulation and naturalization) find unrepresented in present assessment system.

Investment on ICT infrastructure in school education has been a thrust area for policy makers. The research studies on the effect of ICT on mathematics education shares mixed views. Few reasons may be there is a serious lack of research which has been conducted with adequate exposure to ICT treatment over a reasonable period. As the nature of ICT facilities freely or commercially available to end users has changed drastically, there is a need to conduct research to ascertain its effect on improving different dimensions of learning mathematics. There is wide spread claim made by different commercial agencies engaged in development of multimedia teaching learning material (TLM) that students can use these materials for self-learning to improve their mathematics concepts. Most of the studies conducted differ widely over the variety of ICT infrastructure used in their study. Keeping in mind the financial constraints of our society and the advantages of ICT mediated learing, it may be required to study the effect of using one projector, laptop, smart phone with internet connectivity on learning mathematics. It is assumed that these basic infrastructures may be made readily available without much financial burden or an enthusiastic teacher can manage to use these as TLM. Most of the available studies have been conducted to see the effect of different open source educational software like GeoGebra, RoboCompass, to name a few, while providing individual systems to students. It is also assumed that students would be having access to personal computer or Tablet or Laptop with internet at home to receive and submit their learning related tasks. In India like country there is a wide variety of schools like classrooms without roof or chalk board in acute cases, schools with manageable infrastructure and academic staff, model schools with a lot of infrastructure run by local bodies, government or welfare organizations, private schools of all standards(best to worst in comparison to government schools) . There are schools without any distant dream of using ICT in classroom to schools with all sorts of latest ICT facilities. Also somehow or other, ICT in the the crude form like smart phone or TV has entered to the daily life of our common people of all strata, though in the form of entertainment and means of social communication. There is also a generous and sincere attitude of government machinery towards investment in school education to improve the quality of education. This is visible in the form of recent efforts taken by government like coming up with visionary document ‘Learning Outcomes at Elementary Stages 2017’ developed by NCERT with instruction from Ministry of HRD, GoI. This document gives importance to pedagogical processes, instead of product, as educational strategy under constructivist pedagogy. To start with, a blended effect of ICT mediation, with minimum intrusion of ICT in our traditional classroom set up seems interesting, useful and

meaningful transition from chalk board based behaviorist classroom set up to learner centered constructivist lesson. This transition is economical and in consonance with our product oriented assessment system; there is very remote chance in recent future to get rid of the ill effects of present day product oriented assessment system looking at the huge demographic figure of our schools, economic disparity between citizens, external examination as a medium for economical inclusion or placement in higher education, lack of alternatives to grow as independent entrepreneurs, remaining unskilled even after spending 16 to 18 years time on acquiring formal education. Studies conducted over small samples tend to show higher impact of ICT on achievement in mathematics.




**Recent Research Works**

Ali et al.(2011) attempted to check the impact of motivation on problem based learning environment on the academic achievement of High achievers and Low achievers in the subject of mathematics. The study was experimental in nature and pre-test- post-test design was used the study. Students were distributed into two groups. An experimental group comprising 19 participants received problem based learning practice including students motivational techniques, e.g. (well-structured problems, quiz, projects, self-learning in groups, discussion in groups, representation, self-assessment, peer assessment). A control group comprising 19 participants received treatment of traditional teaching in shape of lecture/demonstration method for four weeks. At the end, post-test was administered and the

scores of pre-test and post-test were served as data of the study. It indicated the significant impact of motivation on the academic achievement of students in problem based learning environment. The result further indicated that motivation in problem based learning plays more effective role than traditional method of teaching.

Rachmawati and Johancynthia(2010)conducted an ICT based learning schools to assess the challenges on implementation. Results indicated that in ICT based learning the role of teachers were significantly changed from transferring of knowledge into facilitating of learning, from a main source person to be a manager of learning. Other challenge is also addressed to head teachers in encouraging teachers to implement ICT based learning in order to improve students capability and skills.

Husain(2010) in his study "Teacher competencies for the Use of Information Communication Technology" found that all the teacher educators were agreed for the following ICT competencies that teachers need to develop are: 1. Use of ICT Skills in developing and presenting information. 2. Prepare ICT based learning environments designing effective learning experiences and creating rich learning environments.

Ponraj and Sivakumar(2010) in their study "Computer-Assisted Instruction in Zoology in Relation to Learner's Personality" found that experimental method of teaching is more effective than the traditional method. The sample consisted of 40 students in control group and 40 students in experimental group. The data was collected by using Myers-Briggs Types Indicator (MBTI) personality test and two syllabus based computer software packages. Collected data was analysed by using "t- test" and "F-test". The major findings of the study are that CAI provides greater opportunities for the students to learn and it is better than the traditional method of leaning. It brings a new kind of experience for the students.

Nimavathi & Gnanadevair(2009) in their study "Developing Study Habits through Multimedia Program" found that the students learning with the help of multimedia fared better in their study habits than the students learning through conventional method. During this study, the sample consisted of 180 secondary school students (9th class). The Pre-Test and Post-Test Equivalent group design was followed for the study. Study habits inventory by B C Patel was used to assess the study habits of secondary schools students and data was analyzed by using t-test.

Wood & Ashfield(2008) in their study "The use of Interactive Whiteboard for Creative Teaching and Learning in Literacy and Mathematics: A case study" found the ways in which the interactive whiteboard may support and enhance pedagogic practice. Data collected from observations of whole class lessons, alongside individual interviews and focus group discussion with class teacher and initial teacher education students has provided opportunities to consider the potential of such technology to facilitate a more creative approach to whole class teaching. The data suggest that, in the first instance, the special features of information and communication technology such as interactivities, provisionally, speed, capacity, and range enhance the delivery and pace of the session. This research seems to indicate that it is the skill and the professional knowledge of the teacher that mediates the interaction and facilitates the development of pupils creative responses at the interface of the technology, which is critical to enhancement of the whole class teaching and learning methods.

Goulding(2008) in his paper "A Systematic Review of the Use of ICTs in Developing Pupil's Understandings of Algebraic Ideas" found

- Peoples achieve general games of understanding when using one type of ICT.
- Students successfully use visualization with graphing software to fit graphs to Data sets, to solve equations and to transform functions.
- Pupils working in a computer environment reach higher level of thinking and are able to think better than pupils working in a traditional paper and pencil medium.
- Lower attaining students prefer to work arithmetically the tables of value and only later move to integrate the tables of values with computer-generated graphs.
- Pupils have difficulty moving between symbolic, tabular and graphical sums when solving equations.
- Students do not always know how to use the technology, interpret ambiguities in the output or exercise critical judgment when using some of the advanced calculators.

On the other hand, the findings of the study indicate limitations, at least in the British context, of conceptualising the use of ICT in mathematics teaching and learning in terms of an opposition between 'constructivist' and 'didactic'(or 'transmission') pedagogies, and of classifying software in similar terms. First, for the teachers in this study, investigation and consolidation appeared to be complementary aspects of teaching and learning; the former concerned with opening up new ideas, the latter with securing them. Second, certain types of software, and even certain types of task, were claimed to be of value for both purposes; what

changed their functioning was the prior knowledge and learning expectations that teacher and students brought to them.

Biswas & Kumar(2006) in their study "Effectiveness of educational television program: invention of television" found that education through technological devices place a pivotal role in the overall development of the students. Under educational technological de vices, the reach of the television is quite wide because of its effective utilization for giving the benefit to the target viewers. In this opinion, the potential of educational television programmes produced by CIET was field tested among the students and teachers of two central schools. The study also focuses that the students of experimental group observing education television programme achieved higher score as compared to the control group taught through traditional method.

Baskaran and Sadatcharavel(2006) conducted a study on relationship between scientific attitude and achievement. It was conducted on a sample of 114 students of 8th standard (56 boys and 58 girls of Panchayat union aided and municipal schools). It was found that there was no significant difference between the mean attitude scores of the pupils in terms of gender, locality, panchayat and aided schools. There existed a higher positive relationship between scientific attitude and achievement in science. There is a higher positive correlation between achievement in science and that of Mathematics.

The main objective of the study of Sharma, Narayan and Subramanium(2006) was to find out the relationship between self-concept, achievement motivation and achievement in mathematics among boys and girls. The sample of the study constituted 80 students of sixth class of Government and Old Champion Middle Schools of Madhya Pradesh. No relationship between self-concept and achievement motivation among boys was found while significant positive relationship was found between self-concept and achievement motivation among girls. Boys and girls have shown a significant relationship between achievement motivation and achievement in mathematics. More positive the self-concept and achievement motivation of boys greater will be their achievement in mathematics.

Harlen & Deakin (2003) in his study "A Systematic Review of the Impact on Students and Teachers of the Use of ICT for Assessment of Creative and Critical Thinking Skills" found that (i) Computer-based concept-mapping with automated scoring can be used for summative assessment of critical and creative thinking about complex relationship (ii) The use of ICT

can help teachers by storing and recording information about how students are developing understanding of new material, by taking over some of the role of assessing and providing feedback to students so that teachers can focus on other aspects of supporting learning.

