How do Children Learn Mathematics? An Exploration into Mathematics Classroom Processes at Secondary Schools of Bhubaneswar

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Abstract

Considering the change in the perception of mathematics classrooms of India after the emergence of NCF-2005, which emphasises on mathematisation, it is significant to examine mathematics classroom processes. Four secondary schools from Bhubaneswar that are affiliated to CBSE had been selected for the present study. Data was collected using teacher questionnaire, classroom observation and Focus Group Discussion with students. Curricular contents in Mathematics prescribed for Class IX are found quite appropriate, grade specific and properly sequenced as expressed by the teachers. Geometry concepts especially related to Euclidean Geometry are difficult to transact as teachers and students faced problems in understanding these concepts. Although, the resource materials, such as mathematics lab and mathematics kits are available in the majority of schools, their inadequacy from the viewpoint of a large number of students and lack of physical space for storage and use are quite staggering. The preparation of lesson plans/ notes in mathematics is more ritualistic than having any serious and practical pedagogical concern. Methods appropriate to the content and the level of students were found to be used frequently or sometimes by maximum teachers while teaching mathematics. No group activities were conducted and rarely any individual activity took place.

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In most of the mathematics classes, oral and written assessment strategies were followed. The scope for peer and self-assessment is rarely found in mathematics classrooms. The study gives a detailed account of nuances of mathematics classrooms in terms of the content transacted, resources used, pedagogical processes employed, classroom management, and the assessment strategy followed, etc. The finding of the study would support educationists to understand the processes of mathematics learning and would give an insight into the role of mathematics teacher as a facilitator.

Introduction

Mathematics has always been an integral part of school curriculum. Learning mathematics is a continuous process, it does not remain confined to itself but also plays a role in the development of other disciplines. It is a fundamental building block that helps in structuring thoughts in a logical order. Mathematics is inevitable, learning mathematics involves thinking mathematical ideas. Mathematics has a vital role in the classroom not only because of direct application of the content but because of the reasoning processes that the students develop in the learning process. To achieve the wider goal of mathematics learning, NCF 2005 envisages school mathematics as an activity-oriented domain, which takes place in a situation where children learn to enjoy mathematics.The main goal of mathematics education in schools, as mentioned by NCF 2005, is the mathematisation of the child's thinking. It asserts that clarity of thought and pursuing assumptions to logical conclusions is considered as central to the mathematical enterprise. Mathematics helps to develop the ability to handle abstractions, and builds an approach to problem solving by introducing children to concepts, skills and thinking strategies that are essential in everyday life. Children feel delighted to arrive at a solution in mathematics and find some patterns by trying out different approaches to the problems. Mathematics is also a powerful way of communicating by exploring and explaining their ideas through different modes using language, symbols, etc. By understanding the history of mathematics, children would appreciate its contribution to the economy and society. It is undeniable that mathematics provides an important instrument for social analysis (D'Ambrosio, 2008). Mathematics not only prepares children with the skills they may use beyond their school life, but also encourages higher order thinking skills such as creativity and problem solving.

Curricular Provisions of Mathematics at the Secondary Stage of Schooling

Mathematics is one of the core curriculum subjects in schools from Grade I to X. The aims of teaching

mathematics, as understood through researches across countries, is to relate the contribution of mathematics to: (1) everyday life and society; (2) other areas of the curriculum; (3) the child's intellectual development; (4) the child's enjoyment of learning and (5) the body of human knowledge. Mathematics curriculum contains specialised knowledge which needs certain attitudes, frame of mind (analytical and logical thinking) and efforts on the part of learner (Ellis, 2011 and Rojan, 2008). The secondary school mathematics curriculum continues after the development of learning of mathematics in primary schools and at this stage, students try to understand the structure of mathematics. At the same time, the curriculum also aims to enable the students to cope confidently with the mathematics in their future studies, workplace, or daily life. Developing positive attitude towards mathematics and to have self-confidence to deal with all the aspects of number in logical and independent manner is also very significant (NCF, 2005). Integrating previously learnt concepts and skills into problem solving ability is another important concern at secondary stage as mentioned in NCF 2005. Protheroe (2007) found that mathematics instruction given in the secondary classes should build on students' emerging capabilities to improve their abstract reasoning which includes—thinking hypothetically, comprehending causes and effects and reasoning in both concrete and abstract concepts. However, unfortunately, many students have hindrance in using these cognitive abilities for learning effectively (Fauziah and Sugiman, 2018). A large numbers of students have not acquired the basic skill needed in mathematics learning (Mohd Nizam and Rosaznisham, 2004; Berch Mazzocco, 2007) as cited in Thngkingdang and Thongmoon, 2018. Despite valiant attempts by generations of teachers to improve the quality of pupils' learning, abstractions remain difficult to be grasped, which is the crux of mathematics learning.

