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Mathematisation: Channelising Children's Enthusiasm for Developing Concepts in Mathematics

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Abstract

Mathematics! With a slight change in spelling, it can be read as "Ma – the – Magic". Ma – is the creator and creation is knowledge. All knowledge is the creation of mathematics. Humans, with the highest developed intellect, observe and perceive the physical and biological world around them. They process it in the mind and store it in the form of knowledge. One can notice that all 'knowledge' is in the form of NUMBERS? It is MAGIC. How old is civilisation? How many colours are there in the rainbow? What is the circumference (or radius) of the earth? How many stars, planets, satellites, continents, mountains, oceans, and rivers are there? How many people are there in a country? The answer to all these questions is in some form of 'numbers'. There is no situation where numbers do not exist. The human mind works in numbers. The human body is represented through numbers. How many bones, hands, feet, fingers, eyes, and ears are there? Therefore, one has to consider 'all knowledge' as an offshoot of mathematics and mathematics as the mother of all 'knowledge?' Now the question is: 'How to 'Mathematise the knowledge'? How to make children realise that mathematics is nothing but the life they live.

Introduction

The 2005 National Curriculum Framework for schools states that the main goal of mathematics education is to develop children's abilities for 'Mathematisation.' It also endorses the idea that mathematics is not to be perceived as a discipline, but it is about a way of thinking and reasoning and how children's enthusiasm can be channeled into opportunities for

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developing concepts in mathematics. The question arises, what does mathematisation mean? Moreover, how can children's ability be developed for mathematisation? To answer these questions, first we need to discuss the meaning of the term mathematisation, the process of mathematisation and then the process of developing children's ability for mathematisation.

Meaning of the Term 'Mathematisation'

The term 'Mathematisation' means 'the act of interpreting or expressing mathematically, or explaining mathematically, or to reason mathematically or to do mathematical calculation'. It may also be described as an activity for the students who are dealing with word problems, since the basic process through which the students solve their real-life problems is referred to as 'mathematisation'.

Process of Mathematisation

Mathematising includes the processes of modelling, symbolising, generalising, formalising and abstracting. Therefore, mathematisation is a five-stage process, which can be elaborated as:

1. Identification of a real-life problem
2. Analysing the problem, i.e., identifying the relevant mathematics and organising it according to the mathematical concepts involved.
3. Promote the mathematical features of the situation and transform the real-world problem into a mathematical problem, that consciously represents the situation by gently trimming away the reality through processes like accomplishing assumptions, generalising and formalising.
4. Solve the mathematical problem.
5. Making sense of the mathematical solution in terms of the real situation including identifying the limitations.

Moreover, mathematisation involves the following cognitive processes:

- thinking and reasoning;
- discussion or argumentation;
- conversation or communication;
- modelling;
- problem solving and posing
- representation;
- using formal, symbolic and technical language and operations; and
- use of tools and aids.

The process to Develop Children's Ability for Mathematisation

Any mathematical task may comprise one or more of the above mentioned cognitive processes at various levels of complexity. With the help of these competencies, we can identify the ways we anticipate seeing children using numerical reasoning skills or working mathematically. Teacher's questions in the classroom are essential for the

development of learners' reasoning. These questions can encourage children to rationalise, analyse and evaluate their problem-solving strategies. Children can be asked to visit the data again in a systematic manner so that in the data, the assumptions related to patterns and relationships can be more focussed. We know that children are very enthusiastic so we can channel this enthusiasm, into opportunities to develop concepts in mathematics. Questions like, can you explain why this is right, how did you reach this conclusion, why do you think this, can you please show me how you did this, is there another way, might prove useful in probing learners' thinking and hence the ability to develop mathematisation.

In all competency classes mathematisation takes place, since there is a need to identify the relevant Mathematics in any contextualised problem. With the help of the following examples, the different complexities of mathematisation can be understood. The first one is an example where simple mathematisation is required and in the second example complex mathematisation is required.

Example 1: Geeta had ₹368 in her purse. She bought a book for ₹123. How much money is left in her purse?