**Objectives of the Study:**

The study is undertaken in light of objectives as follows:

1. To compare the effect of ICT mediated performance-based learning materials(PBLM) on achievement in mathematics
2. To know the effectiveness of performance-based learning materials(PBLM) in integrating learning and assessment process in mathematics

**Rationale for the hypothesis**

Mathematics is the main component of any subject that a student learns in his classroom. It seems to be fun that the student is not reluctant to use Mathematics in other subjects (knowingly or unknowingly), and still he fears Mathematics. To make the students unafraid of the subject is the major challenge faced by a Mathematics teacher everywhere in the globe (Tannee and Jones, 2000). ICT mediation will help in the practice of constructivist pedagogy. It compensates for the shortcomings of the classroom practice of the constructivist approach. ICT mediation can be used to motivate students and make the mathematics classroom environment student centred. It may facilitate scaffolding and multiple representations. It provides multiple chances to repeat the activity and learn from successful practice. It would improve the academic engagement of students. All of these positive contributions from ICT mediation may possibly help students improve on their academic achievement in mathematics. Moreover, less number of experimental studies has been conducted to see the effect of ICT mediated pedagogy on achievement in mathematics. At least to the researcher's knowledge, no study was found to integrate ICT mediation with constructivist pedagogy for learning mathematics in elementary school. Similarly, the researcher could not find any study finding the effect of ICT mediated constructivist approach on gender of students. Here the researcher finds different ways to intervene and integrate constructivist pedagogical strategies into a regular format Indian elementary school classroom setting of CBSE Board for a period of six months. For this the researcher proposes to integrate ICT with constructivist pedagogy to teach mathematics to class $8^{th}$ students of DMS, Bhopal. The use of ICT will expedite the

process of curriculum transactions in limited available time in regular school. Keeping in mind the usefulness of learning Mathematics in their daily life and for higher studies it is expected to correlate the content of Mathematics with other classroom subjects. Here comes the need of providing students with interdisciplinary programmes in Mathematics.

**Hypotheses of the study**

Hypotheses of the study were as follows:

H01. The mean academic achievement score of the students in experimental group will not be significantly different from that of control group.

H02. There will be no significant difference in the mean academic achievement scores of the girls and boys in both the groups.

**Operational Definition**

**Traditional classroom setting:** It contains writing board (blackboard or white board), textbook which each student is supposed to bring to classroom, students, teacher (experience of teacher), notebooks possessed by students, chart papers and models related to mathematics. Teacher mostly uses chalk and talk method to explain the concepts in mathematics. Occasionally students use boards to demonstrate their understanding or help others understand important concepts.

**ICT mediated constructivist pedagogy:** In the present context the ICT mediation was limited to the use of one LCD projector, laptop, smart phone, multimedia CDs, pen drive and loud speakers as hardware supplement to the existing traditional classroom setting. Among other additions were e-textbook, freely available readymade videos over internet on different mathematical concepts related to mathematics curriculum, videos created during ongoing class to demonstrate both good and bad examples of doing the assigned job, exposure to motivational videos at the beginning of each class, encouraging students to create e-materials in the form of power point presentations to facilitate their as well as other students learning in classroom and to take control of their own studies by resorting to best available source and learning at their own pace through access to repeat the multimedia material.

**Achievement in mathematics:** It was the score obtained in the summative assessments conducted by school, which were teacher made tests at the beginning and end of session.

## Method

### Design and Plan of the Study:

Two sections of students each containing 34 students (already randomly allotted) of class 9 of DMS, Regional Institute of Education, Shyamla Hills, Bhopal affiliated to CBSE, India was selected for the purpose of study. One of the sections was randomly selected for receiving the treatment and the other group served as control group. It was a true experimental design i.e. The Pretest-Posttest Equivalent-Groups design. To bring additional information into picture mixed method research technique was also applied to the whole study. The researcher and his team developed sample material on the ICT integrated learning material of $9^{th}$ standard mathematics and introduced the same as treatment. The activities of the students during the process were put on multimedia platforms. The effectiveness of ICT integrated learning material and its usefulness in assessing the process aspects of learning was established through both formal and informal interview of students on the clarity of concepts and performance in achievement tests conducted by school at the end of semesters.

### Subjects

Class 9 students were chosen as the population of interest for two reasons. First, because of a large variety of concepts in mathematics is introduced at this level as compared to other classes; the class 9 student is likely to have many misconceptions about basic mathematical skills needed to carry out complex calculations. Second, the ninth class students are matured enough to make use of developmentally appropriate practices, and the treatment used in this study was designed in accordance with such practices.

All of the ninth class students in one secondary school in Bhopal participated as subjects in the study. Thirty-four students (21 boys and 13girls) made one sample and 36 students (21 boys and 15girls) the other sample. None of the student had received ICT mediated instruction earlier to the treatment.

### Randomization

School had already assigned students randomly to either section at the time of their admission in the first standard. In addition to the random selection of students to either section, the Ravines Progressive Matrices IQ Test was introduced at the beginning and IQ scores of students of both the sections were compared to assure the equivalence between the groups. As the groups were found equivalent reshuffling was not necessary.

**Treatment**

Real and authentic situations were put before the students who were free to form their groups of four. The authentic situations included( but not limited to)

1. finding the number of bricks on the corridor wall adjacent to their classroom.
2. Volume of a brick.
3. Volume of the overhead water tank
4. Cost of new chalk board used in class given that cost per square foot of board is Rs. 95.
5. Finding the area of the triangles supplied of different shapes given to them.
6. Finding the area of circle using a graph paper to experimentally verify the result.
7. Converting a rectangle to a circle by paper folding.
8. Looking at cylindrical object and predicting its volume
9. Tentative market rates of different qualities of ceramic tiles, vitrified tiles, carpets, vinyl fluoride to cover the floor of classroom.
10. Volume of concrete roof over classroom and the approximate quantity of cement, sand and small pebbles used to make the concrete roof given that the ratio of cement:sand:small pebble = 1:2:1 and approximate thickness is about six inches or ½ foot.
11. Estimating the volume of kitchen containers using the formula □ = □□$^2$h ; subsequently verifying by filling with water. Using common sense to predict the volume of different small size containers.
12. Assigning the names of different concepts to different children

In performance based learning the students were helped to learn the concepts with the mediation of some relevant activity. While learning number system we enacted a play. The play goes as follows:

There were a about ten characters like one student playing the role of Great Grand father, real Number. It had two sons; one rational and other irrational. The child playing the role of rational number was soberly behaving, definition of rational number like P/q, q is not equal to zero, examples of rational numbers like 2/3, -3/4, 0, 1, 2,.., emphasizing that my denominator can never be zero or negative, 2/3 is two thirds, explains the meaning of 2/3 through

demonstration. Describes closure property and deviation of how division by zero does not allow the closed property under division.

Rational numbers are closed with respect to addition, subtraction, multiplication, but division because division by zero is not defined. I have my additive identity, Multiplicative identity, Reciprocal(Except ZERO) of every member

(Only one member spoiled the closure property with respect to division that is ZERO)

Rational number has one son, the integers and integer has one son, the whole numbers.

Rational number calls his son: Integer come here

Integer: Comes and describes himself. A number line representing …-4,-3,-2,-1,0,1,2, 3,4… are displayed on the

Teacher: How are you different from your father?

Integer: I am also closed under addition, subtraction, multiplication like my father, rational number. My father, rational number is also not closed under division, so I am. Do you know why we are not closed under division?

Student: Yes, we know. As zero is a member of your family and division by zero is not defined, so you people are not closed under division.

Integer: Well answered.

Student:

One of the sections was randomly selected to receive treatment and the other acted as control group at the beginning of the study. At the end of the first summative assessment and beginning of the second half of academic session we assigned the treatment conditions to the randomly selected experimental group. During the treatment phase the students were shown introductory motivating video at the beginning of the class for 4 to 5 minutes. The purpose of showing interesting motivating videos was to help students stop gossiping and motivate them for active learning. We collected a large number of motivating videos available over internet and encouraged students to share similar motivating videos with their friends. As we would see in the result section, we were quite successful towards our objective of getting the students ready to learn. The students were asked to share their experience. The table 1 shows some of the sample introductory videos shown to them.

The main source of video content was internet. Now a days free videos are available on youtube on a wide range of topics. We collected many videos related to our topics in mathematics as per the $8^{th}$ standard syllabus of second summative assessment of the school.

The challenge was selecting the right sort of video and it was done by by a team of experts. The videos related to topic were presented for about 7 to 10 minutes with pause as per the demand of students. After the display of the content questions related to the concept were put on screen to check their understanding. Students were sitting in groups of 3 or 4 to help each other in understanding the concept and completing the task. After that they used to pictures of their work on a smart phone given by teacher for displaying on screen their work and group evaluation.