Secondary education stage is important because for about half of those entering it, it represents the terminal point of formal schooling (Rao, 2008). The learning experiences of this stage of education become important for their future life in the society. As summarised in NCF 2005, the vision for school mathematics should be that the children learn to enjoy mathematics rather than fear it by learning important mathematics. The most important skills of learning mathematics are abstraction and generalisation, which are achieved through learning the basic content areas of arithmetics, algebra, geometry and trigonometry at secondary stage. Therefore, it is highly imperative that teachers engage every child through various activities in class with the conviction that everyone can learn mathematics. The experiences are to be designed in such a way that

children get ample opportunities for exploring and arriving at patterns and connections, individually and in group.

Classroom Practices and Learning of Mathematics

Mathematics as a part of children's life experience is the best mathematics education possible, wherein opportunities are there for children to pose and solve meaningful problems. As mathematics learning outcomes are linked with its pedagogical processes, low achievement in mathematics could be associated with the curriculum which fails to attract children with its relevance. At the same time, a method of assessment which usually focuses on mechanical way of solving problems is another concern. Mathematics teachers are supposed to design pedagogical processes in a diverse and inclusive manner; however, teachers find themselves less skilled in it. Lack of teacher preparation and support in the teaching of mathematics is another concern (NCF, 2005). Mathematics teaching depends on two factors, namely, the readiness of learners and the teaching skills of teachers. If any one of these factors falls behind, then the wagon of learning will not go in a balanced manner. The teaching of mathematics at secondary level requires psychologically balanced teaching methods. Also, Shellard and Moyer (2002) showed that there are three critical components of effective mathematics instruction. First, teaching for conceptual understanding; second, developing children's procedural literacy and last one is promoting strategic competence through meaningful problem-solving investigations. Though importance of learning mathematics is well researched and mathematics is implemented from Class I, it is unfortunate that students develop a sense of fear towards the discipline itself. As teaching-learning activities have a great impact on students' achievement, it is essential to investigate how pedagogical processes in mathematics are executed. From this discussion, it could be concluded that the most suitable strategies followed by mathematics teachers in the classroom may help students to appreciate the nature of mathematics, through which learning of mathematics could be improved significantly.

Teacher quality has been consistently identified as the most important school-based factor in student achievement (McCaffrey, Lockwood, Koretz, and Hamilton, 2003).Much research in education and learning mathematics has produced a number of insights into how students think and learn, but all too often, the resulting impact on actual classroom instruction is uneven and unpredictable as far as the mass is concerned. Decades of research in learning mathematics suggest that the students utilise individual learning styles to keep pace with the classroom processes.

The mathematics learning is much associated with the problem solving and recalling the skills needed to model a mathematics problem. The difficulties in understanding mathematics are qualitative in nature and depend on many factors which may be biological or behavioural.

Rationale of the Study

The problems in school mathematics education are— a majority of children have a sense of fear and failure regarding mathematics. Hence, they give up early on, and drop out of serious mathematical learning (NCF, 2005). From the above discussion, it was observed that the curriculum which cannot equally address the needs of students with diverse needs could be considered as one of the major factors contributing to this unfortunate scenario of mathematics education in the country. Teachers' lack of confidence and preparation in designing appropriate pedagogical practices lead the students to not appreciate mathematics learning. Topics which do not make sense cause students to lose interest in the subject and develop phobia towards the subject. Fear of learning of the subject increases the resistance to the learning process. Students develop the habit of memorising formulas and facts merely to pass the examinations. Achievement survey at national level conducted by various agencies indicates that the achievement of students in mathematics is low, though mathematics is seen as an important subject all over the country . It is clear that our efforts to improve the status of mathematics at school level over the past decades have not been largely effective. That's why teaching mathematics at secondary level should be given greater importance. Basically these problems occur due to the lack of teachers to recognise, explore, grow and develop mathematical skills that exist in students (Kusmaryono, 2014). Considering the change in the perceptions of mathematics classrooms of India after the emergence of NCF-2005, which emphasises on mathematisation, it is significant to examine mathematics classroom processes to come out with suggestions to improve the learning process in mathematics. In this context, the present research has been undertaken to qualitatively analyse mathematics classroom processes and make a deeper sense of the process.

Objectives

The objectives of the study are to examine the classroom processes in respect of:

- Content of mathematics
- Pedagogical strategies adopted
- Resource management
- Classroom management
- Assessment

Method

A qualitative survey method was adopted for the present study. The

study attempted to examine the classroom processes in depth with specific reference to the curricular provisions in mathematics and the pedagogical processes followed. Arriving at a qualitative description of the classroom processes in mathematics using various research tools was the focus of the study.