Example 2: Rahul needs stamps of ₹25 for his parcel. He went to the post office. Only stamps for ₹1, 2, 5 and 10 were there at that time. Using those stamps in how many different ways can he make ₹25? What is the heaviest parcel he can send using stamps of ₹25?

The second example requires complex mathematisation, since it requires the child to recognise the relevant mathematics and also to develop and communicate a mathematical argument. Mathematics education should not focus on it being a closed system, but as the process of mathematisation, as an activity. Mathematisation provides a challenge for mathematics education as it becomes important to establish a critical position for mathematical coherence as well as new methods of the construction of meaning.

Mathematics is a process of abstracting ideas and generalising them. For example, if we want students to learn to add the one digit numbers by using drawing lines then, we also want them to abstract the idea of addition from their lines and not get stuck using lines for addition. Being able to do this unlocks the power of mathematics for students, because it allows them to work with more complex ideas in the abstract and then reapply this to the concrete situation. Representation in the physical world will be useful as far as they helps students make abstractions and work with these. For example: Halves and Quarters from Chapter 9, Class IV Math-magic Textbook NCERT, 2019.

9 Halves and Quarters

Mintu cat and Mottu cat were friends. Once they stole a chapati from Malini's kitchen. I will take it — said Mintu. No, I will take it — said Mottu. While they were quarrelling, there came Tittu Monkey. Hi! What is the problem? why are you quarrelling? — he asked. "We don't know how to divide this chapati between us — the cats said. OK! don't worry. I will divide the chapati equally for both of you — he said. Clever Tittu divided the chapati like this:

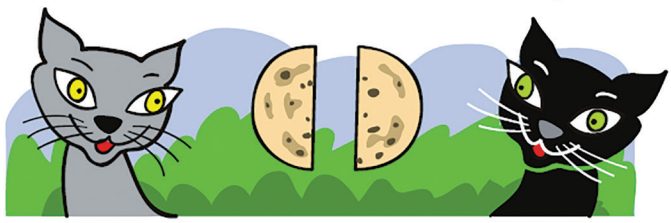
These are not equal, the left part is bigger — Mintu and Mottu said. Oh, no problem, I will make it equal — Tittu said. He then cut a part of the left piece and ate it.

Oh! Now the right part is bigger — the cats cried. I am sorry — said Tittu. He cut a part from the bigger piece and ate it. When there was only a small piece remaining, he said — This is my share for the work. Tittu then quickly ate the last piece and climbed the tree.

Half-Half

- If the cats ask you to divide the chapati equally, how will you divide it?

If you do not cheat like Tittu, the cats will have these parts.



Half of Half

- If two more cats come for food, how will you divide one chapati equally for four cats?

Half of Many Pieces

Rani got a chocolate. She divided it equally and gave half to her friend Reena.

- Circle the portion that Reena got.

Students should be taught to 'mathematise' the situation, to see the mathematics involved, its structure, and be able to articulate this through symbols. However, this process of mathematisation takes place in two different phases: Horizontal mathematisation and vertical mathematisation.

Where horizontal mathematisation is a process of interpreting the real world in terms of the mathematical world. For example 'Who is Heavier' Chapter 8, Class III, *Math-Magic* Textbook of NCERT.

