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Azim Premji University

i wonder...

Rediscovering School Science

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Experiencing How Things Work

An Azim Premji University Publication

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About us: i wonder... is an Azim Premji University publication. Our main aim is to publish articles and resources (like activity sheets, teacher's guides, posters, and booklets) that support the classroom instruction of preparatory-stage (Grades III-V) Environmental Studies (EVS) and middle-stage (Grades VI-VIII) science teachers. We present critical perspectives and pedagogical approaches that are aligned with the broader curricular goals and competencies that the National Curriculum Framework for School Education (NCF-SE) 2023 recommends for children at these stages of schooling.

About this issue: Welcome to our Aug 2025 issue. The theme section of this issue is 'Materials Around Us'. If any of the articles and detachable classroom resources featured in this issue support your classroom practice, tell us how. Experiences that can be of help to other teachers will be featured in our next issue.

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Editorial

Children are formally introduced to 'Materials Around Us' in the Grade VI science textbook (NCERT, Reprint 2025-2026). While they may not immediately think of it, one of these materials is 'air'. We live our entire lives at the bottom of an 'ocean of air' that is the Earth's atmosphere. This is a material that children are naturally interested in and have their own interesting ideas about. But this curiosity is not limited to children.

Humans, over millennia, have wondered about the nature of air, often drawing from their everyday experiences and expectations. Most cultures and civilizations of antiquity considered air as one of the elements that make up the material world. Almost 2500 years back, the Greek philosopher Empedocles demonstrated that air is not just empty space or a void. He took an empty bowl with a small hole at the bottom (which he covered with his finger) and placed it upside down in a water container. He observed that a pocket of air did not allow water to immediately rush in to fill the bowl. This led him to conclude that air is a substance that can push back water. If children were to try this, and removed the finger from the opening of the hole, they would be able to sense the air emerging from it. Another breakthrough came about four centuries ago. The Italian physicist Gasparo Berti showed that the air that surrounds us does have weight. This is what we call atmospheric pressure. Around 250 years back, through careful experiments and measurements, the French chemist Antoine Lavoisier (and other contemporary chemists) found that a component of air, which he named oxygen, is involved in burning or combustion. He also found that when we account for the mass of oxygen in the air (the experiments were done in closed containers), the mass of the substances involved in combustion is the same before and after the reaction. Among other ideas and techniques, this law of conservation of mass allowed for the further development of chemistry.

But, even today, children as well as grown-ups find it difficult to accept that air is made of matter or has mass. This is not surprising, given that it has taken us millennia to reach a nuanced understanding of the nature and properties of air. How do we help students develop a good understanding of what is air? How can we help them arrive at notions that are scientifically accurate? These questions are the focus of two of the articles in this issue of i wonder... In the article, 'Does an 'Empty' Tumbler contain Air?', Vipin Kumar shares his experience of sustaining a dialogue with students about their ideas regarding the properties of air. Drawing on his extensive experience in working with children, he shows how experimental evidence can nudge children to gradually refine, revise, and sharpen their understanding. In the second article, 'Does Air add Weight to an Inflated Balloon?', Saurav Shome and Vijeta Raghuram present an idea for a simple activity with everyday materials that can lead students to a sophisticated scientific understanding of the mass of air. As the founder director of the National Centre for Biological Sciences (NCBS), Bengaluru, Obaid Siddiqui once said, *"Sophistication should be in the mind, not in fancy gadgets or laboratory spaces."* The ideas from both these articles could also be developed to explore a broader theme around air across topics and grades.

We hope that these articles and the related resources prove useful to you in your classrooms with your students. We are sure you will find ways to adapt and extend these pedagogical ideas further. As always, we look forward to hearing from you about your teaching experiences!

Anish Mokashi
Editorial Team Member

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MATERIALS AROUND US

DOES AN 'EMPTY' TUMBLER CONTAIN AIR?

VIPIN KUMAR

Students learn about the properties of matter in Grade VI. But can they connect these concepts with observations and experiences of air from their everyday world? Can we use an empty tumbler and a bucket of water to help them make these connections?

