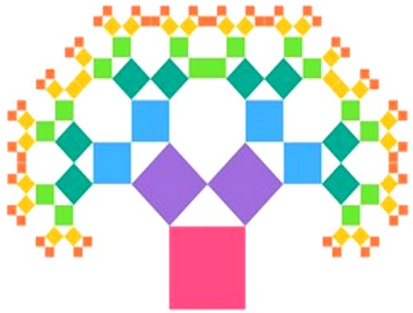
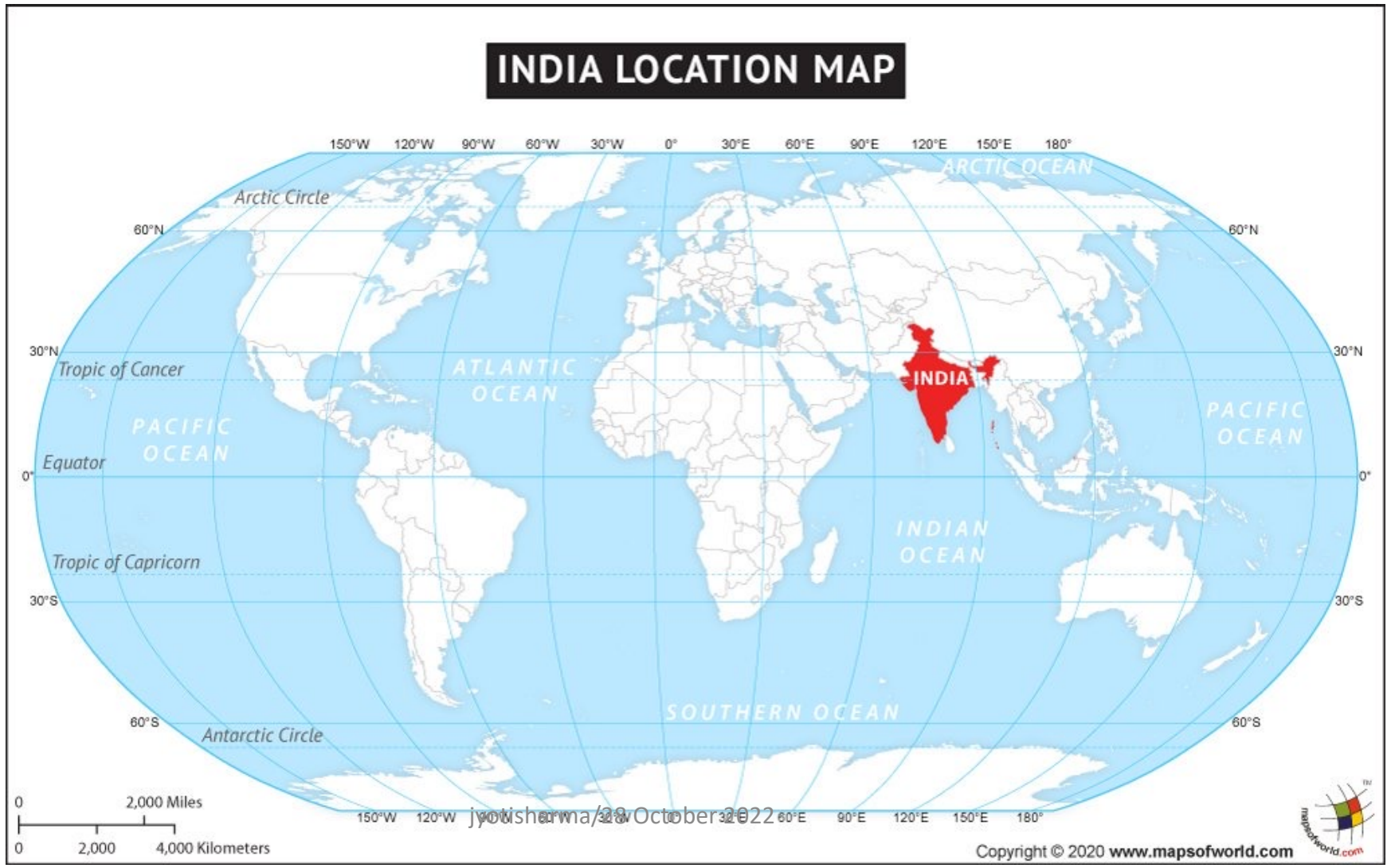


‘Creativity’ in math classroom: A way forward for a ‘Democratic’ learning space

Jyoti Sharma
Cluster Innovation Centre
University of Delhi

Education in India: An overview



Education in India: An overview

- 2nd Populous country
- The youngest nation with a median age of 29 years
- The right to Education is a fundamental right
- Signatory of UNESCO education initiatives on Inclusive Education, Sustainable Development Goals

Education in India: An overview

Highly diverse country

- Language
- Culture
- Social
- Geographical
- Economical
- Religious

22 Official languages as per the 8th schedule of the Indian Constitution and 19,500 languages or dialects spoken as mother tongue

(Registrar General and Census Commissioner, India as reported in Indian Express on July 1, 2018)

Education in India: An overview

- Education is the joint responsibility of the Centre and State (Province)
- Ministry of Education (Centre) and Department of Education (Province)
- National Education Policy - 2022
- National Curriculum Framework
- National/SCERT Council of Teacher Education Research and Training
- Central Board, State Boards, International Boards and Independent Boards

Education in India: An overview

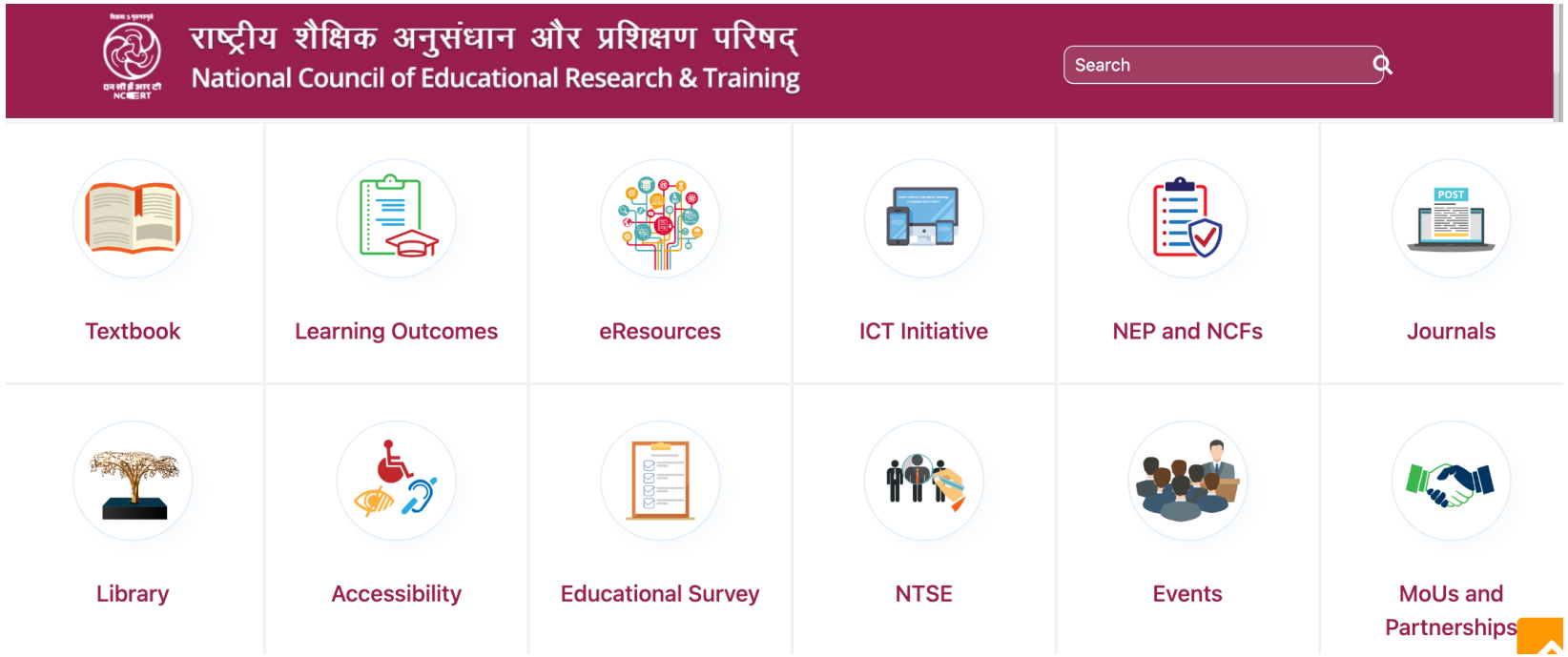
National Council of Teacher Education

Teacher Education Programs

- Degree level
- Diploma Level
- Research level

Education in India: An overview

School Curriculum: NCERT Advisory/Suggestive or Model Textbooks



States : redesign/fresh/same textbooks

Education in India: An overview

Vision Statement

- Children learn to enjoy mathematics;
- Children learn important mathematics;
- Children see mathematics as something to talk about, to communicate, to discuss among themselves;
- Children pose and solve meaningful problems:
- Children develop logical thinking through math learning and use such habits in communication and working
- Children understand the basic structure of mathematics;
- Teachers engage every child in class.

Education in India: An overview

The Pedagogical Framework for Math teaching

- Constructivist
- Exploration
- Sequential and incremental
- Broader and less Taller
- Localized and experiential
- Process-oriented
- Mathematical communication
- More conceptual and less procedural
- Developmental

Mathematics Textbooks: An overview

1

Shapes and Space

Inside - Outside

The Arab and his Camel.

It was a cold winter day. The was travelling on the back. At night, the pitched his tent and went inside it. The was outside.

May I put my neck inside? It is too cold outside.

Okay! You may put your neck inside.

Teachers Note

Teacher's Notes

Introduction

The National Curriculum Framework (2005) quotes from the Secondary Education Commission (1952), "Citizenship in a democracy involves many intellectual, social and moral qualities...a democratic citizen should have the understanding and the intellectual integrity to sift truth from falsehood, facts from propaganda and to reject the dangerous appeal of fanaticism and prejudice ... should neither reject the old because it is old nor accept the new because it is new, but dispassionately examine both and courageously reject what arrests the forces of justice and progress....". The quote reaffirms the commitment of our education system to democracy and reiterates that citizens in a democracy should be able to think for themselves and be able to sift truth from falsehood. In other words, education should necessarily help learners develop independent and critical thinking, among many other capabilities.