8 Who is Heavier?

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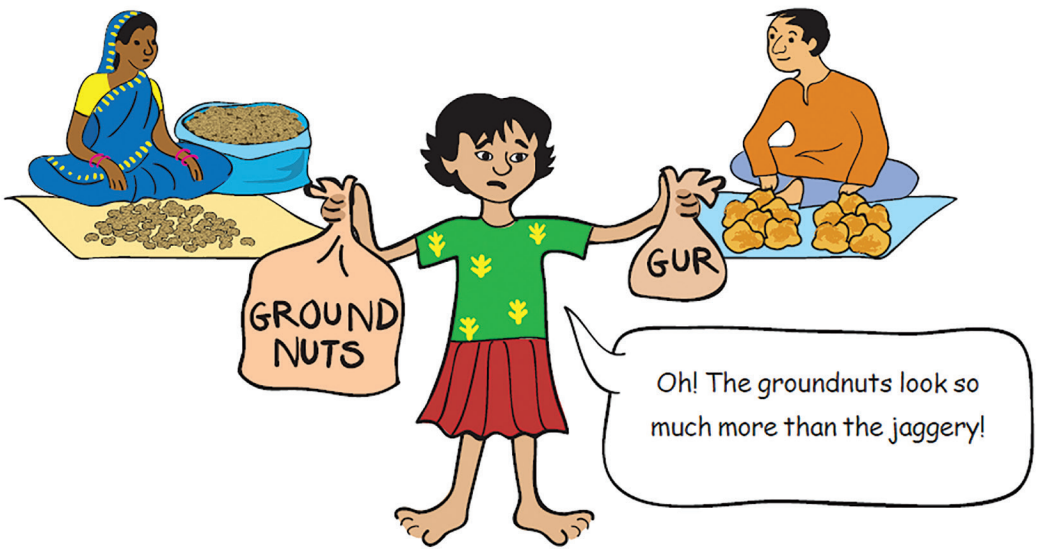
Gur (jaggery) and Groundnuts

Shabnam loved to eat jaggery (gur) and groundnuts.

One day she bought 1 kg of jaggery and 1 kg of groundnuts.

(You know that kilogram is also written as kg.)