Chapter 6 ('Materials Around Us') of the Grade VI science textbook (NCERT, 2025-2026) introduces students to matter and its fundamental properties: "*Anything that occupies space and has mass is called matter... The space occupied by matter is its volume.*"[1] It then poses these questions: *"Can all the materials around us be considered as different examples of matter?... For example, water is matter, sand and pebbles are matter and so is the cup... Is air matter?"*[1]

Exploring the properties of air

I was in a Grade VI classroom in a government upper primary school in Sirohi, Rajasthan. I started a discussion on air with the question: *"Does air exist?"* To this, all the students replied, *"Yes!"* I asked, *"I cannot see air. How do you know it exists?"* Some of them agreed with me, *"Yes, we cannot see air."* I repeated the question, but did not receive a response. So I gave the students a few minutes to discuss this with one of their classmates. In my experience, children feel more comfortable articulating their observations and reasoning with their peers. Often, this allows them to confirm the validity of their ideas and gives them the confidence to present these ideas to the rest of the class. When I asked the same question for the third time, I received a flurry of responses: *"We cannot see air. But we can see trees move in the wind. Sand flies. Other things fly too. We can hear the wind when it blows with force."* Chapter 11 ('Nature's Treasures') of the Grade VI science textbook (NCERT, Reprint 2025-2026) tells students that: "*Moving air is called wind. Sometimes it blows fast, for example, during a storm, and sometimes it blows gently as a breeze.*"[2] I asked, "*Do all things fly in the wind?"* The students said that they had seen light things (like "*empty polythene bags*", "*grass* straw", and "*feathers*") fly. I replied, "*So wind can lift light things. What about heavy things*?" Getting no response, I shared that when the wind speed is high, heavier things, like tin sheets used for roofing, can be blown away. This is explained in more detail in Chapter 6 ('Pressure, Winds, Storms, and Cyclones') of the Grade VIII science textbook (NCERT, 2025-2026): "*When high-speed winds blow over houses, a low-pressure area is created over them, as high-speed winds are accompanied by a reduced pressure. Therefore, the air pressure above the roofs of the houses is lower than the pressure below them. If the pressure difference is large and the roofs are weak, they may be blown away....*"[3]. I asked, *"So we can 'see' that wind makes things fly. We can 'hear' the wind blow. Can we also 'feel' the wind?"* To this, the answer was emphatic: *"Yes!"* Many students shared observations and experiences to support their response. A common one was of experiencing this force when their bicycle, bike, or bus was moving in a direction opposite to that of the wind, and *"the wind hits us from the opposite direction."*

After a pause, I asked, "*So we know that air exists because we see, hear, and feel the wind. What if there is no wind? Does air still exist?*" Many students were unsure. After some thought, some students said, "*Yes*." I asked, "*Where can we find it?*" Many of them said that air is found everywhere "*outside*." I asked, "*And what do we breathe in and breathe out?*" One of the students replied, *"We breathe in oxygen."* I asked, *"Do we breathe in air or oxygen?"* Some of the students replied, "*The air we breathe in has other gases, too*." Other students started reciting the names of the gases they could remember, *"Carbon dioxide"*, *"Nitrogen"*, *"Hydrogen"*. In Chapter 10 ('This World of Things') of the Grade III Environmental Studies (EVS) textbook (NCERT, 2025-2026) students first learn that: "*...objects can be classified as solids, liquids and gases.*"[4] Then, in Chapter 11 of the Grade VI science textbook (NCERT, Reprint 2025-2026), students learn that: "*The air which surrounds the Earth is a mixture of gases... Air contains nitrogen, oxygen, argon, carbon dioxide, and other gases in small quantities.*"[2] I confirmed that all their responses were correct. I also briefly explained what a mixture is. This concept is now introduced in Chapter 8 ('Nature of Matter: Elements, Compounds, and Mixtures') of the Grade VIII science textbook (NCERT, 2025-2026): "*When two or more substances are mixed, where each substance retains its properties, it is called a mixture. The individual substances that make up a mixture are called its components. The components of a mixture do not react chemically with each other.*"[5] To help them relate to this, I pointed to a heap of sand in the school courtyard and asked, "*Can that heap be called a mixture*?" Many students said it was. When I asked why, they replied, "*It has sand, small stones, and some pieces of iron*." Some of them told me how they used magnets to fish the iron pieces out of that heap. I had seen them doing this. This had prompted my question about the heap. I said, "*The different components of air are mixed up like that, too. You named some of the gases in air. Do you know any other things that are part of this mixture?*" When no answer came, I asked a question based on one of the observations they had shared before: "*Can wind make sand fly?*" The students said: "*Yes, you can see it in the air. And dust, too.*" Then, I asked, "*What about water? If we throw some in the open courtyard, what will happen to it?*" The students replied that it will disappear. We tried this out. Since it was summer in Rajasthan, it took only a few minutes for the water to disappear. I asked, "*Where did the water go?*" The students answered that it went into the air. I explained that the water changes into a gas and mixes with the other gases in air. Students learn about 'Water's Disappearing Act' in more detail in Chapter 8 ('A Journey Through States of Water') of the Grade VI science textbook (NCERT, Reprint 2025-2026): "*The process of conversion of water into its vapour state is called evaporation.*"[6] To give students a quantitative understanding of the composition of air, I asked, "*We know that air is a mixture of many gases. But in what quantities are these gases found?*" When there was no response, I asked the students to look into their textbooks to see if they could find the answer. The students flipped through the pages of their textbook till they found this information and read it out aloud. I recorded their responses on the board: Nitrogen: 78%; Oxygen: 21%; Carbon dioxide: 0.03%; Other gases: 0.97%. Chapter 11 of the latest Grade VI science textbook (NCERT, Reprint 2025-2026) presents this information as fractions: "*Out of 100 squares, 78 are occupied by nitrogen, 21 are occupied by oxygen, and 1 by argon, carbon dioxide, and other gases.*"[2]