Mathematics perhaps is one of the best ways to develop independence of thinking, ability to examine truth and to stand by it. In mathematics we try to understand the world through shapes, numbers, quantities and logical relationships. We always experience the world, even without mathematics. But when we start noticing symmetry of shapes, become sensitive to rhythm in music, start seeing more or less in objects, etc. we are becoming mathematically keen. The discipline of knowledge build on these things— spatial forms and relationships; quantitative concepts and relationships; and abstract logical relationships, is called mathematics. The study of mathematics is expected to result in the understanding of spatial and quantitative concepts and relationships, and is expected to enhance the ability to use language in more precise manner, to use notations, and to be able to use reason in a more effective manner. Thus, it directly helps future citizens in a democracy to become independent and critical thinkers.

Knowledge of the world that we live in makes up the larger part of the curriculum we pursue in order to achieve educational aims. Different subjects in the curriculum can be seen as different ways of understanding the world around us. Just as mathematics attempts to understand the world through spatial, quantitative and logical relationships, Natural Sciences could be seen as the body of knowledge about the natural world built in terms of material properties and methods through which that knowledge is created. Language can be seen as the primary ability to make sense of the world through symbols. And similarly, other curricular areas look at the world from their specific perspective. Thus, mathematics becomes one important strand in the total curricular knowledge that the child is to slowly build through experience, reflection and interaction with other people, including the teacher.

Child's experiences, ways of reflection and formation of concepts all are an integrated whole. Integrated in the psychological sense that it involves logical thinking, emotions and intentions, and physical activity, all simultaneously. Similarly it involves seeing the world in terms of spatial and quantitative relationships (mathematics), social reality as human relationships (Social Sciences), properties of substances and natural categories (Natural sciences) and its beauty, right and wrong, etc. all as a composite whole and simultaneously. All this seeing and thinking about the world becomes possible only through the use of language. Therefore, for the child all these curricular subjects are inter-related and development in one is effected as well as effects development in all others. In teaching of any subject we need not restrict the child's experiences and thinking to any one subject area. Teaching of mathematics will be better if the teacher talks to their peers about the mathematical relationships and ideas. If children are encouraged to ask questions and voice their disagreements and confusions, they will learn better. Let the physical or other aspects of the objects be examined and discussed, and not be too narrowly focused only on the numbers and mathematical aspects alone.

Mathematics Textbooks: An overview

- Learner centric
- Concepts (Examples and non-examples)
- Procedures supported by examples
- Exercises for practice
- Pictures/figures
- Inclusive and gender-sensitive
- Regional languages

https://ncert.nic.in/textbook.php?eemh1=1-14

[Mathematics Education Society]

[Gifted Education Program]

Nature of Mathematics

jyotisharma/28 October 2022

The moving power of mathematical invention is not reasoning but imagination."—Augustus de Morgan (1866, p132)

Abstract world of mental concepts to the real world of physical entities without being completely located in either of the two;

Formal Mathematics: Grammar rules (correct applications of local rules)

Meaningful Mathematics: Journalism (tells an interesting story … but it should be true)

Best Mathematics: like literature (brings a story to life and involves you intellectually and emotionally)

(Ian Stewart, 1995 preface)

The moving power of mathematical invention is not reasoning but imagination."—Augustus de Morgan (1866, p132)

Axiomatic

Study of patterns

Language of Universe

Abstraction and Generalization

Mathematization

Precision

Accuracy

Minimalist/Parsimony

Algorithmic approach

Convergence to the correct/perfect/ideal solution

The moving power of mathematical invention is not reasoning but imagination."—Augustus de Morgan (1866, p132)

Mathematization: Understanding your experiences from a mathematical lens

↓

Communicate (Verbal/Written)

Draw

Construct

Enact

Solve

…… other forms of expression and communication

The moving power of mathematical invention is not reasoning but imagination."—Augustus de Morgan (1866, p132)

Mathematization

↓

Communicate (Verbal/Written)

Draw

Construct

Enact

Problem Solving

…… other forms of expression and communication

Precision

Accuracy

Minimalist/Parsimony

Algorithmic approach

Convergence to the correct/perfect/ideal solution

The moving power of mathematical invention is not reasoning but imagination."—Augustus de Morgan (1866, p132)

Overemphasize on the deductive-postulational character of mathematics

Combination of Logic and intuition

Analysis and Construction

Generality and Individuality

Usefulness/Immediate utility to The desire for aesthetic perfection

Beyond mathematical formalism and manipulation

frustration and disillusionment

Empty drill of problem-solving

deprives intellectual independence

Nature of Creativity

Nature of Creativity

The human mind is inherently creative (Gardner, 2011).

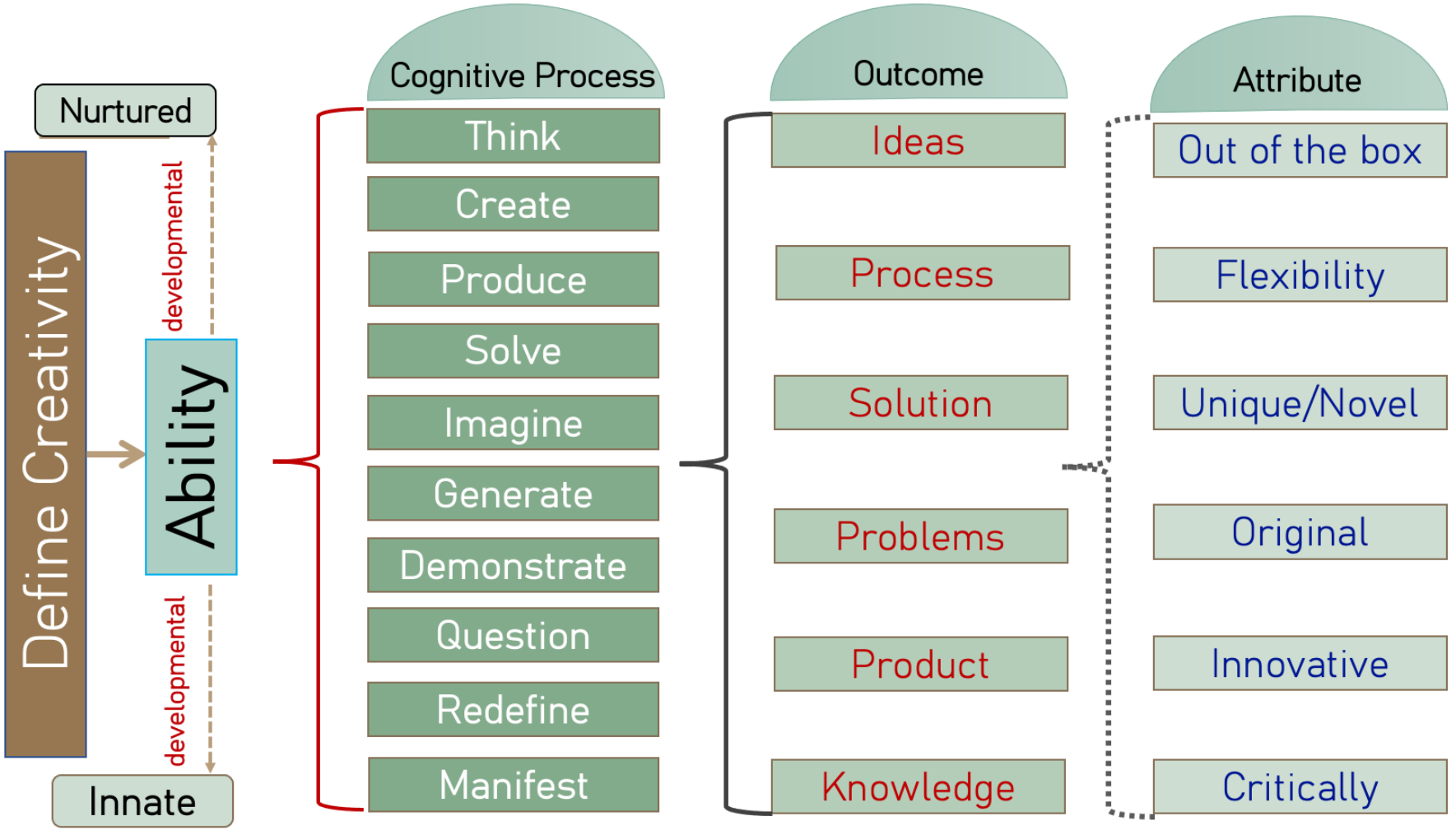
Creativity is considered as an integral trait of human genius, creative people or gifted individuals (Guilford, 1967; Renzulli & Reis, 1997).

Creativity brings novelty to routine practices (Sarkar & Chakrabarti, 2008; Villanova & Miguel, 2020).

Creative thinking ignites innovation and change (Lumsden, 1999; Starko, 2005).

For an idea or a product to be creative, it should be original, novel, effective and acceptable to the reference group (Stein, 1953).

Creativity lies at the heart of problem-solving (Main et al., 2012; Torrance & Torrance, 1978; Treffinger, et al., 2013; Weisberg, 1988).



(Delcourt & Sharma, NERA, 2021)

Nature of Mathematical Creativity

The essence of mathematics is thinking creatively, not simply arriving at the right answer (Mann, 2006).

Mathematical creativity entails conceptual knowledge, risk-taking to flexibly apply conceptual knowledge in new applications, problem finding, problem creating and solving real-world problems (Balka, 1974; Haylock, 1985; Kilpatrick, 1987).

Creativity in mathematics, or in general, often begins by an individual discovering something new although the result is known to others (Sriaman, 2005).

Chamberlin and Moon (2005) considered divergent thinking as a component of mathematical creativity.

Creating useful and meaningful mathematical concepts by combining already known concepts is a creative act of doing mathematics (Ervynck, 1991; Chamberlin & Moon, 2005; Delcourt & Sharma, 2021).

Nature of Mathematical Creativity

Hong and Aqui (2004) found that creatively talented students in mathematics were more cognitively resourceful than people who were more academically bright.

A good mathematical mind demonstrates flexible thoughts and abilities to can manipulate and investigate a problem from many different aspects (Dreyfus & Eisenberg, 1996).

Converging evidence that students leave high school with adequate skills to accurately carry out arithmetic and algebraic procedures but inadequate problem-solving skills to understand the meaning of word problems (Mann, 2006).

Nature of Mathematical Creativity

Kaufman and Beghetto (2009) Model of Four C Creativity

Mini C	Creative activities and discoveries that occur in our daily lives. might not be high in creativity but are valued for two reasons: because of their personal meaning to an individual and the role they play in the learning process.
Little C	Initial acts of creativity that indicate creative potential
Pro C	Creativity requires in high level professional activities
Big C	Highest level of creativity required in creation of new knowledge and innovation. People possessing Big C creativity are remembered for their contributions for generations.

Nature of Mathematical Creativity

Lijedahl and Sriraman (2006) differentiated between Professional-level mathematical creativity and School-level mathematical creativity.