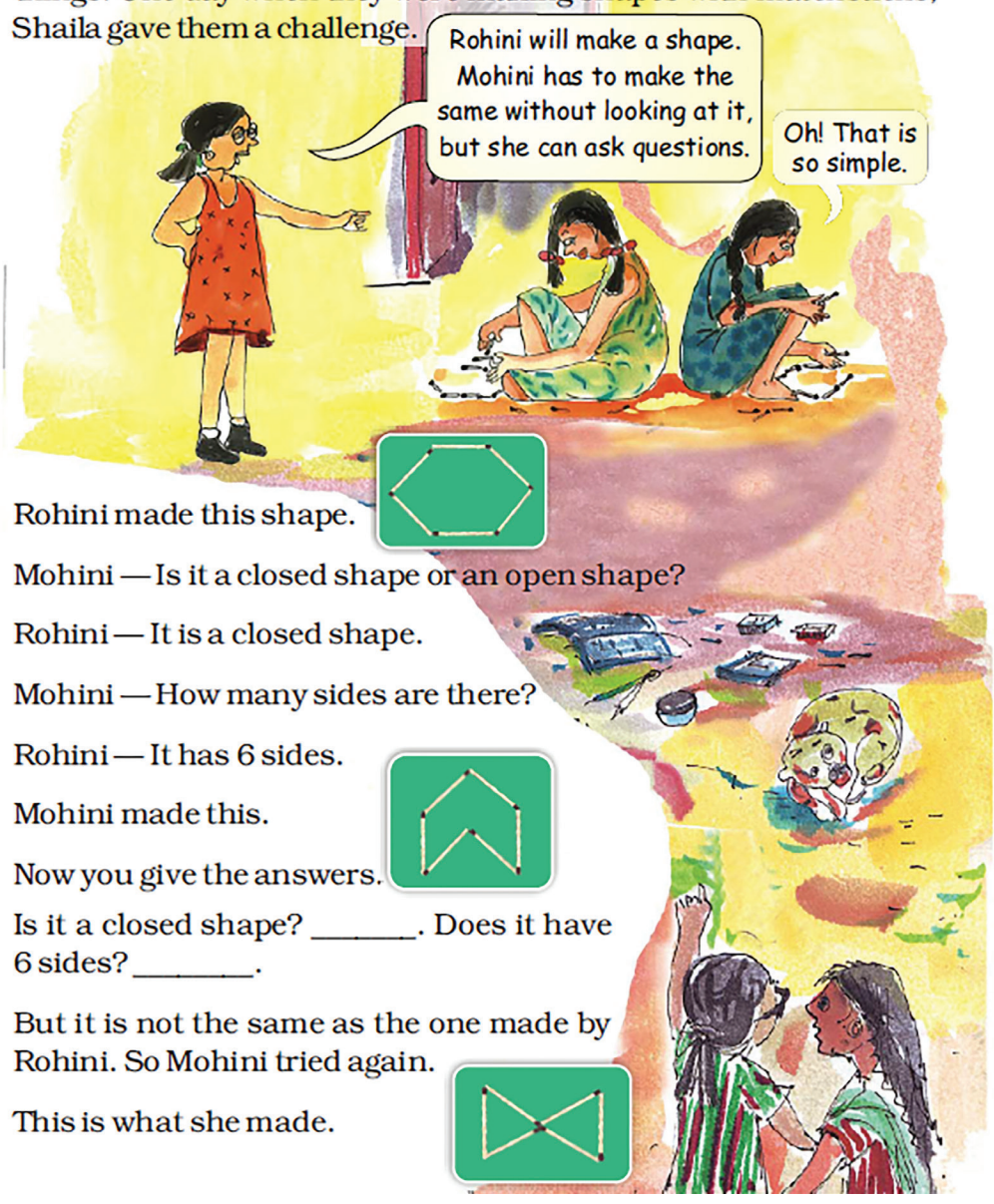


❊ Are the groundnuts really more than the jaggery (gur) in weight or do they just look more?

It explains how the gap between formal mathematics and informal mathematics is extended. It helps students to shift from the world of real life into the world of symbols. It encourages the students to initiate mathematical tools to organise and solve the real problem. Whereas, vertical mathematisation is the process of working on a problem within the mathematical world and using mathematical tools to solve the problem. It refers to the students working with the world of symbols. For example, 'Shapes and Angles' Chapter 2, from Class V *Math-Magic* Textbook, NCERT (2019).

2 Shapes and Angles

Rohini and Mohini are twin sisters. They love doing the same things. One day when they were making shapes with matchsticks, Shaila gave them a challenge.



Rohini made this shape.

Mohini — Is it a closed shape or an open shape?

Rohini — It is a closed shape.

Mohini — How many sides are there?

Rohini — It has 6 sides.

Mohini made this.

Now you give the answers.

Is it a closed shape? _____. Does it have 6 sides? _____.

But it is not the same as the one made by Rohini. So Mohini tried again.

This is what she made.

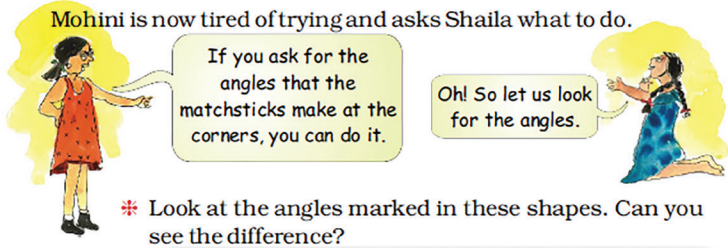
Is it a closed shape with 6 sides? _____

Is it the same as the one made by Rohini? _____

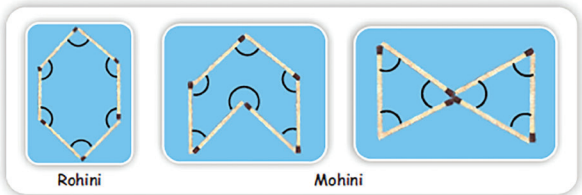
Is there some way to say in what way these shapes are different?

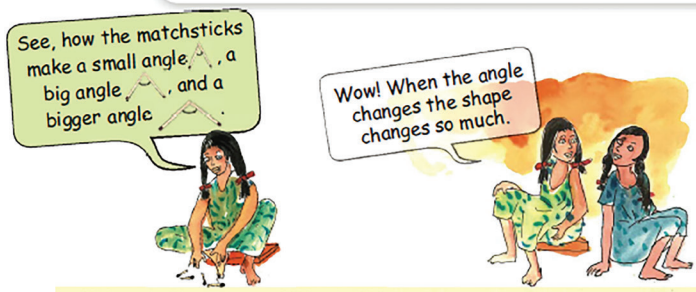
❊ Mohini tried again but got different shapes. Guess and make two more shapes Mohini could have made.

Mohini is now tired of trying and asks Shaila what to do.



❊ Look at the angles marked in these shapes. Can you see the difference?