I held up a steel tumbler that I had brought into class. I turned it around so that students could see inside it. Then, I asked students, "*Is this tumbler empty or does it contain something*?" The students replied, "*Empty*." I asked, "*Does it contain air*?" Many of the students quickly said, "*No*." Some of them looked confused and did not respond. I gave the class some time to think before I repeated my question. This time, looking at each other, all the students said that there was no air in the tumbler.

I filled a bucket with water and brought it into class. The students watched with curiosity. I turned the tumbler upside down and asked the students again, *"Are you sure there is no air in this tumbler?"* Again, the students said, *"Yes."* Then, I asked, *"What if I put this empty tumbler into this bucket of water upside down? What do you think will happen?"* One of the students predicted that if I pushed the tumbler into the water and released it, it would bounce back to the surface of the water. This suggests that the student had observed the effect of the buoyancy of water on objects submerged in it. Students are formally introduced to this concept in Chapter 5 ('Exploring Forces') of the Grade VIII science textbook (NCERT, 2025-2026) through a similar activity: "*Take an empty plastic bottle (with its lid closed tightly) and a bucket full of water. Push the bottle in the water... Do you feel an upward push? Release the bottle. Does it bounce up? You would have felt an upward push and the bottle bounces back to the surface of the water. This indicates that water applies a force on the bottle in the upward direction. In fact, all liquids apply a similar force. The force applied by a liquid on an object in the upward direction is known as upthrust or buoyant force.*"[7] I asked the student, *"Why? Will the tumbler come up because there is air in it?"* He said he was sure there was no air in the tumbler. He did not know why the tumbler would come up, but he knew it would. I said: *"Let us try putting this tumbler in."*

I asked all the students to move closer to me so that everyone could observe the activity properly. I held the tumbler up, and again asked, *"Does anyone think there is air in this tumbler?"* The students did not answer. My intention in asking the same question multiple times was to ensure that the students actively looked for any evidence for the presence of air in the empty tumbler. Then, I turned the empty tumbler upside down, closed its open mouth with the palm of my other hand, and gently immersed this set-up in the water. Holding the tumbler vertically, I asked the students to carefully observe the water in the bucket, *"Can you see any evidence that the tumbler has air?"* The students peered into the water, but remained silent. Then, very slowly, I started removing the palm of my hand from the mouth of the tumbler, while tilting the tumbler slightly (see **Fig. 1**). Immediately, we could all see bubbles coming out into the water and moving up towards its surface. I asked the students, *"What do you think is happening here?"* Their spontaneous response was, *"Air is coming out."* They explained that they had seen other examples of this. Some of them mentioned that the bubbles in the bucket were like those that rise to the surface of water when it is heated to make tea. I said: "*But where could air have come from? You said there was no air in the inverted tumbler before I put it into the water. I closed the mouth of the tumbler in front of you. When I moved my hand away, how did air come out from the empty tumbler?"* Now, the students stated, with certainty, that the empty tumbler must have had air in it because they were able to see the bubbles that came out of it.