Nature of Mathematical Creativity

The human mind is inherently designed to think creatively;

Creativity is developmental;

Creativity needs time for deep thinking, subconscious thinking and reflection;

Even the wow moment of a creative act derives after understanding, analysis and reflection on our past experiences.

Nature of Mathematical Creativity

Mini C/Little C Creativity
Beyond formal and structured mathematical knowledge
Beyond problem-solving

Flexible thinking and expression of translating mathematical understanding in a mathematical / non-mathematical context

Democratic learning space in Math Classroom

Even imperfect voices are accepted;

Different modes of ideas and expressions are encouraged;

Individual experiences and mathematical understanding of those experiences are appreciated;

Different levels of learning are accommodated;

Individual differences are celebrated.

Democratic learning space in Math Classroom

Extending mathematics learning outside the mathematics curriculum

Experience Mathematics with **freedom**

Mathematics Creativity Test

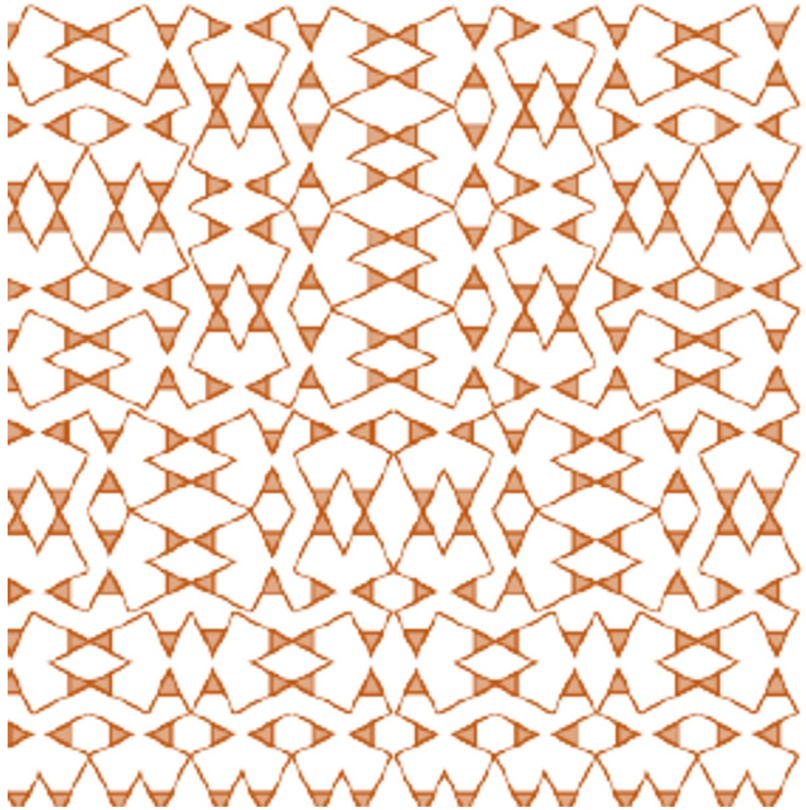
jyotisharma/28 October 2022

Mathematics Creativity Test

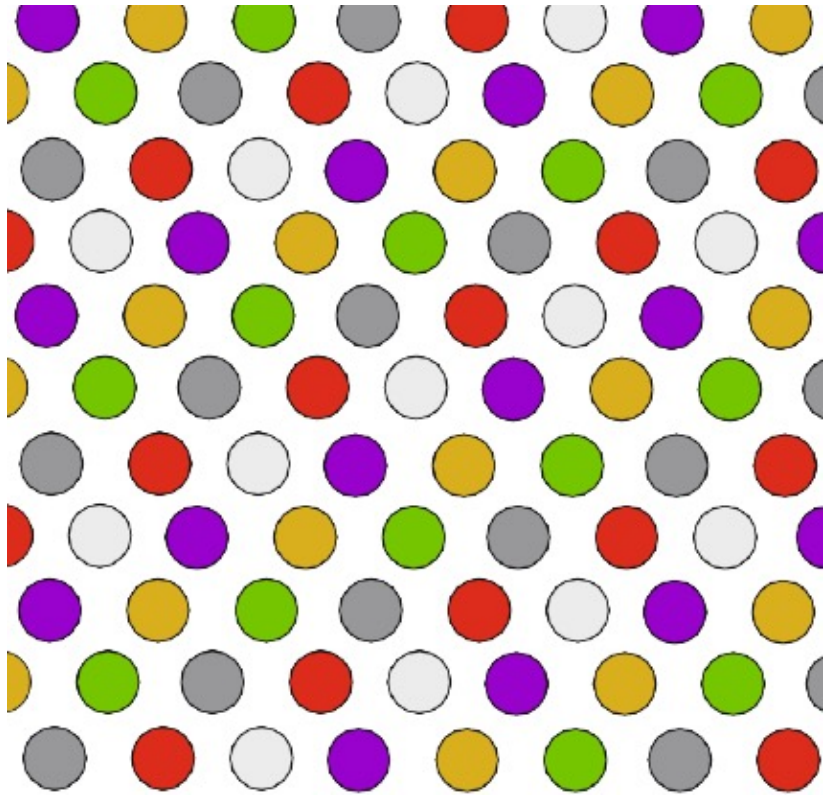
It is an instrument to assess Mathematical Creativity.

It includes both mathematical and non-mathematical (generic) contexts.

It assess the mathematical creativity of respondents based on their conceptual understanding of mathematical knowledge and skills acquired up to primary grades.



Mathematics Creativity Test

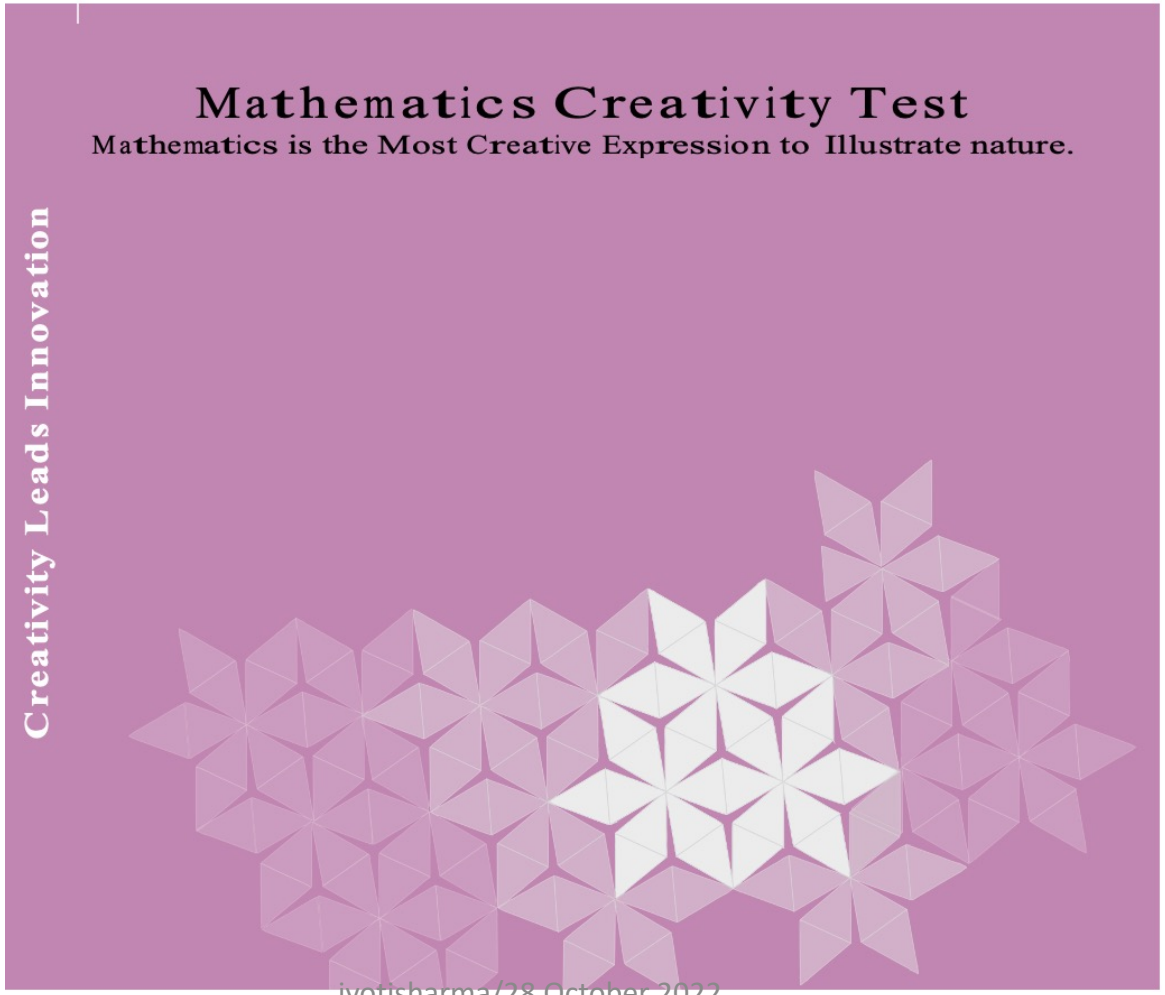


It aims to gauge creative abilities of respondents to use mathematical knowledge in communication, visualization, imagination, creation and problem solving.

It can be used as a preferred instrument to judge the mathematical potential of students beyond problem solving.

The instrument can be used by teachers, researchers, gifted educators, psychologists after being trained into the process of assessment of responses.