When most of the students understood the matter to an appreciable extent then the videos of their work were collected and displayed on screen for the benefit of other students. The representation styles of different students were displayed on screen for critical examination and acceptance of best features before the whole class. This helped transfer of good culture of note preparation, calculation skills and representation on note books among the students without highlighting their weaknesses in a friendly way. This encouraged multiple representation and diversity in our work style while encouraging efficient ways of carrying the work.

Digital folders of their best works related to content were maintained on the laptop during ongoing activity after taking snaps of their mathematics note books. Snaps of chalk board work were also taken for later use.

The snaps of best work style, model procedures and chalk board works were shared using social network site Whats App among the group members. Students also shared their best work online among the group members. The students used to put questions and queries and other students started responding to their concerns online. This created scope for using the social networking sites for a good educational cause.

Evaluation was always carried on by exchanging the notebooks among the group members. The model copy scoring 100% was displayed on screen and students were explained the feasible multiple representation styles of the task. After thorough counseling the students were found quite honest and strict in their evaluation. They used to rectify the note books of their friends after critical examination. At places of doubt they refer the copy to teacher or more knowledgeable friend of theirs.

Before the students exit from the class some motivating messages or pictures were displayed on screen to help them receive correct values and create a topic for discussion on their way back to their classro

**Testing**

We used the pretest-posttest equivalent group design. Pretest scores could be used in analysis of covariance to statistically control for any differences between the groups at the beginning of the study. Subjects were pretested and posttested on their knowledge, understanding and application of concepts using routine first and second summative assessments conducted by school in the middle and end of the session. No separate timetable and test booklet was introduced. The summative assessments were routine half yearly assessments generally carried over in the month of mid September and mid February in school to assess their performance. It is group administered paper-pencil test containing about thirty items of objective, very short answer, short answer and long answer type questions from the relevant 50% syllabus taught to them during four months preceding to their assessment.

## Results

**Table 1 Score Means and Standard Deviations on the Achievement in Mathematics**

| Group | Pretest | | Posttest | |
|---|---|---|---|---|
| | M | SD | M | SD |
| Control | 55.5 | 22.1 | 40 | 28.6 |
| Experimental | 33.2 | 21.9 | 39.7 | 24.4 |

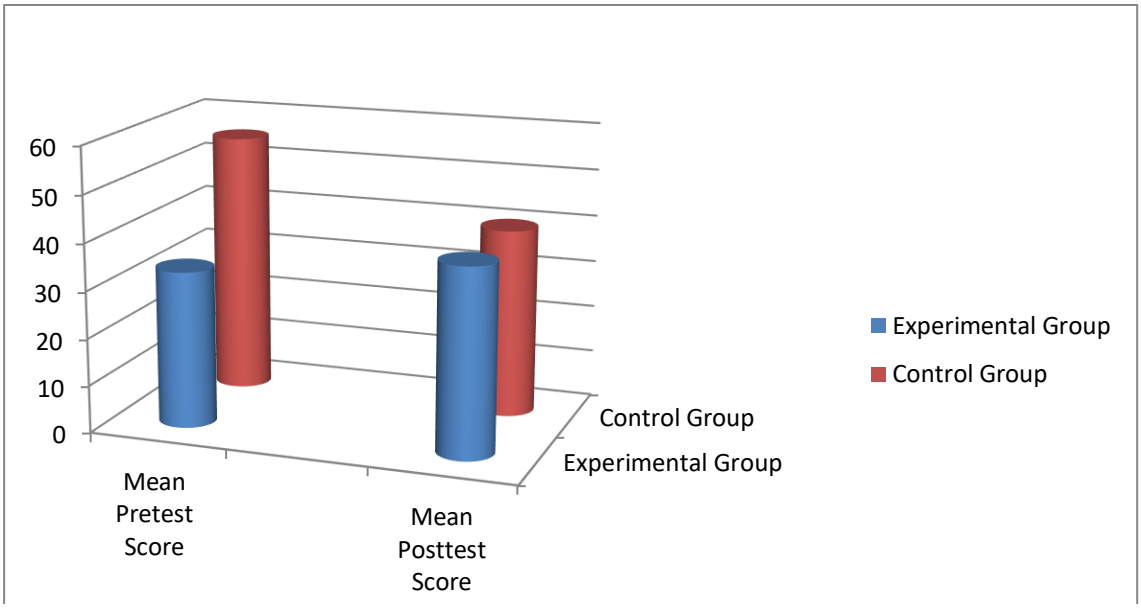



**Figure 1 Bar graph representing Pretest-Posttest percentage scores of experimental and control group**

Table 1 contains the pretest-posttest achievement score means and standard deviations for the ICT mediated PBLM group and traditional pedagogy group on the selected mathematics concepts of class 9. The pretest mean score ranged from 33.2 for the traditional pedagogy group to 55.5 for the ICT mediated PBLM pedagogy group, whereas the posttest means ranged from 39.7 for the ICT mediated PBLM pedagogy group to 40 for the traditional pedagogy group. In order to test the initial pre existing variance between the randomly selected groups, the pretest scores of the experimental and control groups were subjected to independent samples t-test. A two-tailed t-test for independent samples showed statistically significant difference between group means at pretest, *t* observed = -4.07, *t* critical = 2.0, *df* =

66, $p < .001$, indicating that the two groups were not comparable prior to instruction. The achievement of experimental group was significantly lower than that of control group.

Table 1 contains the means and standard deviations of pretest and posttest scores of control group. The means of the experimental (ICT mediated PBLM) group ranged from 33.2 for the pretest to 39.7 for the posttest. A two-tailed t-test for paired samples showed statistically significant difference between group means at posttest and pretest, *t* observed = 2.88, *t* critical = 2.04, $df = 33$, $p < .01$, indicating that the pretest and posttest mean scores were not comparable; that is there was significant improvement in the performance of the students exposed to ICT mediated PBLM pedagogy.

The means of the conventional pedagogy group ranged from 55.5 for the pretest to 40 for the posttest. A two-tailed t-test for paired samples showed statistically significant difference between group means at posttest and pretest, *t* observed = -5.32, *t* critical = 2.04, $df = 33$, $p < .001$, indicating that the pretest and posttest mean scores were not comparable; that is there was significant deterioration in the performance of the students exposed to conventional(traditional) pedagogy.

**TABLE 2 Analysis of the Variance Summary Table for the Achievement in Pretest**

| **Source of variation** | **SS** | **df** | **MS** | **F** |
|---|---|---|---|---|
| Between groups | 8456.9 | 1 | 8456.9 | 16.2* |
| Within groups | 34420 | 66 | 521 | |
| Total | 42877 | 67 | | |

*$p < .05$; *F* critical: 4.00.

Table 2 contains the results of one-way analyses of variance used to compare the pretest means of the ICT mediated pedagogy and traditional pedagogy groups. The one way ANOVA indicated that the two groups were not comparable at pretest in terms of students' achievement.

**TABLE 3 Analysis of the Variance Summary Table for the Achievement in Posttest**

| **Source of variation** | **SS** | **df** | **MS** | **F** |
|---|---|---|---|---|
| Between groups(n=34) | 1.8 | 1 | 1.8 | .006** |
| Within groups | 20600 | 66 | 312 | |

| | | |
|---|---|---|
| Total | 20601.8 | 67 |

**$p < .05$; $F$ critical: 4.00.

Table 3 contains the results of another one-way analyses of variance used to compare the posttest achievements of the ICT mediated pedagogy and traditional pedagogy groups. The one-way ANOVA indicated that the posttest variances between the groups were not significant.

As there is significant pre existing differences between the groups at pretest level, the independent samples t- test at posttest level is not justified. So there seems the need of applying ANCOVA to compare the posttest scores of both the groups. There are three assumptions for applying ANCOVA. First, covariates (pretest scores) should not be highly correlated; second, residuals should be normally distributed and third, the homogeneity of variance i.e. the variances should be similar for all the groups.

The Pearson correlation coefficient for the pretest scores of experimental group to that of control group was found to be .321($r < .8$); this shows that pretest scores (covariate) of experimental and control groups are not highly correlated. So, the first essential condition for applying ANCOVA was met.