I repeated the activity once. Then, I invited the students to try it out by themselves. Some of them repeated what they had seen me doing. But others began to introduce variations. For example, one of the students copied me in tilting the tumbler slightly upward under water. But when bubbles started appearing from under the near-vertical tumbler, they increased its upward tilt. The students watching this remarked that the number of bubbles and the speed with which they came out had increased. The first student continued to move the mouth of the tumbler upward till it was filled to the brim with water. All of us observed that there were no more bubbles in the water. I asked, *"Why are bubbles not coming out of the tumbler now?"* The students guessed that all the air had already come out from the tumbler. They added: *"No air is left in the tumbler now."* Another student, named Yogita, held the tumbler upside down in her hand in such a way that her index finger remained inside the tumbler. She held the inverted tumbler under the water in this position for some time. Then, she took the set-up out of

Fig. 1. Demonstrating that an empty tumbler contains air. An empty tumbler is inverted and immersed into water. When it is tilted slightly, students can see air bubbles escape from it and rise to the water surface.

Credits: i wonder... It was created using a photo by the author, Vipin Kumar, as a template. License: CC BY-NC-ND.

water and looked at her index finger. Showing it to her classmates, she said, *"Look, it's still dry."* I asked Yogita: *"Why do you think your index finger remained dry?"* She replied: *"There is air in the empty tumbler. There is no water. So my finger did not get wet."* While this activity may seem simple, it demonstrates Yogita's use of the scientific process. She had seen bubbles coming out from under the tumbler when we moved our palm away from its mouth. Like the other students, she had inferred that this was air escaping from the tumbler. But does the air from the tumbler need to come out for water to enter? She reasoned that if the tumbler remained filled with air as long as it remained vertical and its mouth was covered with the palm of her hand, any dry object that was kept in the tumbler would remain dry. This was her hypothesis. That her finger remained dry when she took the set-up out of water confirmed it. She now knew, from her own experience, that unless air escaped from the tumbler, water did not enter it. I shared her reasoning with the other students and invited them to test it for themselves.

After giving the students enough time to experiment with this activity, I asked, *"Why does the tumbler not fill up with water as soon we move our hand away from its mouth?"* By this time, many of the students had tried Yogita's version of the activity and seen the same result: The finger inserted into the upturned vertical tumbler remained dry. They replied, *"There is air in the tumbler, how can it fill up with water?"* I asked, *"The tumbler is fully immersed in the water. But no water goes into it till it remains vertical. When does it start filling up with water? Let us try seeing this."* I held up a transparent plastic bottle and asked the students, *"We are going to repeat the tumbler activity with this bottle. If some water does go into the bottle, will we be able to see it?"* The students replied: *"Yes."* After a brief pause, some of them asked, *"But how will we make water go into the bottle?"* I reminded them of the modification some of their classmates had made to the activity. They had continued to tilt the tumbler upward. The more they had tilted it, the more it had filled up with water. The students and I repeated this process with the bottle. We observed that the less the air bubbles that escaped from the bottle, the less the volume of water that filled into it. The more the air bubbles that came out of the bottle, the more the volume of water that filled into it. I asked, *"Why do you think the amount of water that goes into the bottle depends on the amount of air that comes out of it?"* The students replied, *"The amount of water that goes into the bottle is equal to the amount of air that comes out of it."*

I now shared that air fills up all empty spaces on our planet. The tumbler appeared empty. But when we inverted it, immersed it in water, opened its mouth, and started tilting it upward, a certain volume of air came out of it as bubbles. The same volume of water moved into it. This shows that the 'empty' tumbler was filled with air and that air also occupies space. When an apparently empty space gets filled with a certain volume of some other material, an equal volume of air moves out of that space. I emphasized this point with an example they could relate to: *"There is air in this room. It occupies every space that looks empty. It is between the open pages of your book, in your bag, within your body. When you go out of this room, air equal to your body volume comes into the room. And when you come into the room, air equal to your body volume goes out of the room."*

To test the students' understanding, I filled half the tumbler with water. Showing this to them, I asked, *"What is in this tumbler?"* The students replied: *"It has water."* I asked, *"Is the entire tumbler filled with water?"* The students replied: *"There is some water and some air in it."* This demonstrated that the students were able to see that air was present in the space that appeared empty. To confirm this, I explained, *"If I pour water from this tumbler into another tumbler, then some air from the other tumbler will come out to make space for the water. If I filled the other tumbler to the brim with water, all the air will come out of it. The tumbler will then be filled only with water. There will be no air in it."* The discussion ended with students sharing their experience of what they had done, seen, and learned in class.