Mathematics Creativity Test



Mathematics Creativity Test

Section A (Figural)

- Activity 1: Umbrella
- Activity 2: Swirly Ball
- Activity 3: Polyhedron
- Activity 4: Triangles
- Activity 5: Folk Art
- Activity 6: Shells
- Activity 7: String Art

Section B (Context based)

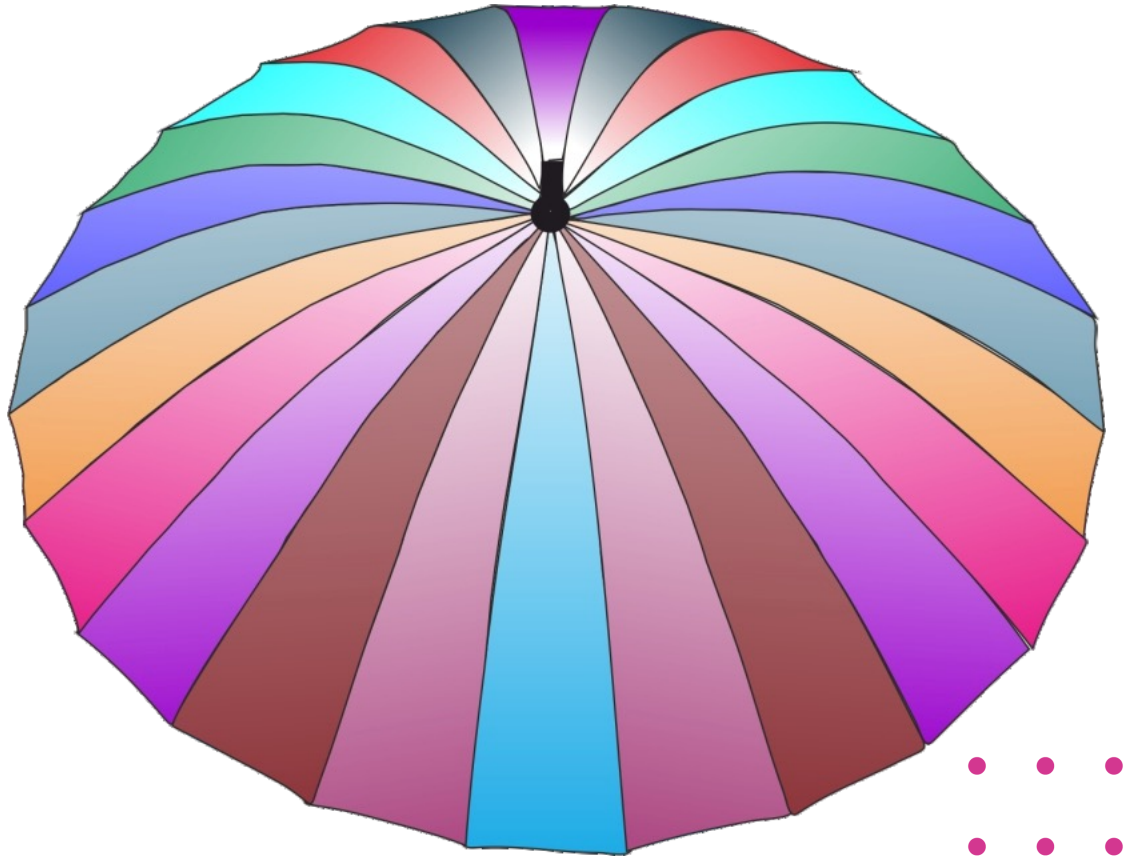
- Activity 1: Create a Number System
- Activity 2: Explain Parallel Lines
- Activity 3: Design a Diary of a Clock
- Activity 4: Invent a Unit of Measurement
- Activity 5: Imagine a Math Super-Power Character
- Activity 6: Plan a Complex Code
- Activity 7: Discuss a Traffic Jam
- Activity 8: Estimate Counting Without Counting

Mathematics Creativity Test

Stimulus 1

You are expected to describe the picture through a mathematical lens.

You can use mathematical concepts, symbols, results, properties or any kind of mathematical representation to describe the picture.



Mathematics Creativity Test

This is a polygon, lots of radius and diameters all connected at the centre point, a figure divided into 24 equal parts, 12 parts =180° and all the parts, i.e, 24 equals to 360° so each part or angle has a measure of 15°, it looks like its circumference is a line connected to each other with a total of 24 line segments.

There are total 12 colours in the Umbrella shape out of which every colour is used twice to fulfil the area inside the umbrella so there are total 24 sides in the shape.

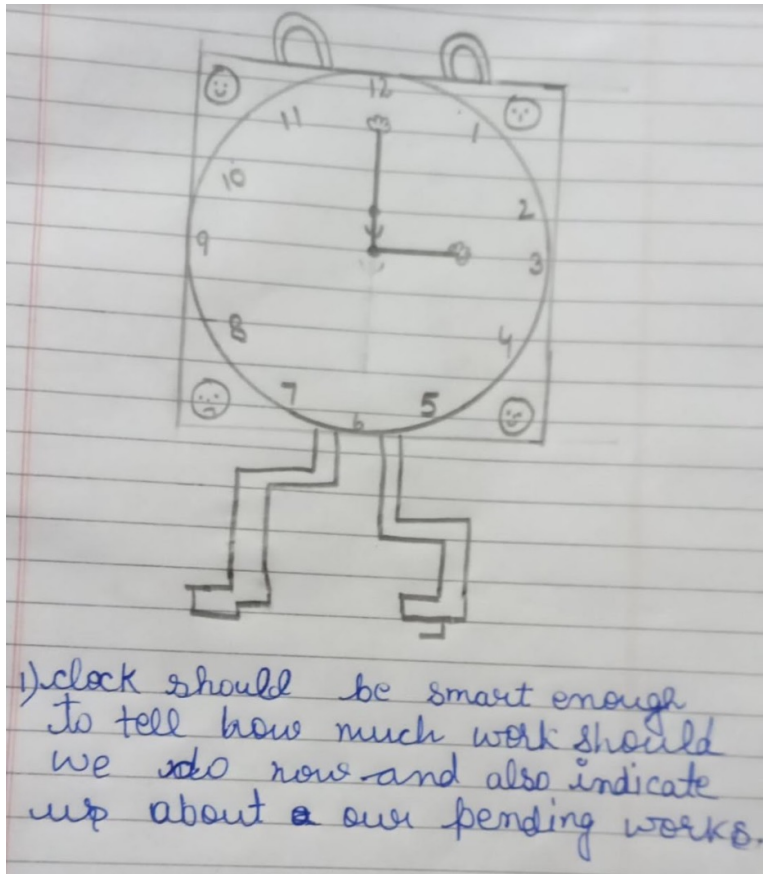
Mathematics Creativity Test

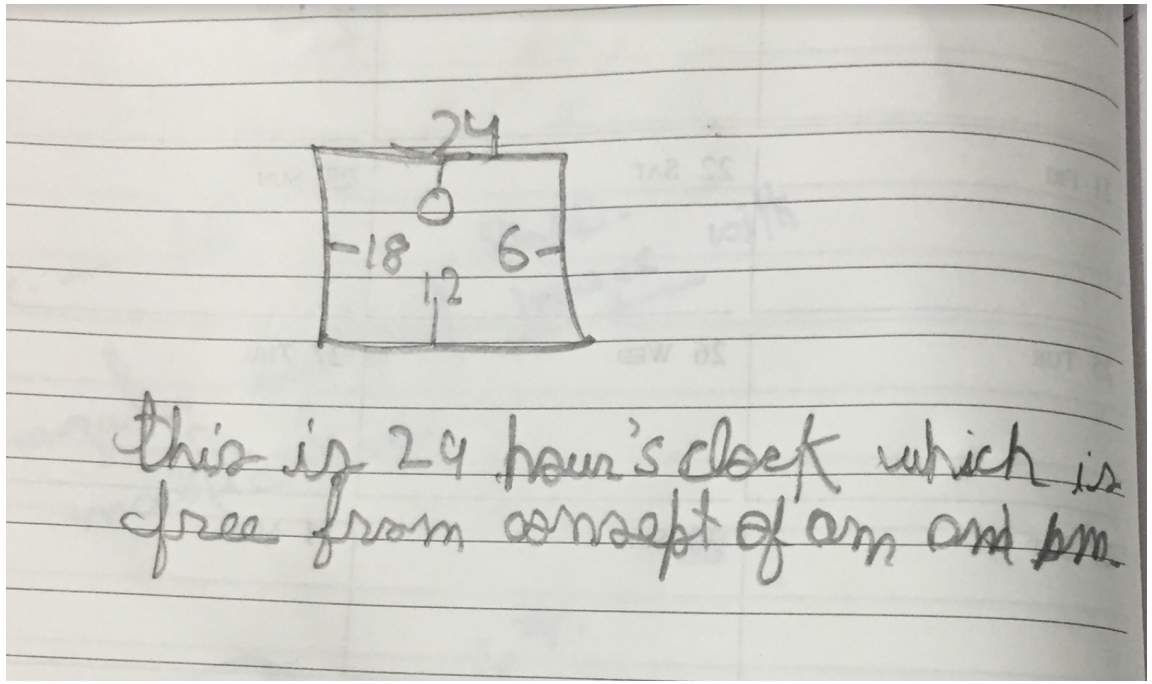
Stimulus 2

I am a clock. I work without rest, moving all day and night. Time keeps changing but I continue walking on the same path, round and round and round, all day and night. Nobody thinks about me. I wish I could also move differently with new looks and new rules.

Can you make the life a clock more exciting by designing a new clock with new rules? You can change its outlook, units or movement. You can add or subtract anything in it. Give reason for the changes you would suggest.

Mathematics Creativity Test





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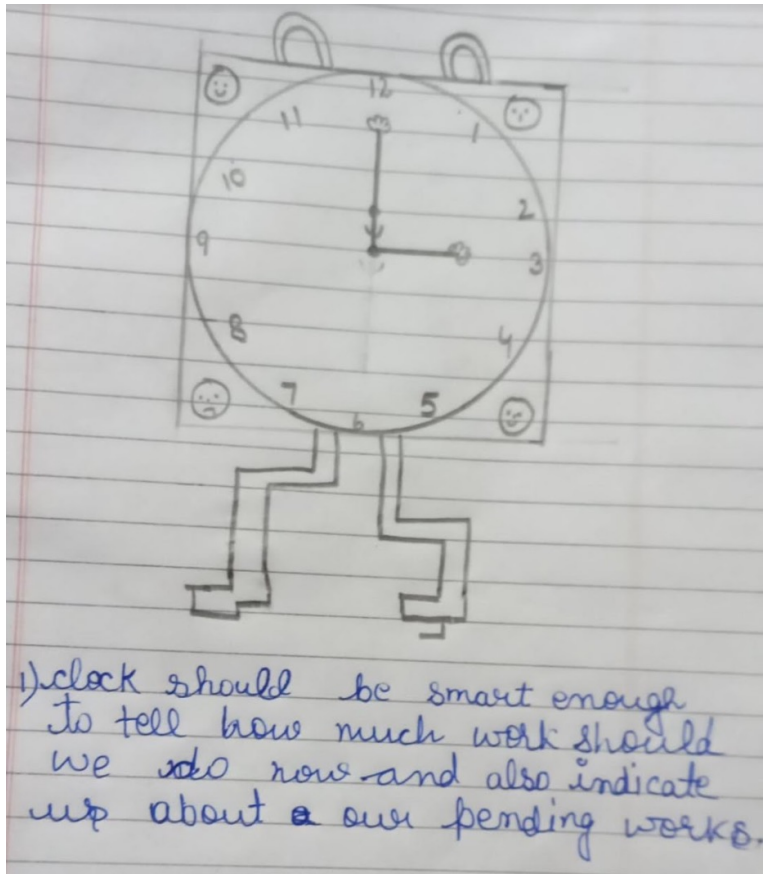

