Guidelines for Mathematics Laboratory in Schools

Class IX

Central Board of Secondary Education
Preet Vihar, Delhi – 110092.

1. Introduction

1.1 Rationale

Mathematics is erroneously regarded as a difficult subject to understand, meant only for persons of 'higher' mental ability. It arouses fear among any students, which in turn creates resistance to learning at and results in an adverse effect on their attainment. But actually, school mathematics is within the reach of any average student. What is needed is to create the right ambience of learning mathematics in every school.

Mathematics needs to be learnt with a sense of joy and delight. It needs to be related, where possible, to life-oriented activities, to create interest in the subject. Mathematical faculty and intuition develop not only through theory and problems given in mathematics textbooks but also through a variety of activities involving concrete objects. Activities can be engaging as well as instructive.

With this in mind, CBSE has endeavoured to introduce the idea of mathematics laboratory in schools.

Some of the ways in which activities in a mathematics laboratory could contribute to learning of the subject are:

- It provides an opportunity to students to understand and internalise the basic mathematical concepts through concrete situations. It lays down a sound base for more abstract thinking.
- The laboratory gives greater scope for individual participation. It encourages students to become autonomous learners and allows an individual student to learn at his or her own pace.
- It helps build interest and confidence among the students in learning the subject.
- It provides opportunity to students to repeat an activity several times. They can revisit and rethink a problem and its solution. This helps them develop metacognitive abilities.
- It allows and encourages students to discuss, think and assimilate the concepts in a better manner through group learning.
- It provides opportunity to students to understand and appreciate the applications of mathematics in their surroundings and real life situations.
- It widens the experimental base and prepares the ground for better learning of new areas in the subject.
- An activity involves both the mind and hands of the student working together, which facilitates cognition.

1.2 National Curriculum Framework and Board's Initiatives.

The National Curriculum Framework for school education (NCFSE) developed by NCERT emphasizes that mathematics learning should be facilitated through activities from the very beginning of school education. These activities may involve the use of concrete materials, models, patterns, charts, pictures, posters, games, puzzles and experiments. The Framework strongly recommends setting up of a mathematics

laboratory in every school in order to help exploration of mathematical facts through activities and experimentation.

With the objective of meeting these national requirements, aspirations and expectations, the Central Board of Secondary Education immediately issued directions to its affiliated schools to take necessary action in this regard. Simultaneously, a document on '*Mathematics Laboratory in schools – towards joyful learning*' was brought out by the Board and made available to all the schools. This document primarily aimed at sensitizing the schools and teachers to the philosophy of a mathematics laboratory, creating awareness among schools as to how mathematics laboratory will help in improving teaching and learning of the subject and providing general guidelines to school on setting up and using a mathematics laboratory. Besides, it also included a number of suggested hands-on activities related to concepts in mathematics for Class III to Class X. Teachers were advised to design more activities of similar nature to suit the requirements of the classes and students under their charge.

There has been a very encouraging response to this initiative from the schools and a large number of them have already established reasonably functioning mathematics laboratories. However, the Board has been receiving queries and observations from many quarters with the request to provide more detailed guidelines to set up such a laboratory, particularly with regard to its size and design, physical infrastructure, materials required and human resources. In addition to including specific activities and project work for Class IX, the present document aims at clarifying these various matters.

1.3. About the present document

The present document has three clear objectives. Firstly, it aims at providing detailed guidelines to schools with regard to the general layout, physical infrastructure, materials and human resources for a mathematics laboratory. This would, it is expected, clear doubts about the minimum requirements for setting up of such a laboratory. Secondly, it includes details of all Class IX syllabus related activities to be done by the students during the academic year. Thirdly, it gives a few specific examples of projects. This is intended to help the schools to have an idea of the nature of project work to be undertaken by the students. Since the schools have already been given directions in relation to setting up of a mathematics laboratory by 31st March, 2005 through circular No……..dated……., it is expected that necessary initiatives have been taken and the desired facilities are available in schools. The schools are now expected to extend and expand these facilities to carry out Class IX syllabus activities from the academic session starting April 2005. Another circular No……dated……has also been issued in relation to the introduction of 20% internal assessment scheme in the subject in Class IX from the ensuing academic session beginning April 2005. The said circular clarifies that the internal assessment is to be given on the basis of performance of an individual in the practical work. The details of assessment in practical work are given in the later sections of this document.

2. Mathematics Laboratory

2.1 What is a Mathematics Laboratory ?

Mathematics laboratory is a room wherein we find collection of different kinds of materials and teaching/learning aids, needed to help the students understand the concepts through relevant, meaningful and concrete activities. These activities may be carried out by the teacher or the students to explore the world of mathematics, to learn, to discover and to develop an interest in the subject.

2.2 Design and general layout.

A suggested design and general layout of laboratory which can accommodate about 30 students at a time is given on page……..The design is only a suggestion. The schools may change the design and general layout to suit their own requirements.