Sample

Four secondary English medium schools from Bhubaneswar, affiliated to CBSE were selected purposefully for the study. The schools were Demonstration Multipurpose School (D.M.School), Sainik School, Kendriya Vidyalaya-1 (KV-1) and Kendriya Vidyalaya-4(KV-4) of Bhubaneswar. Except Sainik School, which has all boys as students, all the other schools are co-educational schools. D. M. School is attached tothe Regional Institute of Education (NCERT) Bhubaneswar, KV schools are under KendriyaVidyalaya Sangathan and the Sainik School is under an apex body of Ministry of Defence.

In total,eleven teachers from these schools who teach mathematics in Class IX are included in the study. Students of Class IX of the schools were participated in the study.

Tools

Following tools were developed and content was validated by the experts.

1. Questionnaire for Teachers— This will have both closed and open ended items based on the dimensions— content, resources availability, pedagogical strategies followed, assessment, monitoring and supervision was administered.
2. Observation Schedule— This tool has three parts. PartI is intended to collect the background information of the teacher teaching Mathematics, school, classroom, students and infrastructure facilities available in the classroom.Part II is used to record the observation of the Mathematics Teacher while teaching Mathematics with respect to:Introducing the Topic, Pedagogical Processes Followed, Classroom Management, Assessment and Resource Management following 3-point scale (Yes/Partially/No) with observation remarks. Part III is intended to record the reflection of the observer on the overall functioning of the class.
3. Focus Group Discussion (FGD) with Students—Eight open-ended items were developed for focus group discussion with students to probe more on classroom processes in Mathematics.

Procedure of Data Collection

Data was collected from eleven teachers teaching mathematics through questionnaire and observation schedule (41 classes) and 40 students (10 from each school selected randomly) using Focus Group Discussion. The entire process

of data collection was completed approximately in 60 days from November 2017 to February 2018.

Analysis of the Data

The major objective of the study is to explore the status of processes being conducted in the Mathematics classroom of the secondary schools, particularly in Class IX. The five major aspects of Mathematics classroom processes, as included in the objective of the study are content, resource management, pedagogical strategies adopted, classroom management, and assessment. Specific indicators for each of these dimensions were identified keeping the overall objective of the study, which was used as the basis of tool development and data analysis as well. Since, the data are mostly qualitative in nature, the analysis of these data mostly followed qualitative techniques, supported at some instances by a few basic descriptive statistical methods.

Mathematics Contents

Curricular provisions in Mathematics, as in other subject areas, constitute the centrality of all the classroom processes without exception. The relevance of the provision of concepts in the curriculum depends largely on the perception of the teacher who is expected to transact those in the classroom. The teachers teaching Mathematics in Class IX in the sampled schools were asked to give their considered opinion regarding—(i) whether the contents are grade specific or appropriate for the grade (i.e. Grade IX), (ii) whether concepts are properly sequenced in the prescribed Mathematics textbook, (iii) whether there are adequate examples and practice activities in the Mathematics textbook, and (iv) whether the content load is appropriate for the class under study. Besides, the teachers and students were further asked to specify the areas in Mathematics curriculum which are comparatively difficult for learning and teaching in Class IX.

- Majority (90%) of teachers expressed that the curricular contents in Mathematics prescribed for Class IX are quite appropriate and grade specific for the students reading in this class and 81.8 percent of them considered the prescribed content to be highly appropriate while 18.2 percent thought the prescribed content to be moderately appropriate.
- While all the responding teachers agreed that the concepts in Mathematics textbook for Class IX are properly sequenced, a section of teachers (18.2%) considered the sequencing to be at average level and suggested that it can be further improved in terms of the order of arrangement and presentation in the textbook.
- There is a distinct dichotomy among the responding teachers in terms of their judgement of adequacy of practice activities for students in the Mathematics

textbook. While majority of 63.6 percent teachers affirmed that there were adequate number of practice activities after each lesson, quite a large chunk of the respondents (36.4%) thought more practice activities could have been provided after each lesson.

- So far as the provision of examples for clarification of different mathematical concepts in the textbook is concerned, majority (i.e., 82%) of teachers think that such provisions are quite glaring in their presence in each section of the textbook.
- Content load in the present Mathematics textbook for Class IX is a contentious issue and quite a substantial section of the respondent Mathematics teachers (27.3%) feel the textbook is highly loaded with contents which can be substantially reduced. But, the majority of the teachers (72.7%) think otherwise.

The above views regarding the proportion of responding teachers on the five aspects of Mathematics content at Class IX level with reference to the existing textbook in Mathematics is shown in Fig. 1.

When asked to specify the areas in Class IX Mathematics, where the teachers encounter difficulties in transacting in the classroom, Mathematics teachers across the sampled schools expressed that Geometry concepts, especially related to Euclidean Geometry, are difficult to transact and students have problem in understanding these concepts. Besides, the students cannot grasp easily the method of proof through contradiction. Large number of theorems and its proofs, concept of pie and irrational numbers are some of the other areas of difficulty as expressed by the teachers.