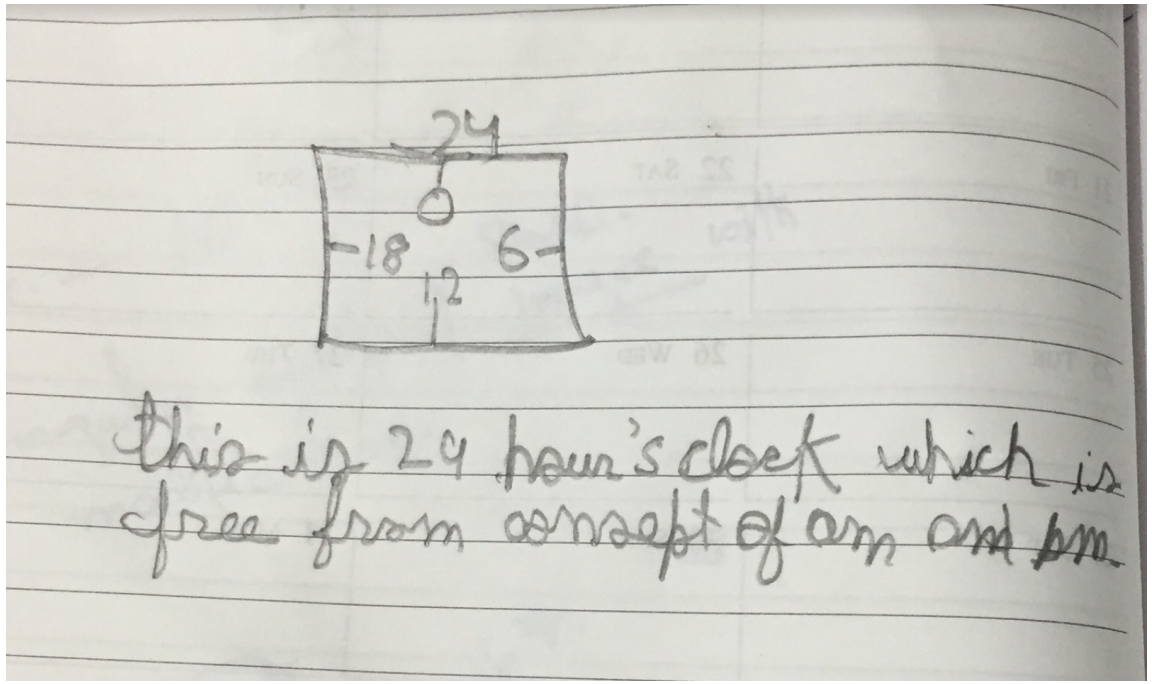

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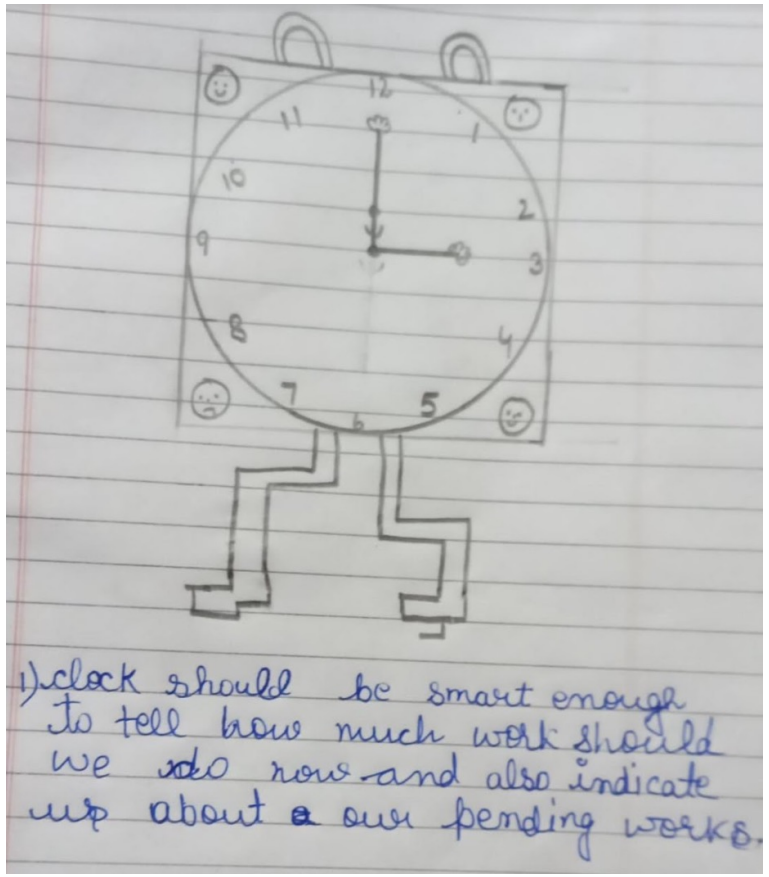

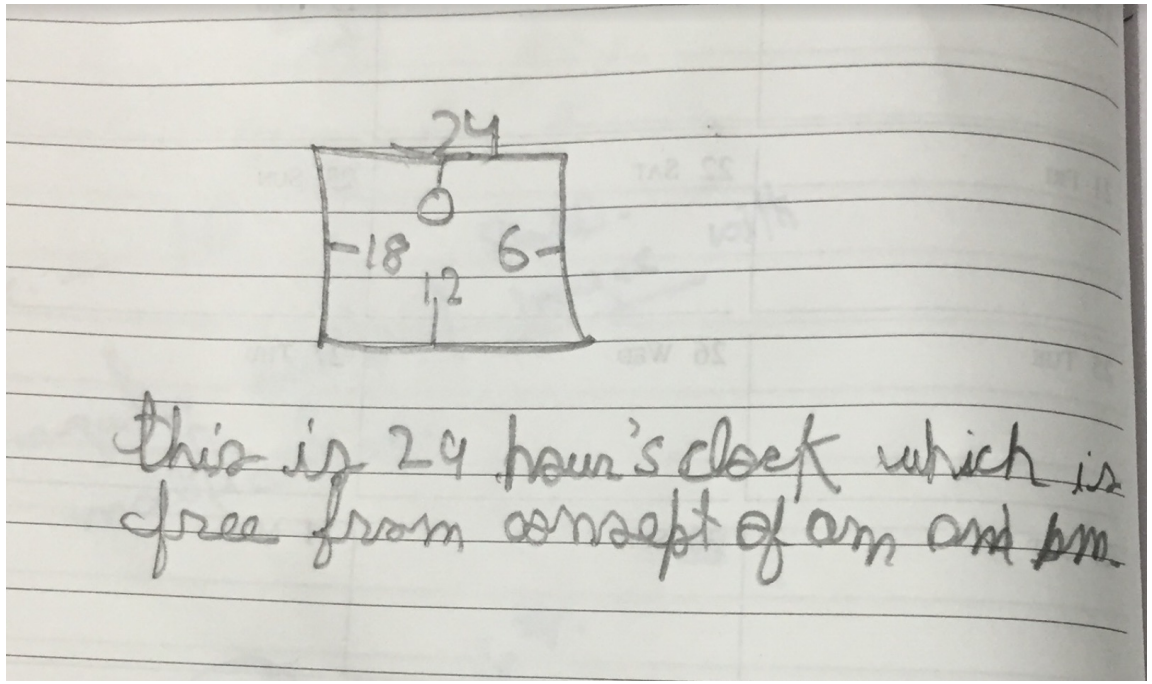

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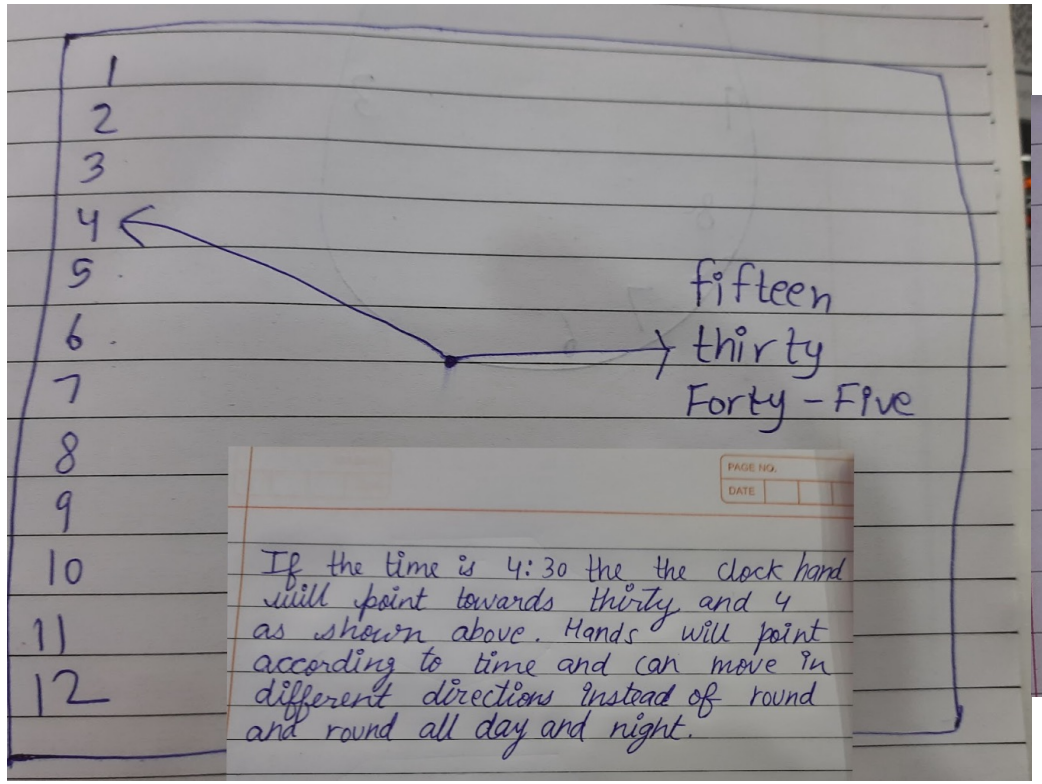