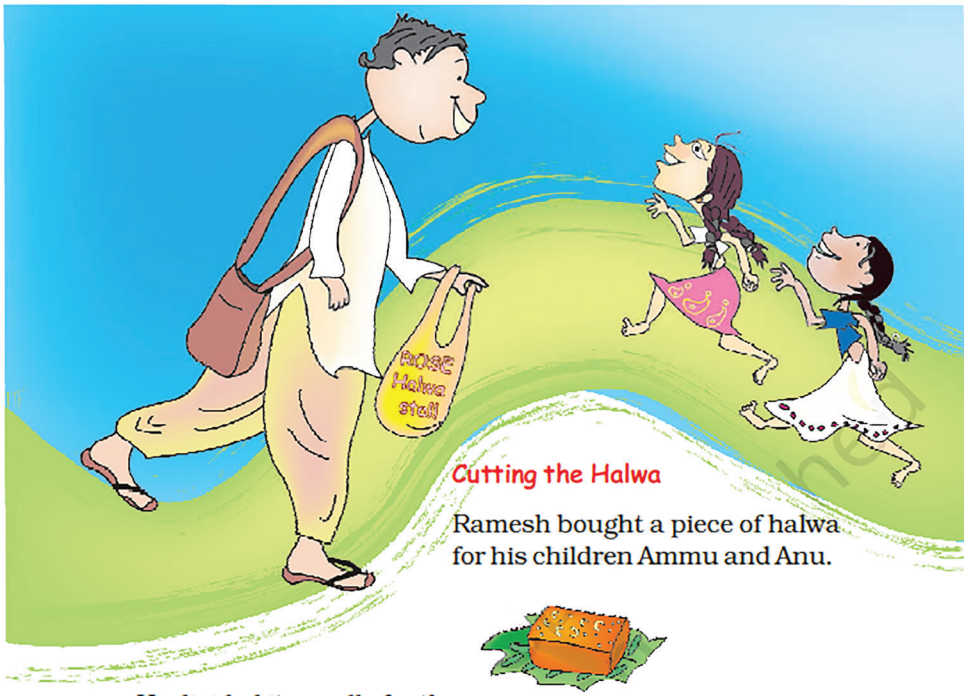




It is important to encourage children to think about the way in which shapes can differ even when the number of sides is the same. This will help them to get a sense of how angles determine the shape of a polygon.

It encourages the students to make connections between the concepts and strategies, leading to reorganisation within the mathematical system. Reflecting on the solution concerning the original problem is an essential step in the process of mathematisation.

Let us take an example of the learning process in mathematising. The topic is 'Fraction', which is the most difficult subject in primary school. A fraction can be learned by two methods, by using situations of fair sharing or by measuring situations. The situations of fair sharing encourage students to develop a fraction language. For example, 'Parts and Whole from Class V, Chapter 4, *Math-Magic* Textbook, NCERT (2019).



Cutting the Halwa

Ramesh bought a piece of halwa for his children Ammu and Anu.

He divided it equally for them.

* Each will get _____ part of halwa.

"This piece is too big. We can't eat it", they said.

So he divided the pieces into half again. Now how many pieces will Ammu get? _____

* What part of the halwa is it? _____

"Make it even smaller, Dad" they asked.