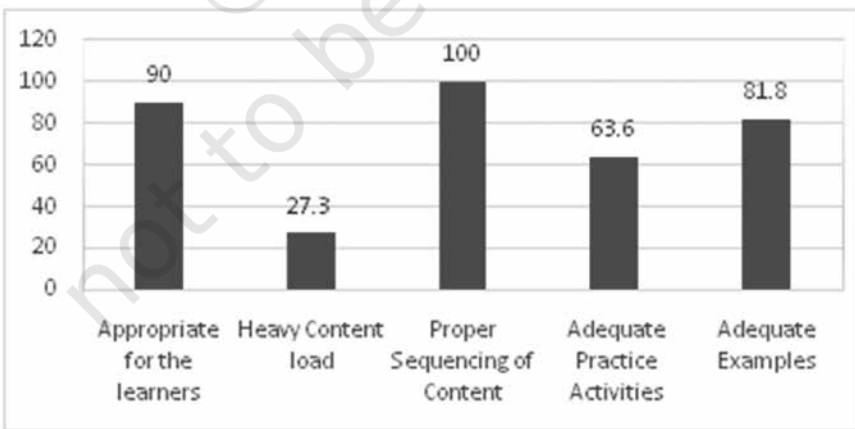

Fig.1 Percentage of teachers responding on different aspects of content of mathematics curriculum and textbook of Class IX

Resources: Availability and Management

Resource management is a skill of continuously creating and procuring the required resources for teaching and learning Mathematics followed by appropriate and optimum utilisation of the available resources. Adequacy of these materials and frequency of the use of materials are the two issues that need to be addressed in the course of any discussion on resource management.

Availability and Adequacy of Resources

The resources for teaching and learning Mathematics at the secondary level can be of a large variety which cannot be listed exhaustibly. But, the minimum requirement for quality mathematics learning at school level include Mathematics Laboratory, Mathematics Kits, Workbooks/Practice Books, Teaching Learning Materials (TLM) especially developed by the teachers and students, and ICT materials. When asked about the resources availability and adequacy of resources for teaching and learning mathematics, it was learnt that mathematics kits were available in all the sampled schools and nearly 81percent of the teachers stated that Mathematics Laboratory is available in their schools while 70 percent of the teachers stated that teaching learning materials prepared by teachers, workbooks/practice books and ICT resources were available in their schools. Although, the resource materials, as stated above, are available in the majority of schools, but are inadequate. The gap between availability and adequacy of

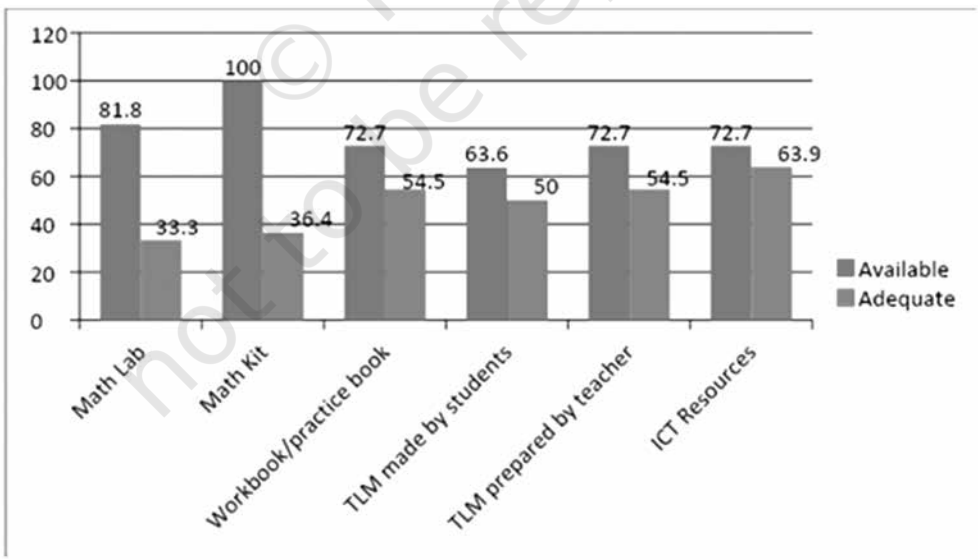

Fig. 2 Teachers' response on the availability and adequacy of resource materials (in %)

resources appears to be the least in the case of ICT resources.