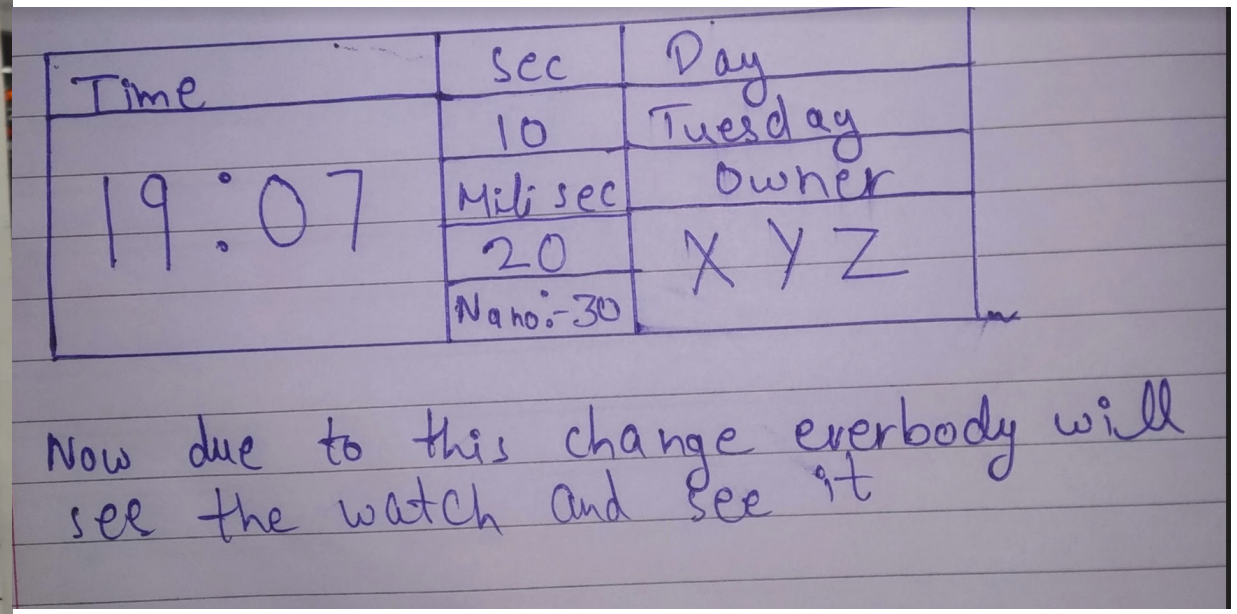

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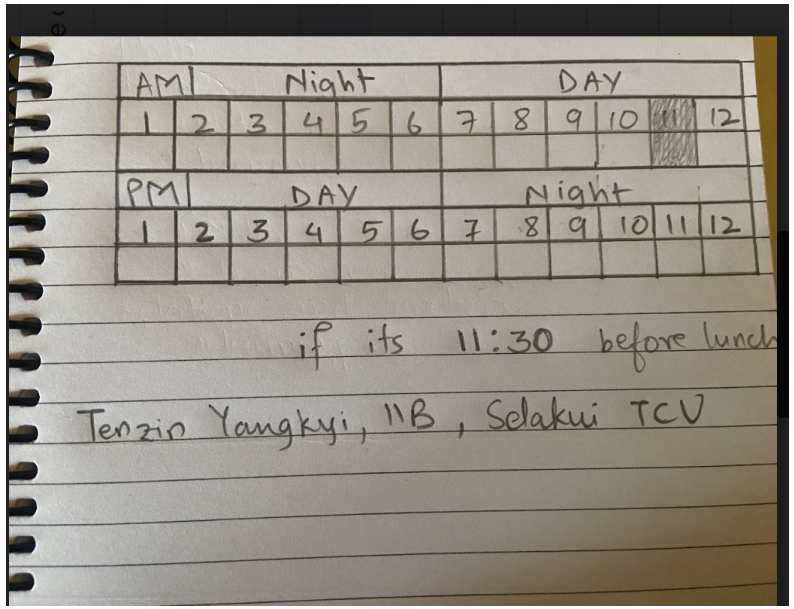

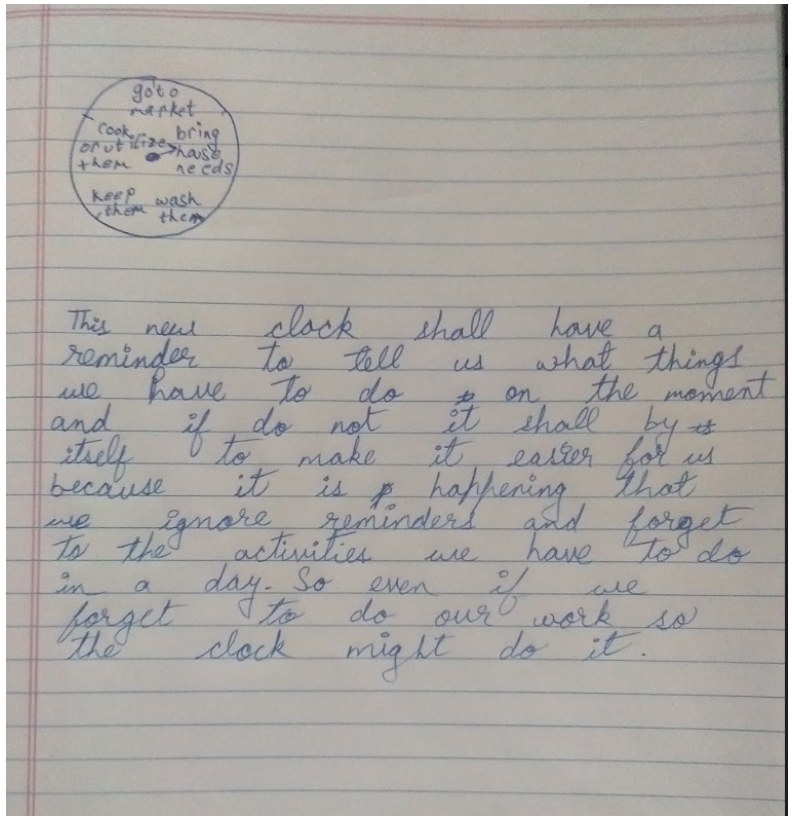

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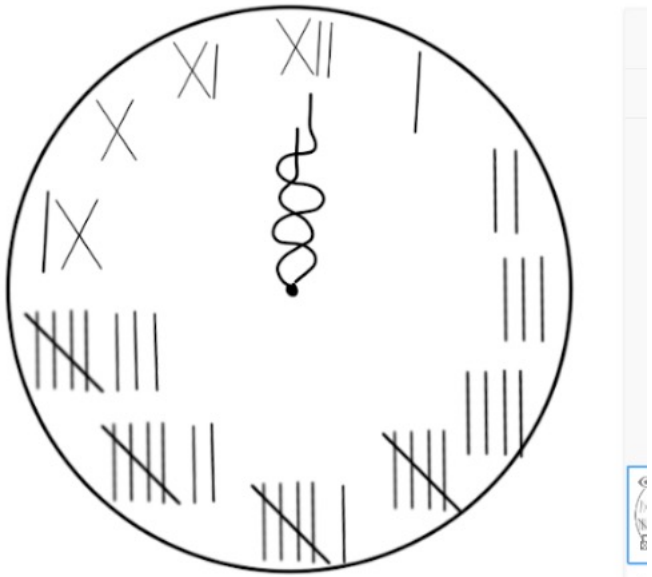

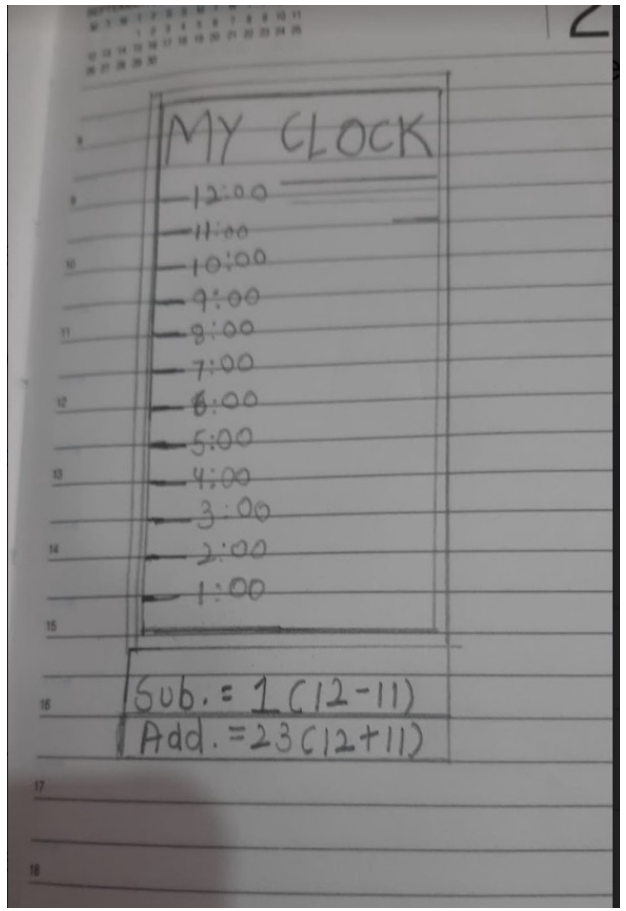

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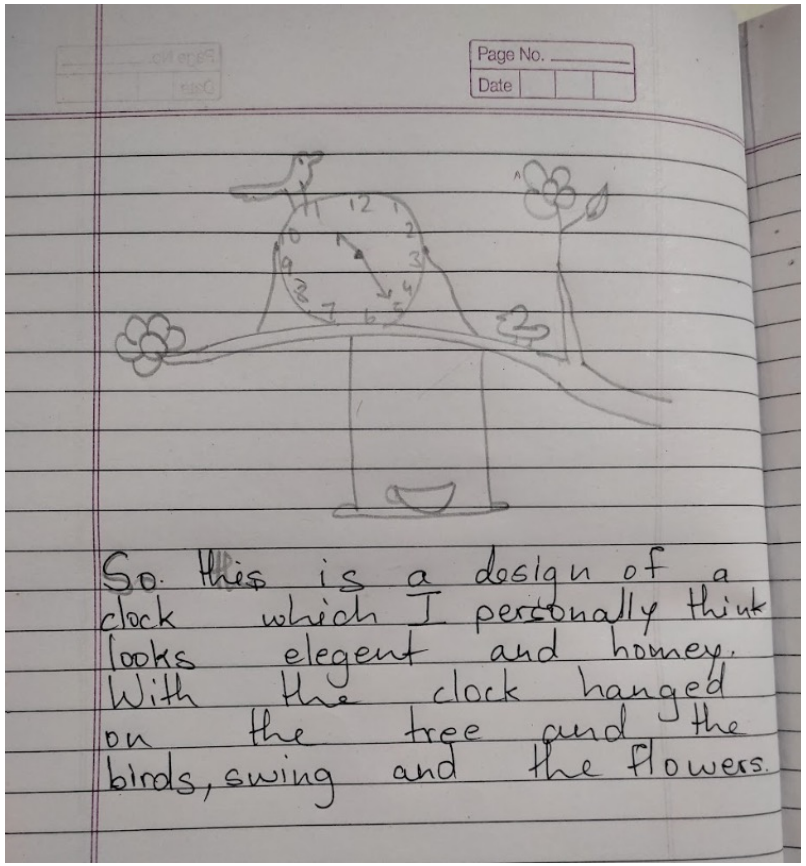