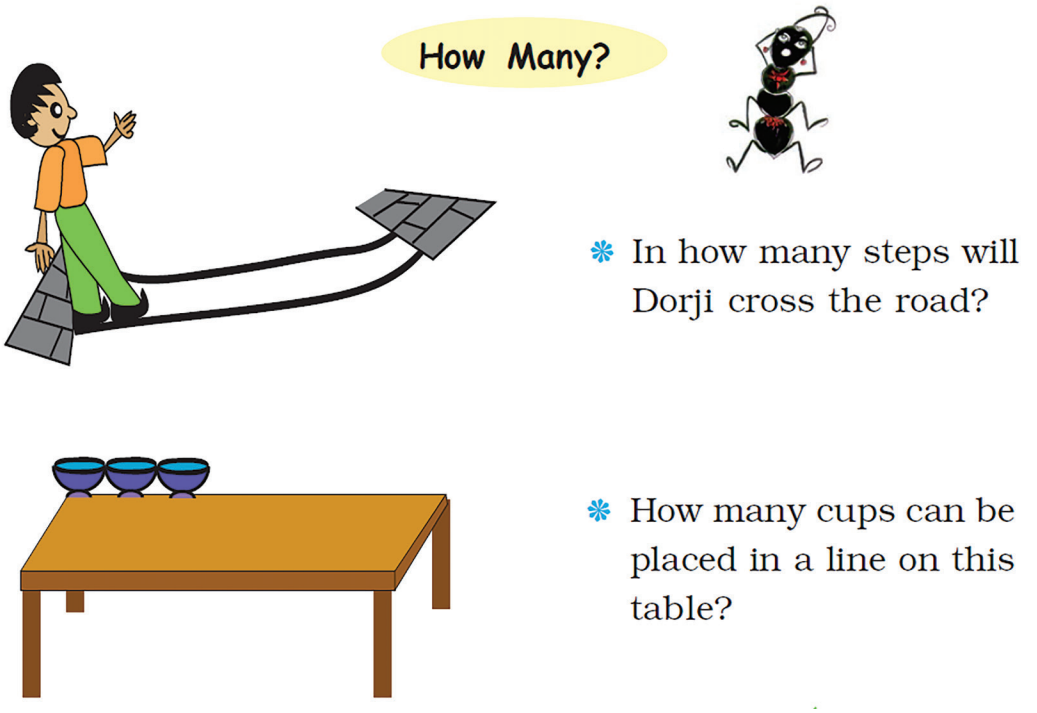
So he again cut the halwa into smaller pieces.

"Ok, thank you, Dad."

The sharing context starts with fractional notation and provides a process to concretise the concept. This sharing context starts with the fraction notation and provides a path to concrete fractions as part of a shape such as a circle. This fraction representation may be elaborated to constitute equivalent fractions and formal fraction subtraction and addition. Similarly, we use fraction language, but through the use of

measuring situations instead of situations of fair sharing. These measuring situations prepare students for positioning fractions on a number line, where equivalent fractions appear as fractions in the same position, hence forming a base for fraction operations. This example of learning Fractions is an example of the process of mathematising, as it can be seen as a process of modeling, symbolising, generalisation, abstraction, and formalisation. Moreover, the learning of fractions aims at vertical mathematisation, as one hardly experiences fractions in daily life; the fraction concept is about abstract and formal relations.

Mathematics must be connected to society and students should learn by the process of mathematisation. There is a need to prepare our students in terms of their problem solving skills and mathematical literacy to meet the challenge of mathematisation. By mathematical literacy, I mean the capacity of an individual to identify and understand the role mathematics plays in the world, for example: 'Long and short' lesson of Chapter 4 of *mathematics* Class III Textbook of NCERT.



This will help students to make well-established judgements and to engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen. It emphasises the importance of solving mathematical problems in real-world settings. Central to this approach to defining mathematical literacy is the notion of mathematising. An important part of mathematics education is the ability to use and do mathematics in different situations. The type of mathematics used depends on the situation in which the problem is presented.

Children's ability for mathematisation can be developed if teachers:

- Emphasise a more interactive approach to teaching mathematics by engaging our students in discussing problems, both before they have solved the problem, and afterward. Identification of the mathematics needed to solve the problem, and discussing the students' reasoning after it has been solved are the main focus areas of discussion.
- Put more emphasis on the use of language in mathematics classes. There is a need to develop language skills in the students (including reading and writing). Students must be encouraged to engage in discussions about how to solve problems and how the solutions to problems can be applied in real-world contexts.
- Help students to develop mathematical knowledge in the context of solving problems. This can be achieved in part by providing students with real-world mathematics problems and by discussing with them the mathematics involved and how this mathematics can be applied to other problems.
- Do not over-emphasise on repetition in classrooms and exams. This can lead to students not getting an opportunity to apply higher-level competency, including connecting and reflecting. We should emphasise on the full range of cognitive competencies (processes) during teaching. Likely, the application of these competencies by students at all levels of ability will result in greater conceptual understanding and more independence in solving problems.

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