2.3 Physical Infrastructure and Materials

It is envisaged that every school will have a Mathematics Laboratory with a general design and layout as indicated on page……with suitable change, if desired, to meet its own requirements. The minimum materials required to be kept in the laboratory may include all essential equipment, raw materials and other essential things to carry out the activities included in the document effectively. The quantity of different materials may vary from one school to another depending upon the size of the group. Some of the essential materials required are given on page 11.

2.4 Human Resources

It is desirable that a person with minimum qualification of graduation (with mathematics as one of the subjects) and professional qualification of Bachelor in Education be made incharge of the Mathematics Laboratory. He/she is expected to have special skills and interest to carry out practical work in the subject. It will be an additional advantage if the incharge possesses related experience in the profession. The concerned mathematics teacher will accompany the class to the laboratory and the two will jointly conduct the desired activities. A laboratory attendant or laboratory assistant with suitable qualification and desired knowledge in the subject can be an added advantage.

2.5 Time Allocation for activities.

It is desirable that about 15% - 20% of the total available time for mathematics be devoted to activities. Proper allocation of periods for laboratory activities may be made in the time table.

Scheme of Evaluation

As an extension of the Board's intention to make learning of mathematics a more meaningful exercise, it has been decided to introduce the scheme of internal assessment in the subject. The objective is not merely to evaluate the learner in a public examination and award marks but to promote and encourage continuous

self-actualised learning in the classroom and in the extended hours of schooling. This internal assessment will have a weightage of 20 marks as per the following break up :

Year-end Evaluation of activities	:	10 marks
Evaluation of project work	:	05 marks
Continuous assessment	:	05 marks

The year-end assessment of practical skills will be done during an organized session of an hour and a half in small groups as per the admission ……. convenience of the schools with intimation to the Board. The break up of 10 marks could be as under :

Complete statement of the objective of activity	:	1 mark
Design or approach to the activity	:	2 marks
Actual conduct of the activity	:	3 marks
Description /explanation of the procedure followed	:	2 marks
Result and conclusion	:	2 marks

Out of all the activities given in the document, every student may be asked to complete a minimum of 15 marked activities during the academic year and be examined in one of these activities. He/she should be asked to maintain a proper activity record for this work done during the year.

The schools would keep a record of the conduct of this examination for verification by the Board, whenever necessary, for a period of six months. This assessment will be internal and done preferably by a team of two teachers.

Evaluation of project work

Every student will be asked to do one project based on the concepts learnt in the classroom but as an extension of learning to real life situations. This project work should not be repetition or extension of laboratory activities but should infuse new elements and could be open ended and carried out beyond the school working hours.

Five marks weightage could be further split up as under :

Identification and statement of the project:	01 mark
Design of the project	01 mark
Procedure /processes adopted	02 marks
Interpretation of results	01 mark

Continuous Assessment

Continuous assessment could be awarded on the basis of performance of students in their first and second terminal examinations. The strategy given below may be used for awarding internal assessment in Class IX :

(a) Reduce the marks of the first terminal examination to be out of ten.

(b) Reduce the marks of the second terminal examination to be out of ten.

(c) Add the marks of (a) and (b) above and get the achievement of the learner out of twenty marks.

(d) Reduce the total in (c) above to the achievement out of five marks.

(e) This score may be added to score of year-end evaluation of activities and to score in project work to get the total score out of 20 marks.

It is expected that the marks obtained by a student in theory examination (80) and laboratory work (20) be indicated separately in the achievement card.

List of activities

1A. To carry out the following paper folding activities:

Finding –

1. the mid point of a line segment,
2. the perpendicular bisector of a line segment,
3. the bisector of an angle,
4. the perpendicular to a line from a point given outside it,
5. the perpendicular to a line at a point given on the line,
6. the median of a triangle.

1B. To carry out the following activities using a geoboard:

1. Find the area of any triangle.
2. Find the area of any polygon by completing the rectangles.
3. Obtain a square on a given line segment.
4. Given an area, obtain different polygons of the same area.

2. To obtain a parallelogram by paper–folding.

3. To show that the area of a parallelogram is product of its base and height, using paper cutting and pasting. (Ordinary parallelogram and slanted parallelogram)

4. To show that the area of a triangle is half the product of its base and height using paper cutting and pasting. (Acute, right and obtuse angled triangles)

5. To show that the area of a rhombus is half the product of its diagonals using paper cutting and pasting.

6. To show that the area of a trapezium is equal to half the product of its altitude and the sum of its parallel sides and its height, using paper cutting and pasting.

7. To verify the mid point theorem for a triangle, using paper cutting and pasting.

8. To divide a given strip of paper into a specified number of equal parts using a ruled graph paper.

9. To illustrate that the perpendicular bisectors of the sides of a triangle concur at a point (called the circumcentre) and that it falls

a. inside for an acute-angled triangle.
b. on the hypotenuse of a right-angled triangle.
c. outside for an obtuse-angled triangle.

10. To illustrate that the internal bisectors of angles of a triangle concur at a point (called the incentre), which always lies inside the triangle.