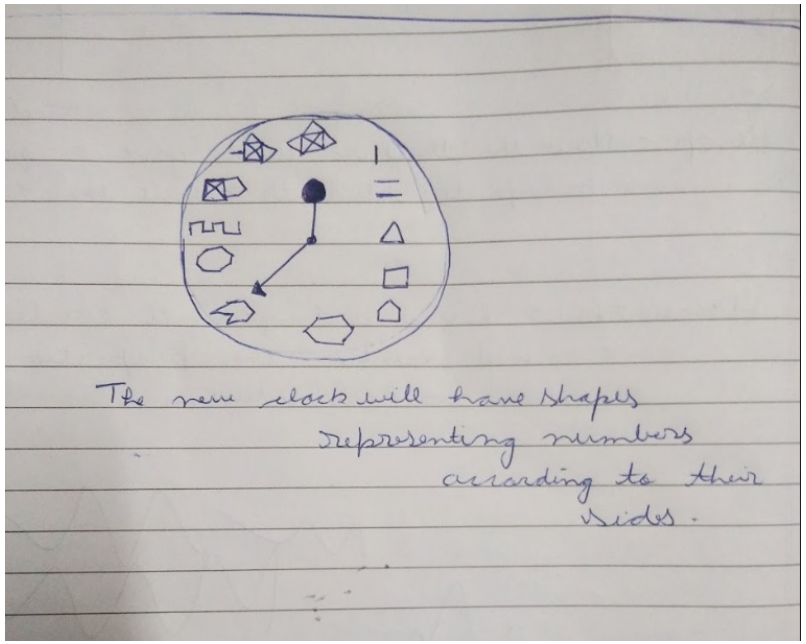

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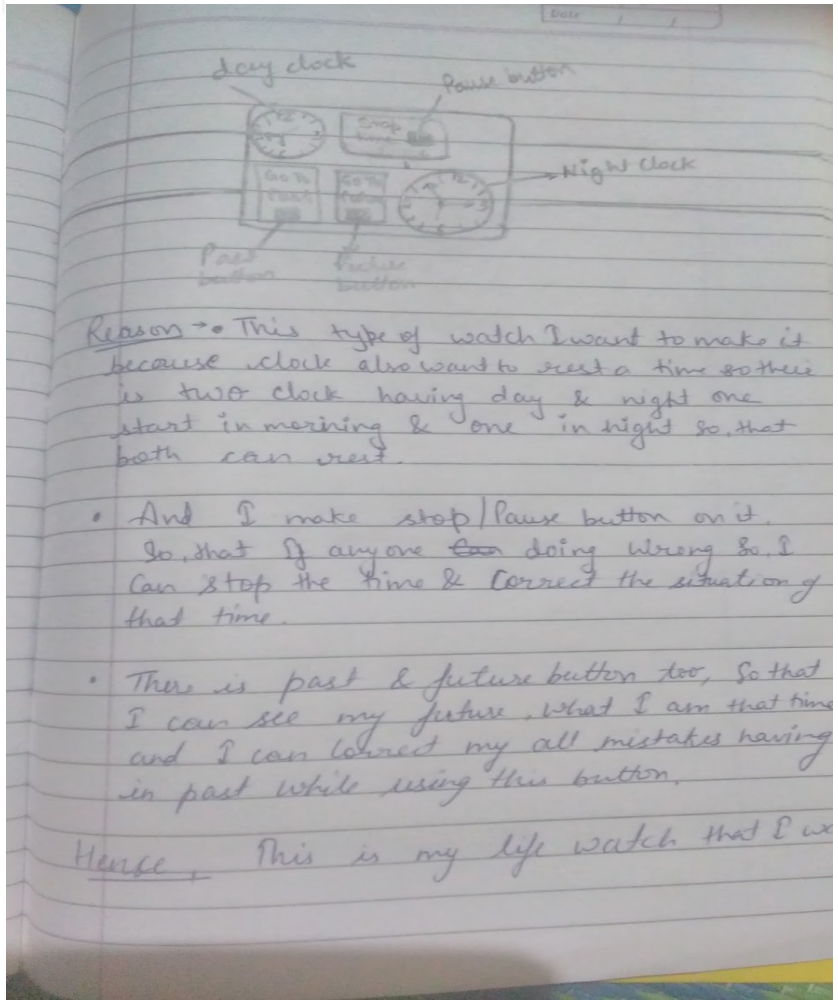

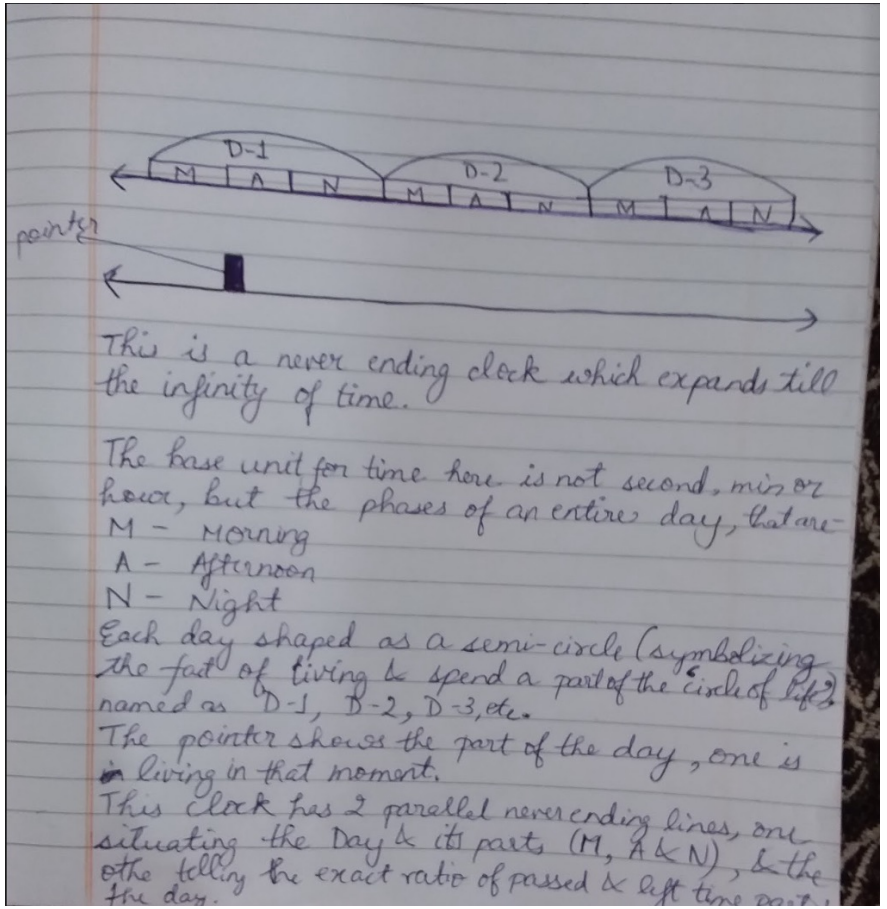

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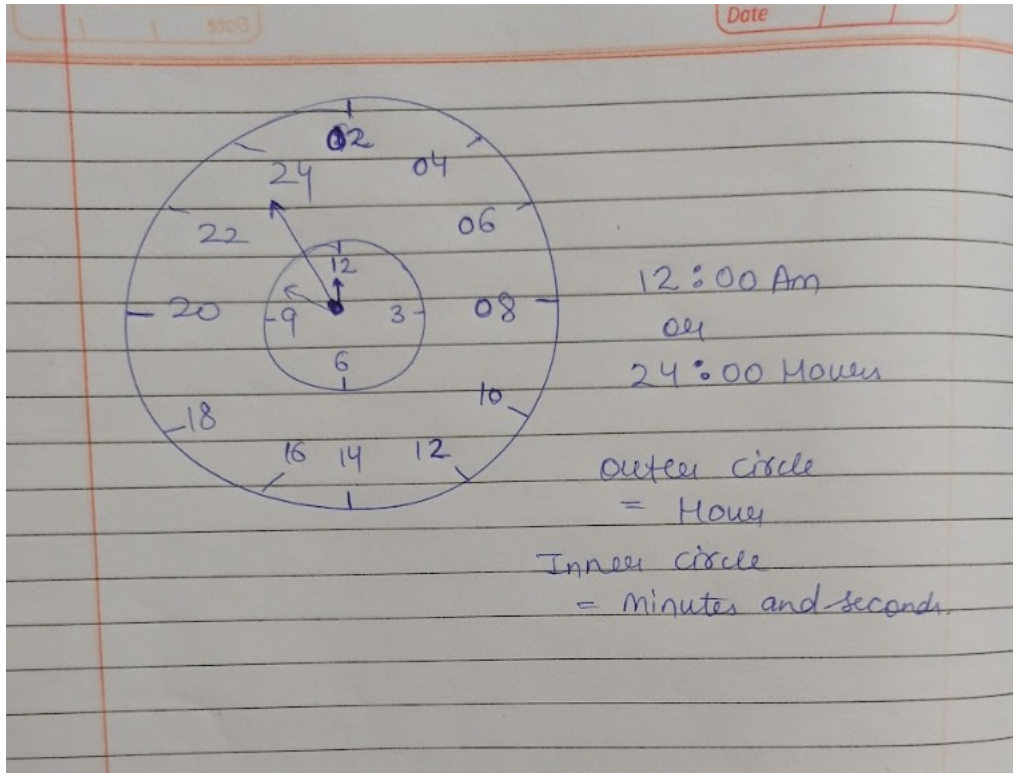