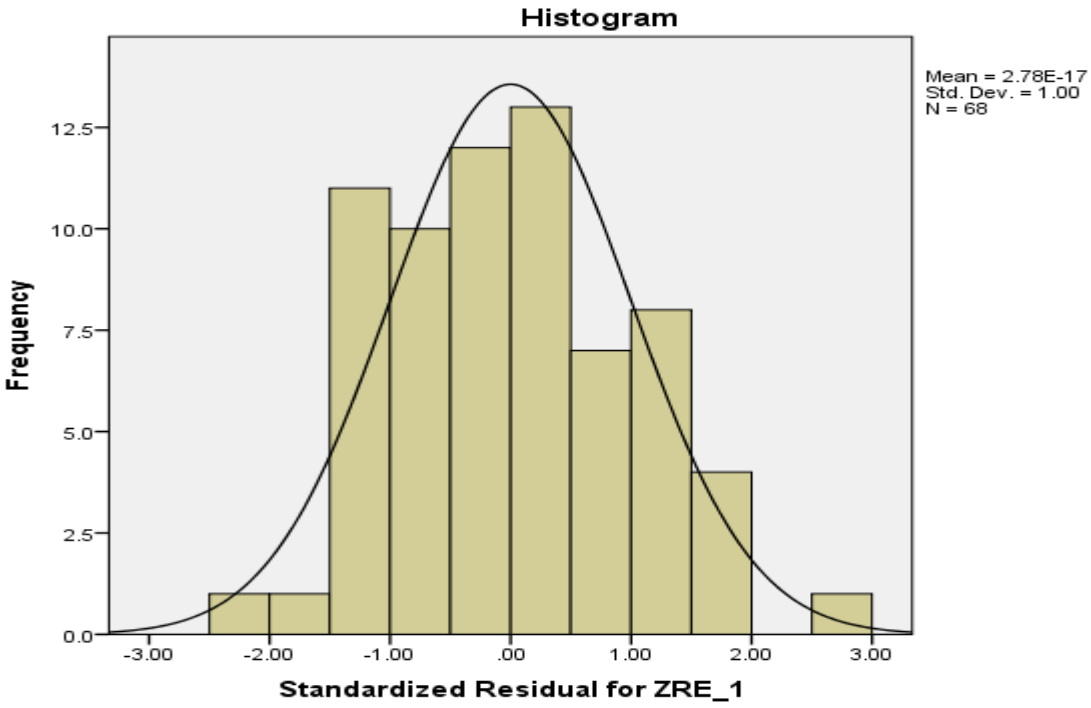



**Figure 2 Histogram with Normal Curve representing Standardized Residuals**

Numerical value of skewness = .43, standard error of skewness = .291. As numerical value of skewness(.43) falls within the range of twice standard error of skewness (-.588 to .588), the distribution of Standardized Residuals can be considered to be normal. So, the second assumption before applying ANCOVA was met.

**TABLE 4 Levene's Test of Equality of Error Variances**

| F | $df_1$ | $df_2$ | Significance |
|---|---|---|---|
| 2.42 | 1 | 66 | .125 |

Table 4 Levene's test of equality of error variances tests the null hypothesis that the error variances of the post test scores of experimental and control group is equal across groups. The results F(1, 66) = 2.42, p = .125 indicates that the error variance of the post test scores of the experimental group is no different from that of control group. So, the third assumption before applying ANCOVA was also satisfied.

As, all the three assumptions before applying ANCOVA were found satisfied, it may be appropriate to use ANCOVA to compare the post test scores of both the groups with due consideration to the pre-existing difference between the pretest scores of both the groups.

T**ABLE 5 ANCOVA results for the posttest of experimental and control groups**

| **Source** | **Type III Sum of Squares** | **df** | **Mean Square** | **F** | **Sign.** | **Partial Eta Squared** |
|---|---|---|---|---|---|---|
| Group | 6020 | 1 | 6020 | 25.7 | .000 | .285 |
| Error | 15130 | 65 | 95 | | | |

R squared = .675 (Adjusted R Squared = .665).

Table 5 contains the results from analysis of covariance of posttest scores of experimental and control groups. A one-way ANCOVA was conducted to compare the effectiveness of treatment by taking into account the pre existing differences between the groups at the time of pretest. Levene's test and normality checks were carried out and the assumptions met. There was a significant difference in mean post test achievement scores [F(1,68)=25.7, p <

0.001] between the experimental and treatment groups. Comparing the estimated marginal means showed that the more score was gained on ICT mediated treatment given to experimental group (mean=50.4) compared to conventional treatment given to control group (mean=29.4). The results indicated there was significant difference between the variance of the two groups which could not be accounted to error variance.

**Testing of first hypothesis**

H01. The mean academic achievement score of the students in experimental group will not be significantly different from that of control group.

The following observations were summed up from the above results:

First, there was significant difference on the mean pretest scores of the experimental and control group. The groups were not comparable before giving treatment. The control group had performed significantly better than the experimental group in pretest.

Second, there was significant difference on the mean pretest and posttest scores of the control group. The posttest performance of control group was found to be deteriorated in comparison to their pretest performance.

Third, there was significant difference on the mean pretest and posttest scores of the experimental group. The posttest performance of the experimental group was found to be significantly better than their pretest performance.

Fourth, there was significant difference on the estimated mean posttest scores of the control and experimental group by taking into consideration the significant difference in their pretest scores.

These results indicated students in the experimental ICT mediated group ($M$ = 39.7, $SD$ = 24.4) scored better in posttest than did the students in the control group ($M$ = 40, $SD$ = 28.6). These results suggest ICT mediated interaction has significant impact on improving the achievement in mathematics.

**Table 6 Gender wise Score Means and Standard Deviations on the Achievement in Mathematics**

| Treatment group | Gender | Pretest | | Post test | |
|---|---|---|---|---|---|
| | | M | SD | M | SD |
| ICT mediated PBLM group(n=34) | Girl(n=13) | 40.5 | 25.6 | 48.6 | 27.7 |
| | Boy(n=21) | 28.7 | 21.1 | 34.2 | 21 |
| Traditional pedagogy group(n=34) | Girl(n=13) | 60.4 | 22.3 | 49.3 | 32.3 |
| | Boy(n=21) | 52.5 | 22.5 | 34.3 | 25.1 |

Result from Table 6 was analyzed to see the effect of gender on achievement and effect of ICT mediation on gender. Pretest means ranged from 28.7 for boys to 40.5 for girls in ICT mediated PBLM group. A two-tailed *t* test for independent samples showed no statistically significant difference between gender means for ICT mediated pedagogy group at pretest, *t* observed = 1.45, *t* critical = 2.04, *df* = 32 , *p* = .15 > .05, indicating that the gender groups were comparable at pretest. Posttest means ranged from 34.2 for boys to 48.6 for girls in ICT mediated pedagogy group. A two-tailed *t* test for independent samples showed no statistically significant difference between gender means for ICT mediated pedagogy group at posttest, *t* observed = 1.18, *t* critical = 2.04, *df* = 32 , *p* = .25 > .05, indicating that both the genders in ICT mediated group were comparable at posttest.

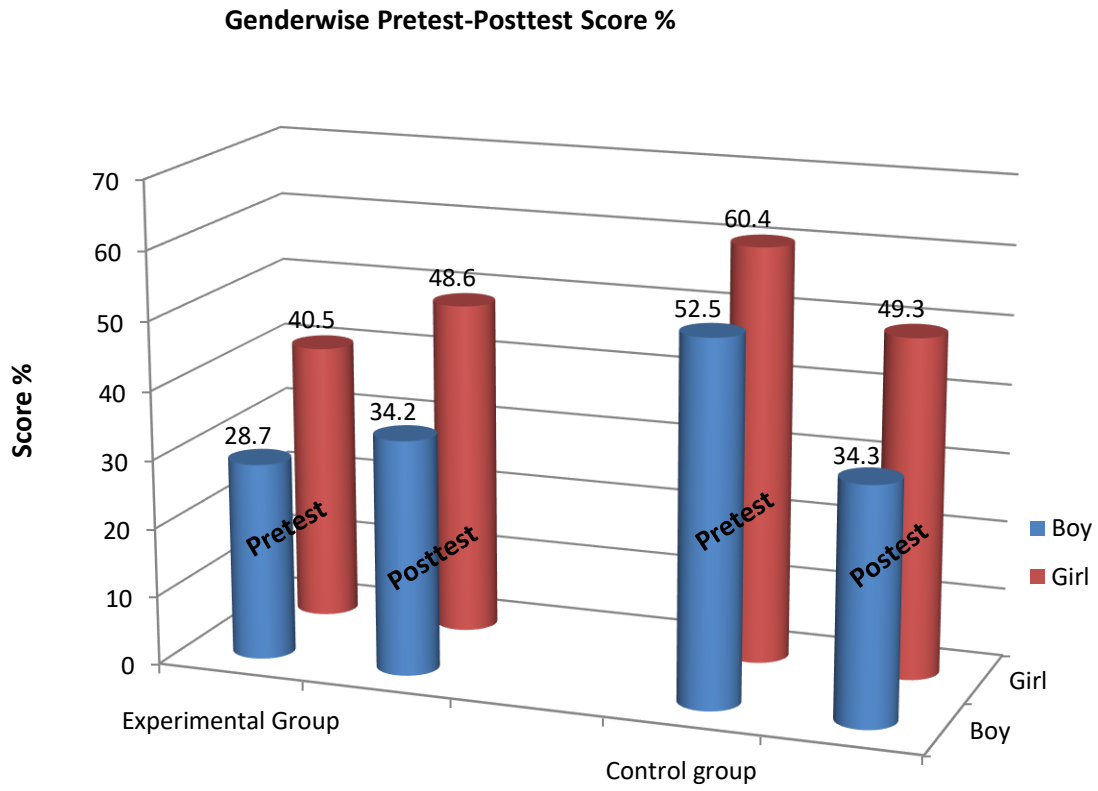



**Figure 3 Bar graph representing gender wise percentage score in Pretest-Posttest**

The heights of the columns in figure 3 clearly demonstrated that at pretest there was significant difference between the mean percentage scores of boys and girls for both experimental and control groups. Mean test scores of girls and boys of both the groups were quite comparable at pretest; whereas after receiving the treatment the girls and boys of experimental group showed significant improvement in their mean test score.