11. To illustrate that the altitudes of a triangle concur at a point (called the orthocentre) and that it falls

a. inside for an acute angled triangle.

b. at the right angle vertex for a right angled triangle.

c. outside for an obtuse angled triangle.

12. To illustrate that the medians of a triangle concur at a point (called the centroid), which always lies inside the triangle.

13A. To give a suggestive demonstration of the formula that the area of a circle is half the product of its circumference and radius. (Using formula for the area of triangle)

13B. To give a suggestive demonstration of the formula that the area of a circle is half the product of its circumference and radius. (Using formula for the area of rectangle)

14. 1) To verify that sum of any two sides of a triangle is always greater than the third side.

2) To verify that the difference of any two sides of a triangle is always less than the third side.

15. To explore criteria of congruency of triangles using a set of triangle cut outs.

16. To explore the similarities and differences in the properties with respect to diagonals of the following quadrilaterals – a parallelogram, a square, a rectangle and a rhombus.

17. To explore the similarities and differences in the properties with respect to diagonals of the following quadrilaterals – a parallelogram, a square, a rectangle and a rhombus.

18. To show that the figure obtained by joining the mid points of the consecutive sides of any quadrilateral is a parallelogram.

19. To make nets for a right triangular prism and a right triangular pyramid (regular tetrahedron) and obtain the formula for the total surface area.

20. To verify Euler's formula for different polyhedra: prism, pyramids and octahedron.

21. Obtain length segments corresponding to square roots of natural numbers using graduated wooden sticks.

22. To verify the identity $a^3 – b^3 = (a – b) (a^2 + ab + b^2)$, for simple cases using a set of unit cubes.

23. To verify the identity $a^3 + b^3 = (a + b) (a^2 – ab + b^2)$, for simple cases using a set of unit cubes.

24. To verify the identity $(a + b)^3 = a^3 + b^3 + 3ab (a + b)$, for simple cases using a set of unit cubes.

25. To verify the identity $(a – b)^3 = a^3 – b^3 – 3ab (a – b)$, for simple cases using a set of unit cubes.

26. To interpret geometrically the factors of a quadratic expression of the type $x^2 + bx + c$, using square grids, strips and paper slips.

27. To obtain mirror images of figures with respect to a given line on a graph paper.

Group Activities

1. To find the percentage of students in a group of students who write faster with their left hand / right hand.

2. To help the students establish interesting mathematical relationships by measuring some parts of the body.

List of projects given as examples in the booklet

1. **Observing interesting patterns in cricket match.**

   Comparison of the performance of two teams in a one–day international cricket match.

2. **Design a crossword puzzle with mathematical terms**

   To review mathematics vocabulary, to give the opportunity for creative expressions in designing puzzles, to act as a means of monitoring the study of a given unit and to give recreation.

3. **A measuring task**

   To investigate your local athletics track to see whether it is marked fairly for runners who start on different lines.

4. **Project in history of mathematics**
   i. Study various aspects of Pythagoras theorem.
   ii. Investigation of various historical aspects of number π.

Suggested list Of Projects

P1 Cricket

Collect data on runs scored in each over for a one–day international (ODI) cricket match and obtain frequency distribution between runs and overs. Do this for both the teams and also for the first 25 and the remaining overs of the match. Observe any interesting features of the match. Compare it with similar analysis for a few other ODI's.

P2 Age profile in your neighbourhood

Survey any 30 households in your locality and collect data on the age of the persons. Determine the age profile (number of persons Vs age) for men and women. Report any significant observation from the data.

P3 Educational Background in your neighbourhood

Survey any 30 households in your locality and collect data on the educational background of the persons. Obtain significant observations from your data.

P4 Number of Children in a family in your neighbourhood

Survey any 50 households in your locality and collect data on the number of children (male and female) in each family. Report any significant observation.

P5 Making of Platonic solids

Obtain and construct the nets of five platonic solids. Make these solids and observe the properties (number of faces, edges and vertices) of the solids. Try to find out, why there are only five platonic solid. (Try taking regular hexagon)

P6 History of Mathematics

Refer history of mathematics sources from your library or Internet and prepare a poster or a document on any topic of your interest. The students can choose several topics from history of mathematics, for doing a project. For instance the topic can be about an Indian mathematician or the concept of zero in various ancient civilizations.

P7 Mathematics line designs

Using strings obtain interesting designs and patterns. Use threads and shapes made by cardboard, try to make designs on it by making slits on the cardboard. Observe different patterns on it.

P8 Computer project

Using a spreadsheet programme on a PC obtain the graph of the equation ax + bx + c = 0 for a different values of a, b and c and note the interesting features and patterns. Interested students can also try for quadratic equations.

List of methods and materials used in the mathematics laboratory

i. Paper folding
ii. Collage (Paper cutting & pasting)
iii. Unit Cubes (wooden or any material)
iv. Geo–board, rubber band
v. Transparency sheets, cello tape
vi. Graph paper
vii. Pins & threads
viii. Broom sticks
ix. Chart papers, glazed papers, sketch pens.
x. Stationery