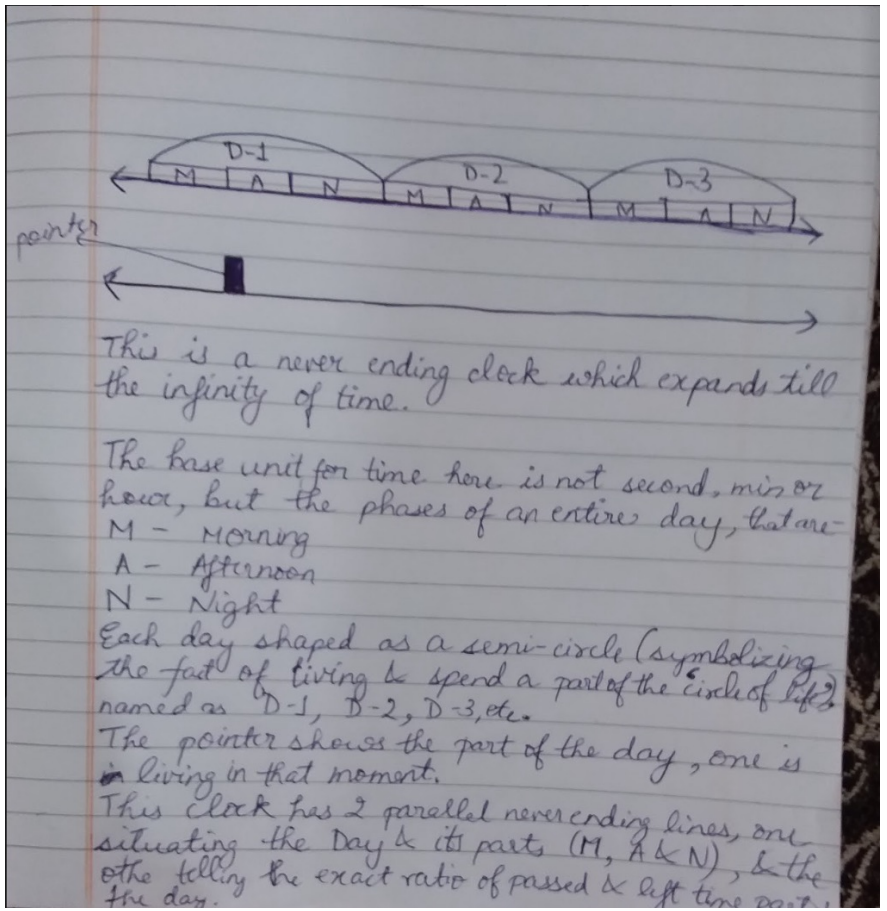

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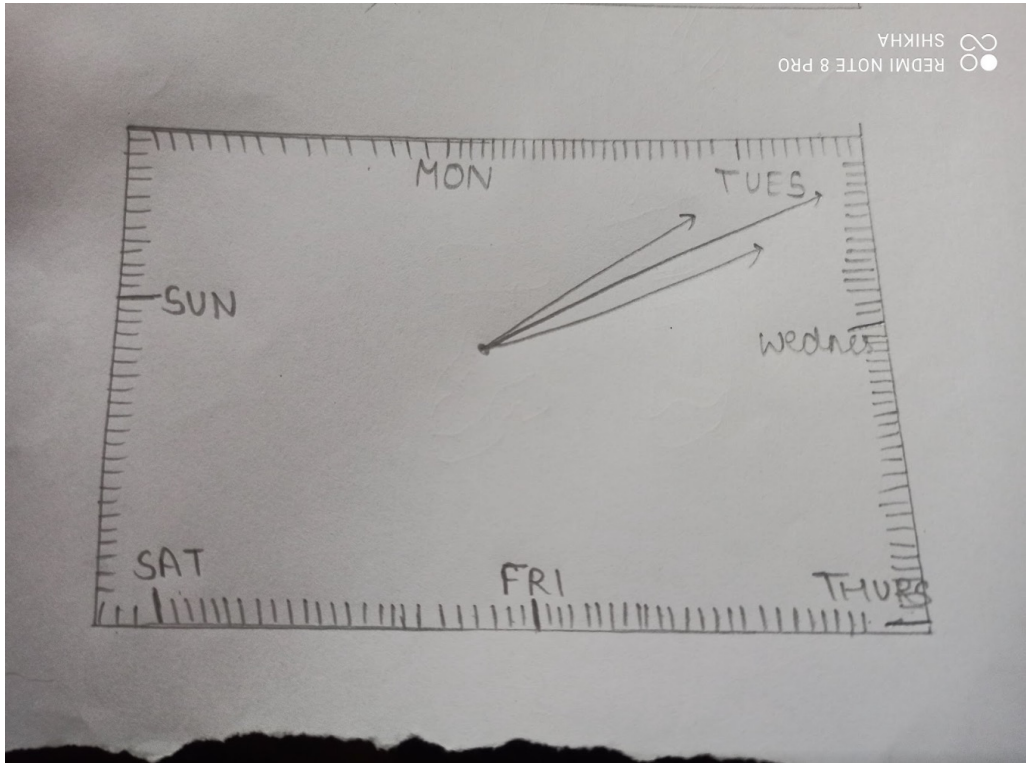

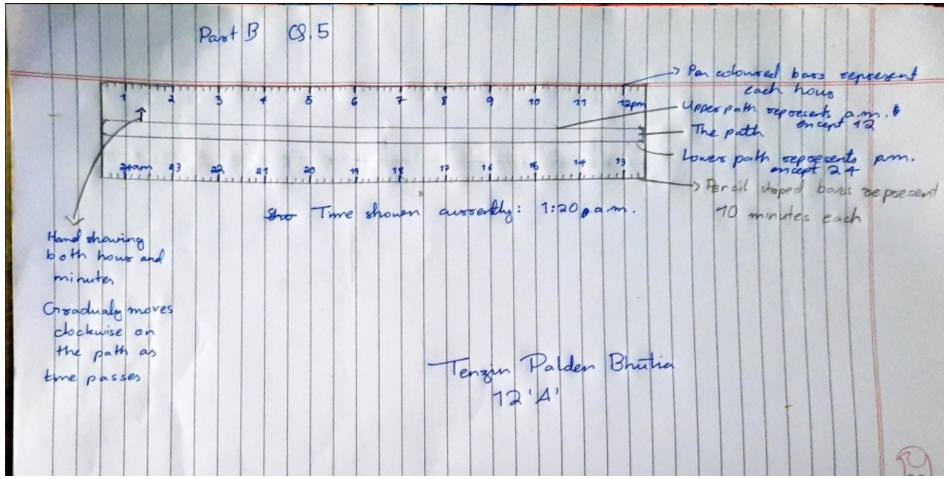

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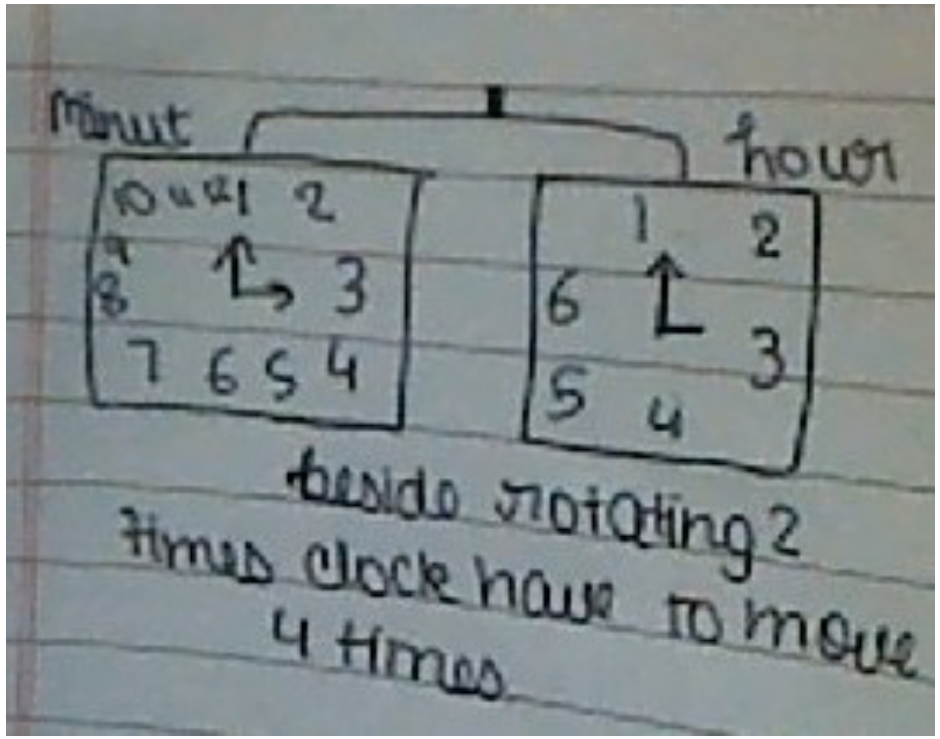

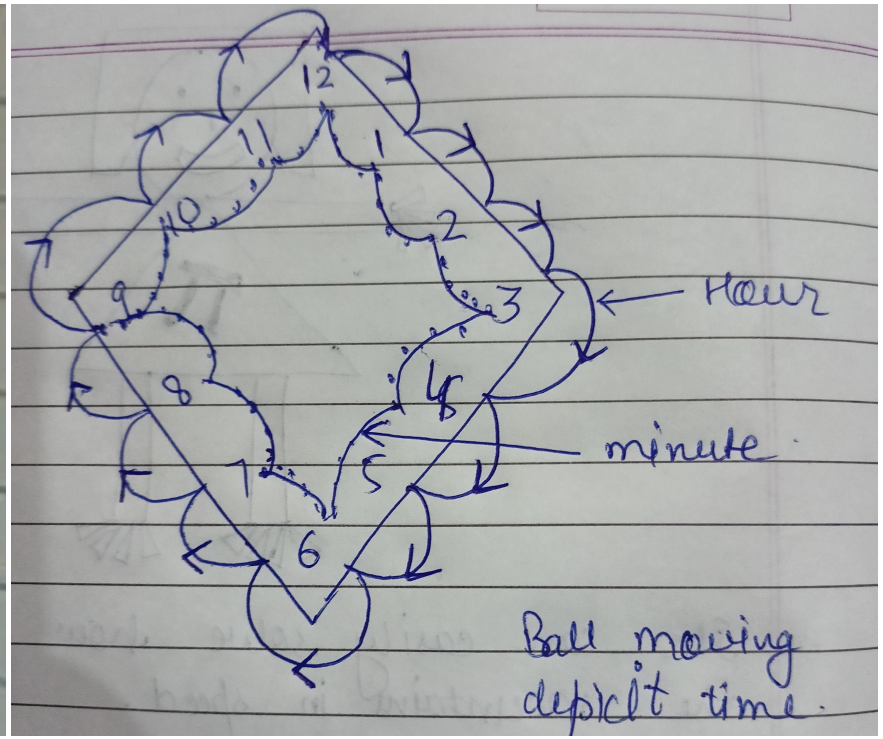

MCT as a pedagogical tool

- Openness
- Confidence to think independently
- Fearless expression
- Flexibility
- Originality

MCT as a pedagogical tool

Level of conceptual understanding

Misconceptions

Creative potentials

Diagnostic/Ability assessment tool

Transfer of knowledge outside the mathematical domain

Initial stage of creative potentials ⟶ Higher level of creative thinking ⟶ Outcome oriented creative thinking

MCT as a pedagogical tool

5-day Teachers' Training Program

Day 1	**Understanding Nature of Mathematics**
Day 2	**Creativity and Mathematical Creativity**
Day 3	**MCT as a stimulus for promoting creative behavior**
Day 4	**MCT and learning outcomes**
Day 5	**MCT as ability assessment and diagnostic assessment**

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