**Testing of second hypothesis**

H02. There will be no significant difference in the mean academic achievement scores of the girls and boys in both the groups.

The analysis of all the *t*-tests indicated that gender had no significant effect on the mean test score. Moreover, ICT mediation seemed to facilitate significantly both the genders to improve their scores in comparison to control group.

**Qualitative Observation**

I. Engage in task

As part of treatment students were shown every day some sort of motivating video, mathematics puzzle, or interesting heart touching media clips demonstrating sincere efforts for about 3 to 5 minutes at beginning of the class. The intention behind playing such video was to mentally prepare the students for the day's work with renewed vigor. As soon as the students entered the classroom the clip was ready to play. Here I describe my experience with introducing this treatment vis-à-vis my experience in conventional classroom .

The introductory motivating videos helped the class to come to a standstill. Silence prevailed over the class. Students seemed to be touched by the videos. Figures 4 is an example of the situation prevailing in classroom at the beginning before venturing into the day's job. Conventionally when students enter classroom or at the start of a new class there is a lot of chaos and noise in class. Students take about 4 to 5 minutes time to settle down with teacher's interference in the form of rebuke, stern look, repeated announcement with a louder voice to stop talking( maintain pin drop silence, those who want to make noise go out of my class, silence please, sometimes one of the students stand up and announces madam/ sir has come – just keep quiet, sometimes teacher takes names of certain students deeply merged with talking and instructs them to stand up as exemplary sort of punishment to catch other's attention or to dissuade other's from talking). Sometimes for new teachers this becomes a challenge; especially for pre service teachers it becomes a challenge to calm down the class or to get rid of disturbance in the form of talking at the very onset of class. Playing a motivating video in the form a mathematics puzzle, inspirational life story of successful persons, natural motivating videos on values etc. seems to engage them at the beginning of the lesson. Teacher's verbal interference to calm down students really helped both. Students used to rush to come to mathematics laboratory to see something new. They used to complement teacher for showing such good quality inspiring video. Videos depicting importance of hard work, perseverance and patience started working on them like magic. These changes were visible in the form that about seven students who never complete their class work

were found asking for help to complete their work; about four to five students requesting the teacher for additional home task; looking at these students who were asking for additional home tasks some other students also started conveying their intention of doing additional work; on the next day there was renewed excitement in them to announce about the precious works done by them to teacher; except in some exceptional case like child was having some physical problem or the child had not attended the class, most of the students (more than 90% on most of days) submitted their home assignments; there was an appreciable rise on the number students taking up additional tasks which shows visible increase in internally motivated students.

**Figure 4 Students feeling self motivated to work**

II. Exploring the Day's Job

Textbook in the e-form was displayed on screen and there was no need on the part of students to carry the textbook to classroom. Students with good reading ability read the textbook and their voices were recorded and played simultaneously to help other students read the textbook. It helped cover each corner of textbook. The

examples, figures and introductory texts to concepts given before examples were read and discussed aloud among the group members and class as a whole. Figure 5 is a snap of NCERT mathematics textbook taken during the class to acquaint the students with the problem. Students henceforth shying away from participation were seen to ask their fellow group members about their observations and clarify any mismatch. As we started recording the voices of the students while reading the students turned not only more cautious but also it helped them improve their reading by providing the best. Even they were seen requesting for a next time better recording their voice. Students were asked to record their reading the textbook using a smart phone and put the same in their e-portfolio. It was decided to play their voices to the class to ensure correct reading style. Students grew smarter in meaning making; probably the critical examination of each word and line of their mathematics text book on big screen in a group helped everybody in class. It was never seen before experience for me as a teacher. Earlier in spite of putting a lot of effort I was never able to do such thorough analysis of text book in class; the main reason being not able to catch hold of their attention for a longer duration. In traditional setting sometimes some gaps used to arise between me and students while analyzing the texts from a book. This gap seemed to melt away with group analysis and reading using a big screen to display the textbook.

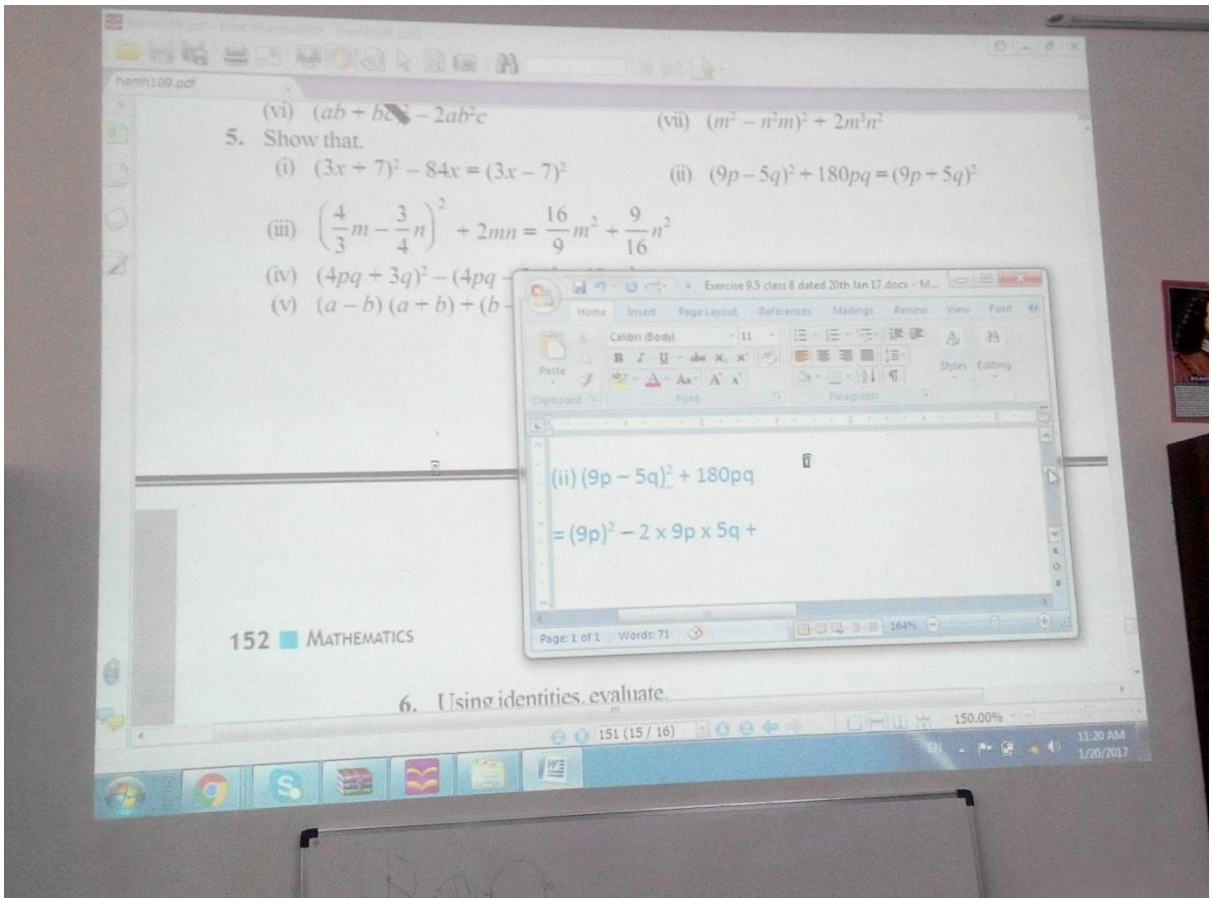



**Figure 5 Onscreen simultaneous display of NCERT textbook and live solution procedure**

## III. Explaining the concept

**Figure 6 More able peer helping fellow peers in their attempt to acquire the concept**

## IV. Elaborating the concept

Additional videos prepared by student using their smart phone, materials prepared by student to understand the concept at a deeper level probably helped the students at disadvantage to learn the concept. Teacher used multiple sources to strengthen their concept. Figure 7 and 8 shows such an attempt.