Parting thoughts

Giving children the opportunity to learn through an inquiry-based approach allows them to become familiar with the scientific process (see the **Activity Sheet** and **Teacher's Guide**). I have observed that children can get so involved in investigating a phenomenon we are exploring that they often modify an activity I have demonstrated or design new activities around it. When I shared Yogita's modification with children from other schools, it inspired other variations. For example, in one school, a student did this activity with a pencil inserted into the inverted tumbler. In another school, students glued some paper to the bottom of the inner surface of the tumbler. Like Yogita, these students found that the pencil and paper remained dry

Box 1. Curricular connections:

These activities and the supporting discussion can help meet the following:

A. Curricular goals for middle-stage science:

- CG-1: [The student] explores the world of matter and its constituents, properties, and behaviour. Specifically, it can help students develop the competency (C-1.2) to: *"Describe changes in matter (physical and chemical) and use particulate nature to represent the properties of matter and the changes."*
- CG-6: [The student] explores the nature and processes of science through engaging with the evolution of scientific knowledge and conducting scientific inquiry. Specifically, it can help students develop the competency (C-6.2) to: *"Formulate questions using scientific terminology... and collect data as evidence (through observation of the natural environment, design of simple experiments, or use of simple scientific instruments).*[8]

B. Curricular expectations for middle-stage science: Students are expected to develop process skills of science which includes observation(s), posing question(s), searching various resources of learning, planning investigations, hypothesis formulation and testing, using various tools for collecting, analysing, and interpreting data, supporting explanations with evidences, critically thinking to consider and evaluate alternative explanations, reflecting on their own thinking.[9]

C. Learning outcomes (LO) for middle-stage science:

- Conduct simple investigations to seek answers to queries.
- Relate processes and phenomenon with causes.
- Explain processes and phenomenon.
- Apply learning of scientific concepts in day-to-day life.
- Exhibit creativity in designing, planning, making use of available resources, etc.[9]

when the inverted glass was dipped into water and kept vertical. This, for them, validated the presence of air in the empty tumbler. They were also more confident about this conclusion because it was drawn from their observations of a variation that they had come up with themselves (see **Box 1**).

If students are consistently allowed to apply this process in the science classroom, then they will develop the skill to test the validity of textbook facts for themselves, use their own observations to draw logical conclusions, and create their own knowledge of phenomena. Such experiences can also play an important role in helping them develop into citizens with qualities like *"scientific temper, humanism, and the spirit of inquiry and reform"* that are enshrined in Article 51A (h) of our Constitution.[10]

Key takeaways

- Students are introduced to the difference between solids, liquids, and gases in the preparatory-stage EVS curriculum and to the concept of matter and its properties in the middle-stage science curriculum. But students may not connect these concepts to air.
- Asking questions that encourage students to share and examine their everyday experiences of air can help them connect their sensory perception of its properties with textbook concepts on matter.
- Involving students in a hands-on investigation to check for the presence of air in an empty tumbler can allow them to validate this fact for themselves.

Notes:

(a) Credits for the image (Metal tumblers) used in the background of the article title: FullyFunctnlPhil. URL: https://www.flickr.com/photos/83626281@N00/5085420947/. License: CC BY-NC-SA 2.0 Generic Deed.

(b) The editors thank Amol Anandrao Kate and Shiv Pandey from Azim Premji Foundation for sharing this draft with us. We also thank Rajesh Utsahi from Azim Premji University for sharing the English translation of the original draft (written in Hindi).

(c) This article includes two detachable classroom resources: **Activity Sheet: Test the Presence of Air in the Tumbler** and **Teacher's Guide: Designing an Inquiry-Based Approach**.

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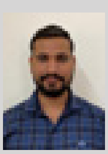

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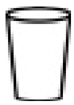
ACTIVITY SHEET I: IS AN EMPTY TUMBLER EMPTY OF MATTER?