Frequency of Use of Resource Materials

Among the resource materials available in the schools, workbooks or practice books are most frequently used in their schools as stated by the majority of teachers (63.6%). Mathematics kits are not used frequently in schools as stated by 90 percent of the teachers. Teaching-learning materials, either made by students or teachers, are rarely used by more than one-third of the responding teachers. ICT resources are adequately available in their schools, as stated by more than 63 percent of teachers.

However, while observing the classroom transactions, it was noticed that some resources were used much lesser than that stated by the teachers. It was observed that most of them (82.9%) did not use appropriate TLM, though there is a resource as well as availability of materials.

FGD with the students revealed that the teachers bring 3D models like cone, cylinder, cube to the class to demonstrate. During the classroom observation, it was found that while teaching statistics, graph paper was used both by the teacher and students. While teaching construction of plane geometric figures, it was observed that both the students and teacher were using geometric instruments to construct them. Apart from these observations, appropriate TLMs were very less frequently used as given in the graph (7.3%).

Though the materials prepared by teachers are stated to be available in their schools by 72.4 percent of teachers and 54.5 percent expressed the materials prepared by them to be adequately available in their schools. Again, out of the respondent teachers, 36.4 percent stated to be using the materials prepared by

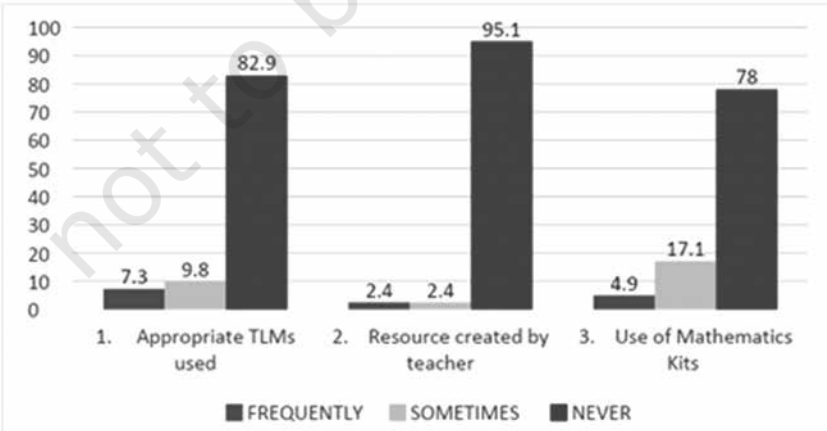

Fig. 3 Use of different mathematics resources in the classroom

them in the class frequently and 27.3 percent used it sometimes. But, from the observation of the classroom practices and from the discussion with students, it was learnt that more than 95 percent of teachers did not use the resource materials developed by the teacher and such materials were used by less than 5 teachers, either frequently (by 2.4% teachers, while making power point presentations) or sometimes (by 2.4% teachers, while focusing on the concept of lateral and closed surface area of cylinder).

As per teachers' response to the questionnaire, all the schools have mathematics kit supplied by NCERT and 36.4 percent teachers expressed that the kits are adequate considering students' strength in the school and more than 90 percent of the teachers stated both the students and the teachers frequently or sometimes use the kit. But the use of mathematics kit, as noticed during the classroom observations, was found to be used frequently only in 4.9 percent of classes and it was used sometimes in 17.1percent of classes. In the majority of 78 percent of classes, these kits were never used although the kits were available in all the schools.

Mathematics laboratory is found to be in 81.8 percent of schools, but adequately available in 33.3 percent of schoolsonly. In more than half the number of schools (63.6%), these are being used sometimes and in 18.2 percent schools, it is in use frequently. But when we asked the students in focus group discussion, we got an idea that students have mathematics lab only in 3 of the sampled schools, where students go to the lab and the teacher demonstrates the activities and then the students perform the mathematical activities like verifying properties related to the similarity of triangles and verifying Pythagoras theorem.

The workbooks or practice books, which are usually required in Mathematics classes to be used by the students, were stated to be available to 72.7 percent as reported by the teacher respondents and 54.5 percent teachers expressed that these were adequately available in their schools. While 63.6 percent teachers have said that students use workbooks frequently, 9.1 percent of them said that the students use them sometimes. Most of the students during the focus group discussion agreed on using Mathematics books by other authors and several problem reference books other than the prescribed textbooks,as recommended by their teachers.

As discussed with the students on ICT resources, they say it makes them interested to learn and with the help of use of ICT resources, they can develop their thinking and knowledge and if the applications of each chapter could be visualised, then the students would be more rigorous towards mathematics learning. But, nearly 73 percent of the teachers reported

that ICT resources are available in their schools and nearly 63 percent consider the available material to be adequate for the purpose. While interacting with the students, it was found that the teachers have used it while teaching triangles, construction and number system.