**Figure 7 Students engaged in performing following the live demonstration on screen**

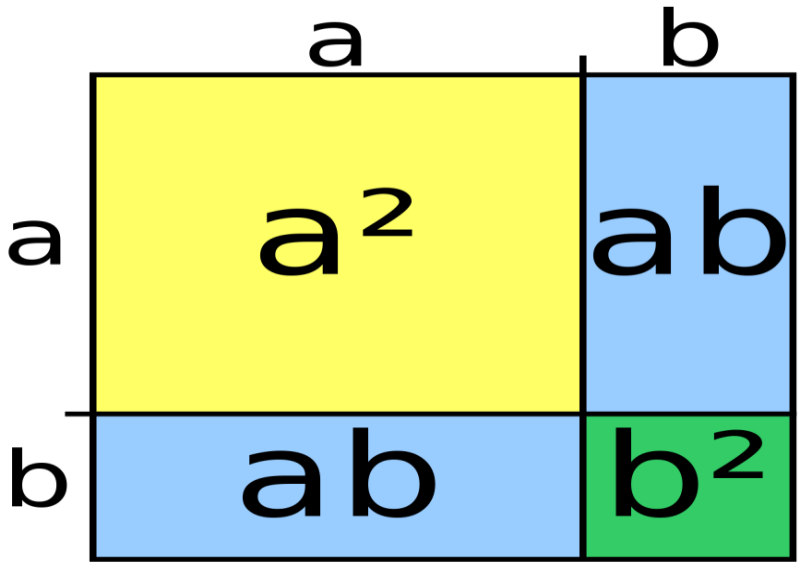



**Figure 8 Students presenting their understanding through their work**

## V. Evaluating the acquired concept

The videos of students while explaining their friend were prepared for later use in scaffolding and encouraging. The students used to come forward to chalkboard and write their name and question number of their doubts; those students who felt confident enough to explain the doubts came forward and wrote their names against the respective doubts(Figure 9). Then the whole class went on with students getting engaged in helping each other understand the difficult concepts. Videos of scaffolding were created by other students using smart phone. Pictures of chalkboard work were captured and posted in social group, Whats App platform formed by the students for further reference. It proved useful for students who were absent or those who still had doubts even after the class. Figure 10 shows the picture of class work notebook of student when the task was given in class. The snaps of their notebooks were taken and kept in their digital portfolio. Then the works were displayed on screen for group evaluation; the concerned students carried out the correction as per the suggestions received from their friends. Students put scores on their own copy as per suggestion of the group. Sometimes the students exchanged their copies in group of three or four students sitting on one desk for cross evaluation and critical comments for improving their work. The snaps of their works were taken for group viewing on screen after due correction in note books. The best components of each work were integrated in each copy; the best copies were appreciated and given group clapping. More and more students stared finishing their work early with the

hope that their work would be displayed first on screen. So the feeling of scare for evaluation turned to be matter of pleasure. Students' tiny irregular writing looked very big on screen; this scaring experience motivated them to improve their presentation.

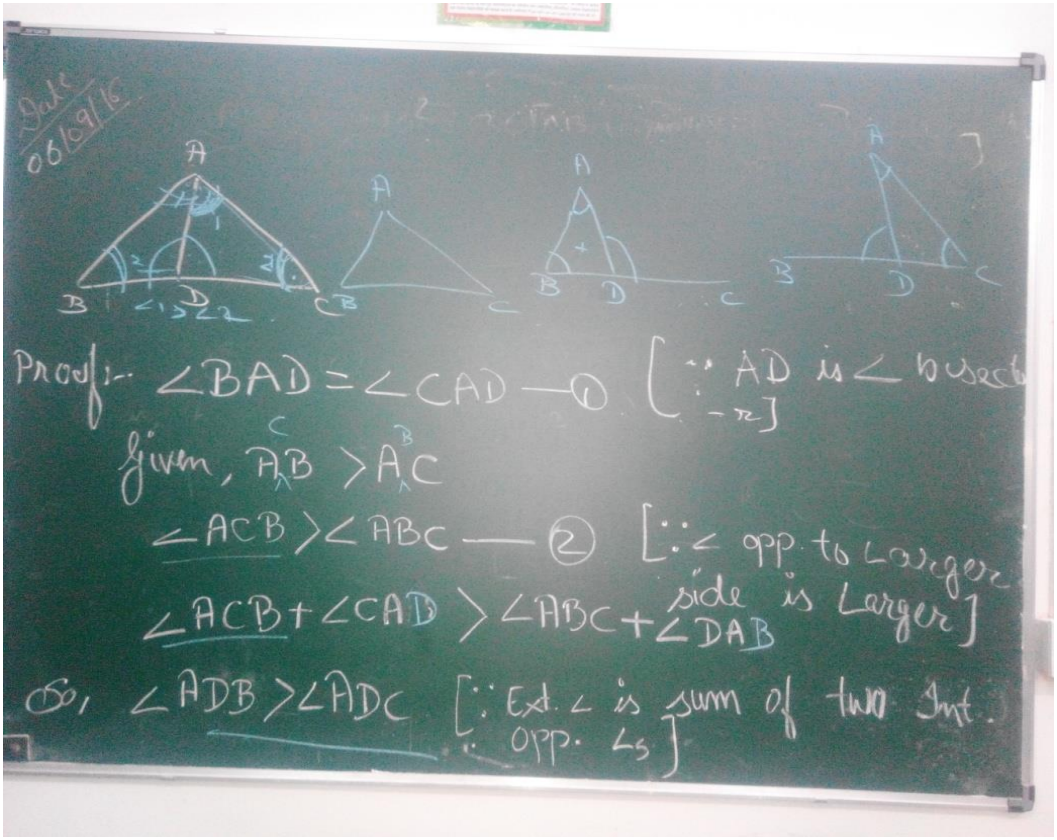



**Figure 9 Students engaged in giving their valuable reflection on the solution of a peer**

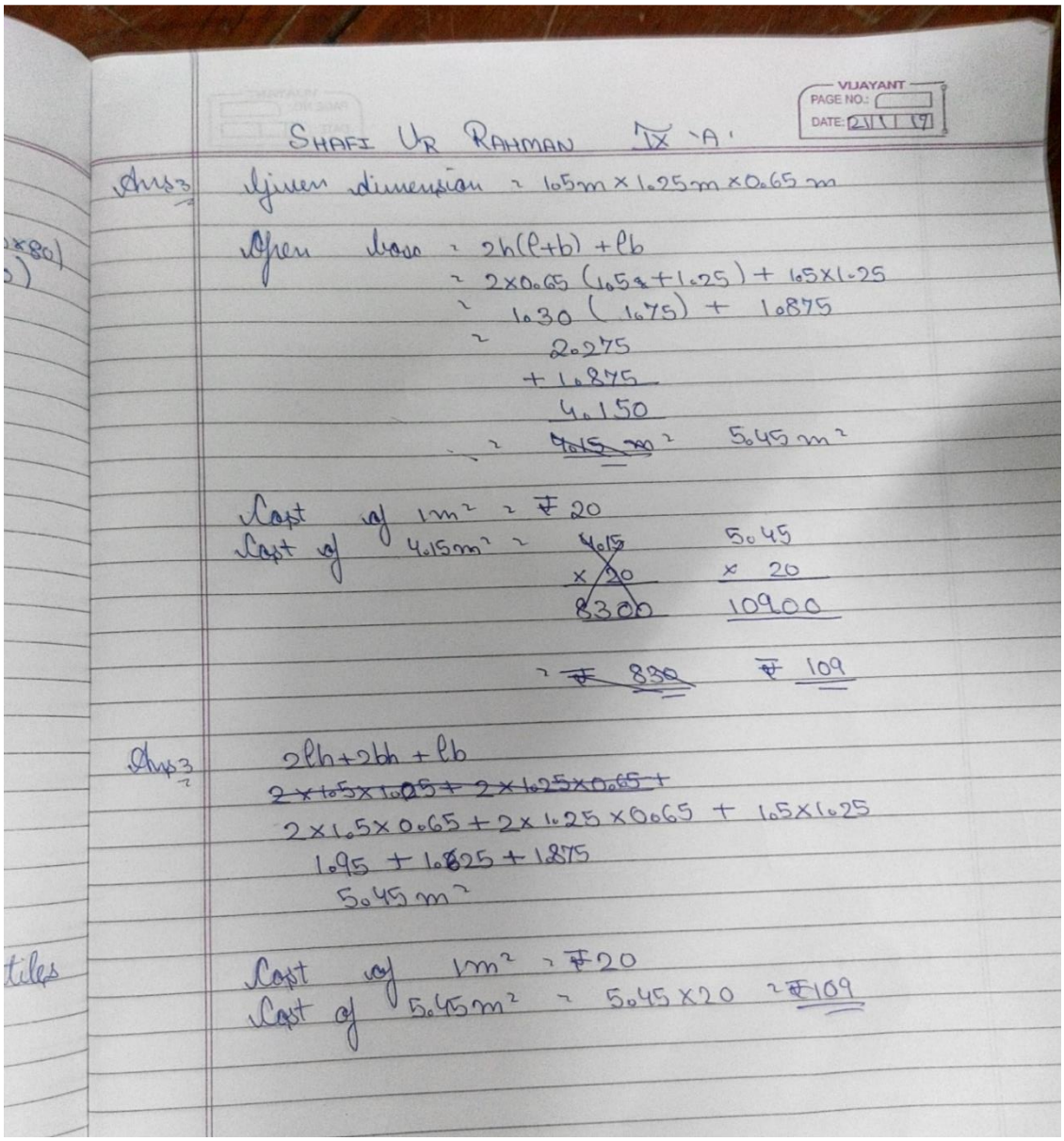



**Figure 10 Picture of student's notebook is presented on screen for critical evaluation by classmate**

**Discussion**

*Reasons for choosing a variety of constructivist strategies:* As the intervention was a semester long and a large variety of mathematics concepts were needed to be covered, no single strategy was found justified. Multiple approaches were encouraged like at least to do justice to the concept to be learnt. For example, I used flipped classroom setting for reciprocal teaching. Sometimes I preferred cognitive apprenticeship within flipped classroom set up. At other times like while learning the concept of volume of different regular geometrical objects like cube, cuboid, cone, and cylinder, I felt problem solving approach within flipped classroom set up can do the justice to the concept. The main thrust was how to involve students with the process, connecting to their real life, and providing scope for multiple representation. If one student could not comprehend the concept from one source, then there must be several other options/ sources before the student to acquire the concept. For example sometimes after my interference also some concepts were not clear to some students. Then I instructed to the students who had understood the concept to prepare a media clip using smart phone by thinking aloud the steps and the reason behind each step in a very slow pace. I played it on the next class and each of us followed it minutely. At places I interfered to rectify certain concept or to give emphasis on certain places. This strategy really helped a lot to students at disadvantage. The concept was dramatized (as in case of number system), understood using construction/ paper folding(algebraic expansion of $(a+b)^2$ like concepts), predicting the similar type of algebraic expanded forms using inquiry strategies, reading aloud and thinking aloud using some student's recorded version in their mother tongue helped the class resolve the mystery surrounding the word problem solution, keeping the names of students in the name of different concepts for role play, playing with mathematical shapes were some sort of model performance based learning strategies I encouraged in classroom transaction of class 9 mathematics.

So instead of using one specific form of intervention strategy I thought of using a range of strategies like *flipped classroom* and *reciprocal teaching*. We define the flipped classroom as an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom(Bishop & Verleger,2013).

*Reciprocal learning.* A group of students read together and co-construct meaning(Tarchi & Pinto, 2016). Reciprocal teaching(Palincsar & Brown, 1984) is a reading comprehension methodology, in which a group of students is collaboratively applying four strategies (questioning, clarifying, summarizing, and predicting) to co-construct the meaning of a written text.

*Theoretical Background for treatment given:* Vygotsky(Wikipedia 2017) guided his students in researching the phenomenon, the development of higher cognitive functions of logical memory, selective attention, decision making and language comprehension, from early forms of primal psychological functions using three different angles:

- The instrumental angle, which tried to understand the ways humans use objects as mediation aids in memory and reasoning
- A developmental approach, focused on how children acquire higher cognitive functions during development
- A culture-historical approach, studying how social and cultural patterns of interaction shape forms of mediation and developmental trajectories

**Cognitive Apprenticeships(Woolfolk, 2004)**

A relationship in which a less experienced learner acquires knowledge and skills under the guidance of an expert. Allan Collins and his colleagues(1989) suggest that knowledge and skills learned in school have become too separated from their use in the world beyond school. To correct this imbalance, some educators recommend that schools adopt many of the features of apprenticeships. But rather than learning to sculpt or dance or build a cabinet, apprenticeships in school would focus on cognitive objectives such as reading comprehension, writing, or mathematical problem solving. There are many cognitive apprenticeship models.

But most share six features:

- Students observe an expert( usually teacher) model the performance
- Students get external support through coaching or tutoring(including hints, feedback, models, and reminders).
- Students receive conceptual scaffolding, which is then gradually faded as the student becomes more competent and proficient.
- Students continually articulate their knowledge- putting into words their understanding of the processes and content being learned.
- Students reflect on their progress, comparing their problem solving to an expert's performance and to their own earlier performances.
- Students are required to explore news to apply what they are learning – ways that they have not practiced at the master's side.

The monitoring of the understanding of a problem and the problem-solving process helps students begin to think and act as mathematicians(Schoenfeld, 1989,1994). To help students become more expert problem solvers, Schoenfeld asks students three important questions: what are you doing? Why? How will this help? These questions help students control the processes they use and build their metacognitive awareness.

While learning $(a+b)^2$, $(a-b)^2$, $(a+b)^3$, $(a-b)^3$, $(a+b+c)^2$, $a^3+b^3$ and $a^3-b^3$; students were asked to draw $(a+b)^2$ using paper followed by demonstration using projector and teacher helping some students who could not cope up with the projector. Soon some students who could complete most of their work of making what constitutes $(a+b)^2$ . Video shown downloaded from you tube with link:

1. https://www.youtube.com/watch?v=BHCQ5sYsVS8 Mar 31, 2015 - Uploaded by Arvind Gupta
2. https://www.youtube.com/watch?v=TsaH0GR15V4 Nov 11, 2013 - Uploaded by MathsSmart

Students followed the steps under these model and the class experience was vibrant. There was no irritation on the part of teacher; though it was a bit more exhausting as teacher was

required to draw his attention to somebody or other at every moment. Many people were at different stages in the same class; all of the students had found something to work on. Some students could complete their work after repeated pause and play of the multimedia document.

**Inquiry Learning(Woolfolk, 2004)** Approach in which the teacher presents a puzzling situation and students solve the problem by gathering data and testing their conclusions.

e.g. If $(a+b)^2 = a^2 + 2ab + b^2$ , can you predict what is $(a - b)^2 = ?$

Similarly predicting other formulas and linking the formulas through some logic to predict their form. Find the numbers those have exactly three factors. Can you predict the emerging pattern?

What is $15^2 – 14^2 = ?$ Can they discover the difference between squares of two adjacent numbers by arranging .dots to represent square of any number?

John Dewey described the basic inquiry learning format in 1910. There have been many adaptations of this strategy, but the form usually includes these elements (Lashley, Matczynski, & Rowley, 2002). The teacher presents a puzzling event, question, or problem. The students:

- Formulate hypotheses to explain the event or solve the problem,
- Collect data to test the hypotheses
- Draw conclusions, and
- Reflect on the original problem and the thinking processes needed to solve it.

  In fact, students might go through several cycles of investigating, identifying patterns, and reporting results before moving on to constructing explanations and making final reports. Another possible cycle is to evaluate explanations before reporting by making and then checking predictions, applying explanations to new situations. Inquiry teaching allows students to learn content and process at the same time(Woolfolk, 2004, p. 365).

**Problem-Based Learning.**

> Methods that provide students with realistic problems that don't necessarily have "right" answers. In problem-based learning students are confronted with a real problem that has meaning for them. This problem launches their inquiry as they collaborate to find solutions. In true problem-based learning, the problem is real and the students' action matter. Some problems are not authentic in the sense that they affect students' lives, but they are engaging(Wookfolk, 2004, p.365).

**Anchored instruction** A type of problem-based learning that uses a complex interesting situation as an anchor for learning. The anchor is the rich, interesting situation. This anchor provides a focus- a reason for setting goals, planning, and using mathematical tools to solve problems. The intended outcome is to develop knowledge that is useful and flexible, not inert. Inert knowledge is information that is memorised but seldom applied(CTVG, 1996; Whitehead, 1929).

For example, While checking if the following statements are true, the teacher used the following anchor.

All squares are rectangles. All squares are rhombuses. All parallelograms are trapeziums.

*Anchored Instruction:* All humans are animal(True). All animals are humans(False).

Using anchor was a common practice in class, the frequency of using anchor comes with the experience of the teacher delivering the concept. Students enjoy the anchor very much. It usually removes temporary boredom from routine concept. It also helped in cultural connection.

Some researchers have shown that discovery methods are ineffective and even detrimental for lower-ability students (Corno & Snow, 1986; Slavin, Karweit, & Madden, 1989).

Excessive and frequent use was avoided. But it was found helpful when discovering the underneath pattern for recalling the different algebraic formulas.

1.While learning to calculate the surface area and volume related problems of cube, cuboid, cone, and cylinder, the teacher used real problems like finding the quantity of bricks needed to make the classroom wall.

2. Finding the volume of a cup or cylindrical paper cup. Extending the learning to harmful effects of using paper cups or the quantity of tea or coffee served by canteen per cup.

**Dialogue and Instructional Conversations** Situations in which students learn through interactions with teachers and/or other students(Woolfolk, 2004, p.367). Students need to grapple with problems in their zone of proximal development, and they need the scaffolding provided by interaction with a teacher or other students. Scaffolding is a powerful conception of teaching and learning in which teachers and students create meaningful connections between teacher's cultural knowledge and the everyday experience and the knowledge of the student(McCaslin & Hickey, 2001, p.137).

e.g. Students grappling with word problems teacher scaffolds them to understand step by step how to formulate the solution.