Resources Used in the Mathematics Classroom

While teaching the construction chapter, it has been observed that in two classes of a school, two different resources were used:

1. The teacher showed the step-by-step procedure of how to construct a triangle when its base, a base angle and sum of two sides are given using a website called Extra marks from which the videos were downloaded. After each step, the teacher used to pause and then explain on the board and then the students would do it. In this way two more cases were showed and explained with the help of this website.
2. The teacher had used the geometry box while constructing perpendicular bisectors on the board followed by asking students to do in their notebook. The teacher in all his classes of construction used the geometry box kit so as to show the methods and procedures how to construct.

Pedagogical Practices

Quality of school learning is largely dependent on the pedagogical practices being conducted in the classroom. The basic pedagogical practices followed for classroom transactions include planning the lesson for attaining the defined learning objective(s), sequencing the activities depending on the arrangement of concepts, adopting appropriate teaching learning methods enhancing the learners' active involvement and participation, use of appropriate and contextual resource materials, using learners' experiences and employing multiple alternative procedures. Besides these practices being used in different variations depending on the situation specific conditions, classroom practices in Mathematics require some specific processes emphasising on analytical and logical thinking skills. The pedagogical process, in its various aspects, practised in the Mathematics classrooms in the sampled secondary schools, as captured through the research tools, are as follows:

- **Pedagogical Planning:** Preparing a brief plan before going to a class is necessary for a teacher which seems to be practised by all the sampled Mathematics teachers except one who expresses constraint of time for not being able to develop a plan before going to the class. Preparation of fortnightly and weekly plans has also been done by two teachers. Asked to mention the dimensions of the lesson plan, 5 out of 11 sampled teachers (nearly 49%) have given various responses without any general agreement among the dimensions. For example, when asked about the

dimension of their plan, one teacher said "Introductory part with examples", while another teacher mentioned, "Method of teaching, content and timing of completion of the lesson" and the third teacher elaborated the dimensions as "Gist of the lesson, Activities planned, Correlation with other subjects, Home assignment, HOTs, etc." Informal interaction with mathematics teachers revealed that the preparation of lesson plans/notes in Mathematics is more ritualistic than plan with any serious and practical pedagogical concern.

- **Teaching-learning Process:** The classroom teaching-learning process has various components and analysis was done based on these dimensions.

Introducing the Topic

From the observation of the classroom practices, it emerged that while introducing a topic, majority (70.7%) of the sampled teachers started the topic by relating it to the previous lessons or knowledge, while the rest partially tried to relate the topic to the previous topics or knowledge just by asking one or two questions from the previous lesson, but without integrating to the current topic of discussion. It was also observed that less than one-third (31.7%) of the teachers tried partially to introduce the lesson using an activity while the rest did not use any activity for the purpose. Invariably, more than 90 percent of the teachers were observed to introduce the lesson by directly stating the topic and then relating it to previous knowledge and/or conducting an activity.

Classroom Transactional Processes

Methods appropriate to content and the levels of students were found to be used frequently or sometimes by more than 95 percent of the teachers while teaching Mathematics. Use of multiple and alternative processes, as against the common belief of uniqueness in the process of solving Mathematics problems was observed in different forms by more than 95 percent of teachers. At the same time, teachers' observations on difficulties in using alternative and multiple processes for solving problems in Mathematics bring some relevant issues to the fore.

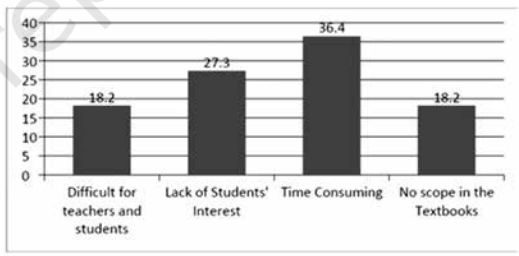

Fig. 4 Percentage of teachers facing difficulties in using alternative processes in solving mathematics problems

The four major difficulties, cited by the teachers, in using alternative and multiple processes are— (i)more time consuming, (ii) lack of students' interest, (iii) difficult for both teachers and students to pursue, and (iv) no scope in the textbooks.

In more than 95 percent of the classrooms, there were visible efforts in engaging students in the practices of developing mathematical skills and procedures. In around 40 percent of the classrooms observed, the teachers strictly adhered to the problems and examples given in the prescribed Mathematics textbook rather than using contextual materials and activities beyond the textbook. On the other hand, more than 56 percent of teachers used contextual materials and examples from the real life situations making mathematics learning more meaningful.

Encouraging Learners in Learning Process

The teaching-learning process involves promoting the ability of learning rather than instructing the students to learn. Facilitating problem solving skills, providing enough scope for discovering mathematics principles and concepts, addressing individual learning difficulties of students, and encouraging the students to ask questions to clarify their doubts are some of the important processes for promoting meaningful learning, especially in Mathematics. These aspects are being focused more and more in the capacity building programmes meant for Mathematics teachers. On these aspects, the study has brought to the fore some encouraging practices as observed in the Mathematics classrooms of the sampled schools. Facilitating problem solving skills and providing opportunities for developing analytical and logical reasoning that are closely associated with Mathematics learning, are being practised by nearly 83 percent of teachers, as observed from their classroom transactions.