Teacher helped students through the derivation of formula for the surface area and volume of solids like cube, cuboid, cone, and cylinder. The activity played on screen was followed by continuous interaction of students and teacher to correlate different aspects.

*Understanding Results*

The *t-test* results for the experimental group show that there exists a significant difference (improvement) between pretest and posttest, but there is also significant difference(deterioration) before and after instruction for the control group. The cause for improvement of achievement of experimental group may be assigned to treatment. The researcher had not conducted any pretest; rather their class 8 annual second summative scores were taken from school register as their pretest score so as to statistically control for any pre-existing variance. It was found that this randomly chosen control group had earlier exposure to treatment in class 8 second semester. Probably their earlier exposure to treatment in their class 8 second semester made them so different from their counterparts in the present experimental group. Prior to that the groups were equivalent in terms of their achievement in

class 8 first summative assessment. ANCOVA results indicated that there was significant difference between the post test scores of experimental and control groups. This shows that exposure to ICT mediation increases achievement and its withdrawal may be detrimental to achievement. The analysis of strategies used by these ninth graders also shows that there is more progress for the experimental group than for the students in the control group. These results suggest that the integration of technology into the mathematics instruction has a positive effect on the learning of number sense for the students in the experimental class. In addition, the pictorial representation via technology-based environment is easy and convenient for teachers to manipulate and demonstrate the mathematical concepts. In the other hand, the technology assisted in allowing students in the experimental class to interact with the mathematical concepts in novel ways. It promoted the students in the experimental class to develop calculation abilities through manipulating the model shortcut live representation of calculation. Therefore, there are several benefits for teaching and learning mathematics concepts via a technology-based learning environment: explaining diagrams and figures from textbook by computer can be done more easily, visual representations could attract the students' attention, and overlapping and separating the graphs can be more efficiently and conveniently accomplished by the computer.

As stated earlier in qualitative observation part that motivating videos were collected from a wide variety of sources and duration was restricted to 3 to 5 minutes. On some days the students used to demand to repeat certain videos like The Top Ten Football Goals, certain mathematical puzzles, moral stories etc. Short moral stories encouraging sincerity, adherence to task, honesty, helping others, reward for hard work, power of determination etc. were played as introductory videos as soon as the students enter the classroom.

These videos worked as boosters for attracting the students to the class. They seemed to rush to the classroom without wasting a single moment at their disposal. There was lighter moment inside the classroom. Teacher was not at all compelling; there was no talk related to whether they have done their homework. Once the videos was getting over students used to discuss in groups of two or three for 2 to 3 minutes regarding the content of the video. The teacher used to act like a group member; swayed with the mood swings of the children. Sometimes a puzzle was placed on screen and students got themselves engaged on the task. When the class got quite immersed on the task, the teacher told them to finish the rest part of the puzzle at leisure time. They were encouraged to engage themselves with such solved or unresolved puzzles and riddles with students of other classes, neighbours, other siblings and

friends for using the wasteful time e.g. while waiting for their school vans after school hours, some period going vacant due to absence of the concerned teacher or any other reason, sometimes they don't feel like studying textbook portions, a lazy afternoon etc. They used to report their success stories enthusiastically before the teacher in class and sometimes did stay even during the lunch breaks to express their success stories. It provided a good platform for those students who were not good at coursework related problems to express their smart jobs. It seemed to provide them self-esteem; as fellow students started admiring their quick responses to unusual situations. These interactions brought the whole class closer to each other. To an outsider the situation would seem to be chaos; but in reality a lot of active learning through over-enthusiastic engagement was taking place inside the classroom.

Jannat: Sir, how amazing the class is full of fun and enjoyment; let us have this type of class everyday(in a friendly voice).

Umrah: Sir, we don't want to move to any other class. Sir, please take the next period; we want to study maths only(with a tone of demand full of affection).

Akshat: Sir, what new thing we will do today?

There was some sort of excitement everyday for coming to mathematics laboratory. Students use to carry a happy face before coming to lab. Students those who were not good at writing part of the mathematics now started showing remarkable participation while getting involved in real problem of finding the volume of cylindrical jar given to them, finding the problem of number bricks used in the making of classroom wall, and so on. They showed their common sense and helped others.

Negative part of the whole event was that there was sometimes

During this whole event I found I have come much closer to the hearts of children; many dark sides of my own personality were visible to me. It helped me bring change in my teaching style. Traditional teaching methods used in the control group did not yield these benefits.

## Conclusion

Although this experiment was carried for a short period for about 9 weeks and was limited to two sections of class 9 students of only one school, the improvement made by the students in the ICT mediated group was readily distinguishable. Though the generalisations of the study were limited due to small sample size and duration of treatment, the results do provide some important and interesting findings.

First, the major contribution of this study is to support the evidence that ICT mediated PBLM learning in mathematics class can promote students performance in summative assessments conducted by school at the end of academic session. Even though many research studies and reports(Dick, 2007; Isikal & Askar, 2005; Inamdar & Kulkarni, 2007; Lin, 2008; NCTM, 2000; Olkun et al., 2005; Ruthven,2007; Vulis & Small, 2007; Zbiek et al., 2007) suggest that technology has a positive effect on mathematics teaching and learning, few practical studies focus on examining the use of technology when teaching a major portion of syllabus(about 50%) to secondary school children. Many teachers were of belief that in short term that is for research purpose the ICT may seem helpful; but in real classroom situation the use of ICT for whole academic calendar may not be successful at completing the whole syllabus within the assigned timeframe. Therefore this study was designed for almost half a calendar year to see whether mathematics can successfully be mediated with ICT to help students to improve their score in annual summative assessment conducted by school. To start with one may need an LCD projector, a laptop, access to internet (not necessarily inside classroom), a digital camera or a smart phone. This was the basic ICT based learning environment that was used in this study. Another limitation of this study was students did not have access to individual computers during mathematics class due to limited resources; although they had basic knowledge of handling the computer, digital camera and smart phone.

The major contribution demonstrates that children's concepts related to number system, algebra, and mensuration can be promoted by using ICT based learning environment. It significantly improved the performance of students in their annual summative assessment. It helped both the genders to equal extent to improve their performance.

Second, it definitely improved the clue grasping power (understanding the intent of question) of the students. As the questions were displayed on big screen and whole class debated on the solution procedure, students most unlikely to participate could gather sufficient information and outlook about the question. Think aloud was the norm of the class. Students seemed to

take benefit of reading the text loudly and explaining the intent of the problem or statement to the whole class. Multiple representation of thought or process was encouraged.

Third, it ensured 100% student participation in the process of classroom communication. Model procedures, tricks, spellings, standard hand written representation of the solution in notebooks and videos of correctly doing the task were made available at different times as per the requirement of individual student or group of students. Whenever anybody got struck up either the concept were replayed or somebody came to their help. Multiple ways to carry the multiplication using Vedic tricks, Chinese ways or any other anonymous trick motivated the children to get engaged in calculations involved in comparing quantities, as these situations provided them the challenge to demonstrate their freshly acquired tricks to prove themselves before others. They could better handle the tricky calculations.

Fourth, it improved their skills related to writing and representation of solution in their notebooks. As their copies were scanned and displayed on screen before others for group evaluation the students were found to be more diligent and particular in their task. Also with continuous exposure to best works of class and encouragement to add best features from different sources to our own work helped them imbibe many good points in their work.

Fifth, it helped the teacher in completing their half year's course well in advance; thereby leaving enough time for revision. The students having doubts noted it on the chalk board and students with correct understanding came forward to help them. They selected and replayed the multimedia document related to their difficult areas. It facilitated social construction of knowledge of mathematics in classroom.

To sum up ICT mediated learning environment proved to have positive effect on improving the student's performance on a range of elementary mathematics concepts in traditional annual summative assessments through social construction of knowledge in classroom.

Even though the application of technology in teaching and learning key concepts of eighth grade mathematics has several benefits, it also has a key limitation. Designing concept wise ICT mediated activities for every class was tedious, skilful and a lot of time consuming affair on the part of teacher. Moreover, designing a complete pack of ICT material for 40 minutes duration consisting of a motivating video of 3 to 5 minute duration, content related well split up small videos each of 3 to 5 minutes duration, followed by activity based questions, real

time monitoring the works of students through live shooting and displaying on screen, capturing students' responses and maintaining their digital portfolios can initially be done only with collaboration with computer professional and other colleagues. It took a lot of efforts on the part of this researcher to prepare the ICT mediated material; obviously the regular classroom teacher may not possess the required infrastructure and available time for this type of ICT mediated material preparation.

One department may be dedicated for this type of ICT mediated material preparation and teacher can directly use the readymade ICT mediated learning material.

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