Table 1
Percentage of Teachers Adopting Different Modes for Encouraging Learners in Learning Mathematics

Processes for Encouraging Learners in Learning Mathematics	Frequently	Sometimes	Rarely
Facilitating problem solving skills of students	53.7	29.3	17.1
Opportunities for analytical and logical reasoning	53.7	29.3	17.1
Scope for discovering mathematics principles and concepts	63.4	26.8	9.8
Addressing learning difficulties of students	39.0	53.7	7.3
Encouraging students' questioning	26.8	56.1	17.1

Providing scope for the development of problem solving skills and opportunities for analytic and logical reasoning process among students through teaching of Mathematics could be observed in around 83 percent of classroom practices observed. Similarly, scope for discovering mathematical principles and concepts by the students were provided in nearly 90 percent of the classrooms observed. In comparison, addressing learning difficulties of students and encouraging students' questioning were not promoted as frequently as in the previous practices.

Activities for Promoting Analytical and Logical Reasoning Abilities

The activities that are being conducted in the sampled schools for promoting analytical and logical reasoning through teaching Mathematics include, as stated by the teachers—non-textual problems to solve;more open-ended questions; scope to ask unusual questions; higher order thinking questions to solve; promoting divergent thinking abilities; solving and developing mathematical puzzles and quizzes; preparation of charts, models and answer sheets; solving challenging problems in groups; and peer learning groups for various mathematics activities.

Classroom Management

Based on the objective of classroom management, the dimensions identified are—stimulating learning environment, peer learning, non-discriminating behaviour of teacher, encouraging learners' participation, and overall balance in time management.

- Participatory approach, ensuring the involvement learner in the classroom learning process, seems to be the most preferred process, fully or partially, by the teachers in all of the mathematics classrooms observed.
- The individual learning needs were not attended frequently (29.3%) in classrooms as per the observation. No group activity was done in the classroom,however rarely (36.6%) individual activity was performed. The students while discussing said that they have maintained an activity copy in which they do all the activities assigned to them. In one school, students do all the activities in their home assignment copy. But, in rest of the schools, they go to maths lab and do a few activities such as, verify Pythagoras theorem, to show triangle similarity, angle subtended by an arc at the centre of the circle, sum of first n natural numbers and many more. If the students have more number of classes based on activities, then they can enjoy and learn mathematics better as they have mentioned that they face difficulties while proving a theorem.
- The scope for peer learning is found to be very less (4.9%). The

learning environment stimulation is found to be 77.3 percent. From the students' comments, it was found that they enjoy mathematics in class mostly when the questions and problems are to be solved in less time. Mostly (97.6%) non-discriminating behaviour of teachers with only 2.4 percent partially discriminating was found when the teacher mostly focused on front benchers who give immediate answers while solving problems. But, if students ask any question after the class, they are also welcomed. Some teachers give personal time to the students asking doubts.

- Time management is a key factor of classroom management, which is found to be 82.9 percent and in rest few it is found that the teacher was in a hurry to get the course completed and more questions though could have done, were not attempted.

LEARNERS' ASSESSMENT

The learners' assessment is analysed with respect to the strategies followed— oral, written or performance wise; self and peer assessment, continuous assessment, provision for follow up and feedback.

- In most of the classes observed, oral and written assessment strategies were followed whereas only in 2.4 percent classes, performance test was used for assessment. There are four formative assessments in terms of unit tests and two summative assessments, i.e., one half yearly and one annual exam. All the exams are in the form of written tests in all the schools.
- It is observed that assessment has been done at the beginning of lesson in 48.8 percent classes.
- Only in 34.1 percent classes, questions were asked beyond the textbook, mainly while teaching probability, statistics and construction. However, in 36.6 percent classes, the questions in examination were focused more on topics such as circles and number system. During FGD, students expressed 'circle' as one of the difficult topics which have been transacted mostly based on the textbook.
- All the teachers said that they assess higher order thinking skillss (HOTS) of the students by asking them to solve a question or prove a theorem in an alternative method other than the textbook method. Students were asked to solve Olympiad and exemplar problems such as, "If the sum of two prime numbers is 99, then what are the two numbers?"
- Though the feedback based on the assessment is found to be 70.7 percent in class, but the teachers claimed that after the evaluation, all of them provide feedback and conduct discussion with learners on strength and weakness of learners. They also mentioned that they motivate learners for

self-learning by assigning new problems to solve. 90.9 percent saidthat they provide alternate learning experiences which contradict from the students' point of view. One of them suggested making a pair of a bright student with a poor student so that a case of peer learning may arise.

- The scope for peer and self-assessment is rarely found from the classroom observation, i.e. 48.8 per cent, whereas the teachers revealed that the scope for peer and self-assessment is 81.8 percent. As per students' corner, self-assessment is mostly followed with peer assessment.
- All the teachers in the sample do continuous assessment by following the strategies like written assignments (82.2%) and oral work, observation, project work and presentation of the students, which are equally followed (72.7%) as compared to portfolio (45.5%).

Major Findings

1. Curricular contents in Mathematics prescribed for Class IX are found quite appropriate, grade specific and properly sequenced as expressed by the teachers.
2. Geometry concepts especially related to Euclidean geometry are difficult to transact asthe teachers and students have problems in understanding these concepts.
3. Although, the resource materials, such as mathematics lab and mathematics kits are available in the majority of schools, their inadequacy from the point of view of number of students and lack of physical space for storage and use,is quite staggering.
4. Among the resource materials available in the schools, workbooks or practice books are most frequently used in the schools.
5. Teaching-learning materials, either made by students or teachers, are rarely used by more than one-third of the responding teachers.
6. The preparation of lesson plans and notes in Mathematics is more ritualistic than having any serious and practical pedagogical concern.
7. Introduction of the topic was mainly done by relating it to the previous lessons/knowledge and least by doing activities.
8. Methods appropriate to content and to the levels of students were found to be used frequently or sometimes by maximum teachers while teaching Mathematics.
9. The four major difficulties cited by the teachers in finding it difficult for using alternative and multiple processes are— (i) more time consuming, (ii) lack of students' interest, (iii) difficult for both teachers and students to pursue, and (iv) no scope in the textbooks.

10. Facilitating problem solving skills and providing opportunities for developing analytical and logical reasoning, which are closely associated with Mathematics learning, are being practised by teachers in most of the classes.
11. The attention to individual learning needs is not given so frequently in many classrooms.
12. No group activities were conducted and rarely any individual activity was conducted.
13. In most of the Mathematics classes, oral and written assessment strategies were followed.
14. The scope for peer and self-assessment is rarely found in Mathematics classroom.

Discussion and Educational Implication

The study gives a detailed account of the nuances of mathematics classrooms in terms of the content transacted, resources used, pedagogical processes employed, classroom management, and assessment strategy followed, etc. The findings of the study would support educationists to understand the processes of mathematics learning and would give an insight into the role of mathematics teacher as a facilitator. The content was found to be adequate by the teachers, though both teachers and students found some areas as difficult. Curriculum developers and textbook writers could reflect on these topics and the transactional modality suggested and can revise the curriculum accordingly. At the same time, the study revealed how ICT helps in making some topics easier forthe students. Teacher educators could focus on capacity development of the teachers in integrating ICT in mathematics classrooms. The pedagogical strategies were appropriately selected by the teachers; however, planning seems to be one of the weakest areas in Mathematics teaching. To fulfil our aim of making 'teacher as a reflective practitioner', planning of the lesson is very significant. Teachers might be oriented to reflect on the classroom processes while planning the lesson, during transaction of the lesson and do a critical reflection after finishing the class. This would definitely help teachers to improve teaching-learning processes in mathematics. Assessment requires serious attention as it is found that oral and written assessment strategies are mainly used in mathematics classroom. Innovative assessment processes have to be integrated so that learning mathematics becomes fun, and not a threat. This is in agreement with many of the research findings on maths anxiety and maths phobia such as,the study conducted by Zakaria and Nordin (2008). Peer learning and peer-assessment were rarely found in the classroom even though the studies conducted by Iqbal (2004) and Ahmadi (2000) found that cooperative learning improves the performance in mathematics.

Therefore, administrators should take steps in providing enough opportunity for teachers to develop their skills of organising peer learning in the classroom.

Conclusion

The study, basically, was an attempt to explore the classroom processes in terms of content, resource management, pedagogical strategy, classroom management and assessment. The findings indicate overall positive learning environment in the schools with respect to the pedagogical processes of mathematics. Teachers have interest in providing a stimulating learning environment to students, however planning of the lessons need to be more reflective in nature. Innovative ways of teaching mathematics using ICT were tried out in the classroom; more focus needs to be given to alternative and multiple ways of solving the problems and peer learning. Assessment of students' learning continued to be conducted in the traditional oral and written questioning manner and it needs a paradigmatic shift. The study would help the educationists to plan in-service programmes for mathematics teachers meticulously focusing on the thrust areas of mathematics learning. Curriculum developers also might get input from the study for revising mathematics curriculum and textbooks to make mathematics learning more meaningful at the secondary stage.

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