What you will need:

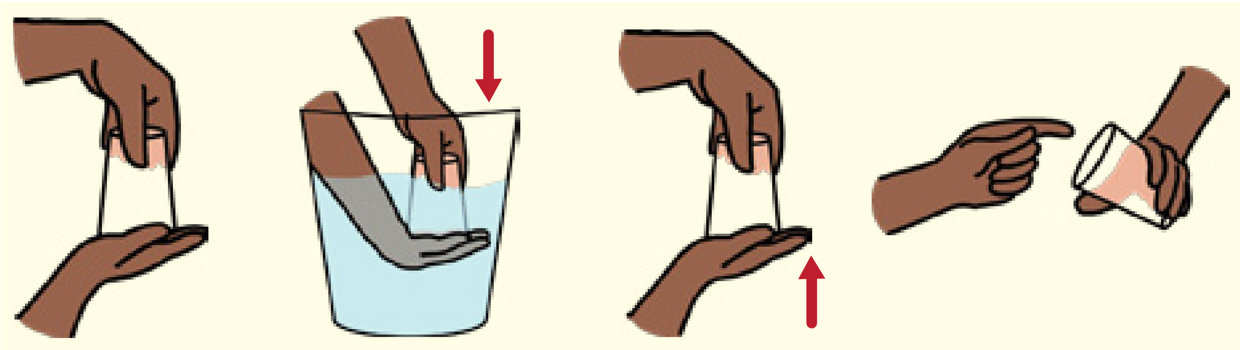

1 tumbler/ transparent plastic bottle


1 bucket of water

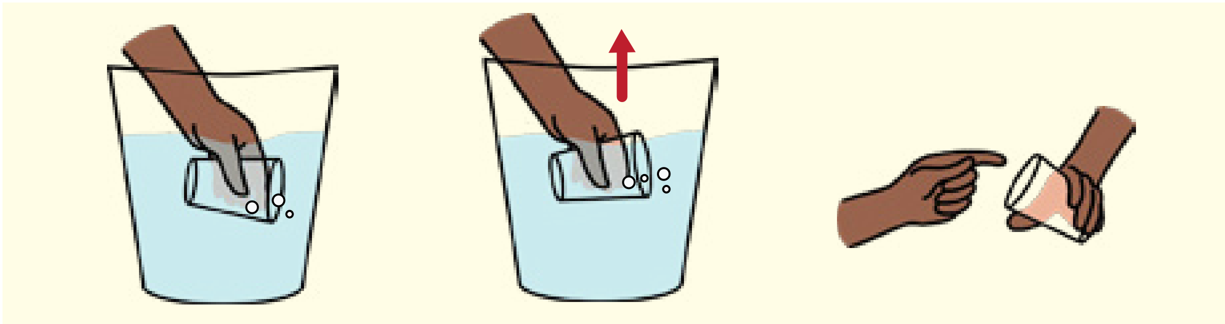

Old newspaper

What to do:

1. Fill a bucket of water.
2. Invert the empty tumbler. Cover its mouth with the palm of one hand. Dip into the water in the bucket. Hold the tumbler, without tilting it, in the water for a few minutes. Bring the tumbler out slowly. Turn the tumbler and touch its inner surface with a dry finger.



3. Repeat Step 2, but once the tumbler is in water, remove your hand from its mouth. Tilt the tumbler slightly. Stop and observe the water. Then continue tilting the tumbler slowly till it is horizontal. Bring it out of the bucket in this tilted state.



Observe:

- Do you see any bubbles in the water when the inverted tumbler is:
  - Held without tilting in Step 2? __________ Why?
  - Tilted in Step 3? __________ Why?
- Is the inner surface of the tumbler wet or dry at the end of:
  - Step 2: __________ Why?
  - Step 3: __________ Why?

Think about:

- Why do no bubbles come out of the inverted tumbler when it is held without tilting?
- Why do bubbles come out of the inverted tumbler when it is tilted?
- Can you increase the number of bubbles that come out from the tumbler and the speed at which they come out? How?
- If the tumbler is empty, where are the air bubbles coming from?
- When do bubbles stop coming out from the tilted tumbler?

Discuss:

- Is the 'empty' tumbler empty of matter?
- You have just made some observations about an 'empty' tumbler in the classroom. Have you seen something similar happening in your everyday life?

You could also explore:

A) In Step 3, the tumbler could be tilted at the surface of the water or at the bottom of the bucket. Will you observe any difference?

B) Take some newspaper and crumple it into a ball. Stuff it at the bottom of the tumbler. When you invert the tumbler, the ball should not fall out. Now, try Steps 1-3. Does the paper ball stay dry or become wet when the tumbler is:

(a) Kept without tilting under water in Step 2? Why?

(b) Tilted under water in Step 3? Why?

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Contributed by:

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Materials Around Us

TEACHER'S GUIDE: USING AN INQUIRY-BASED APPROACH IN THE SCIENCE CLASSROOM

In the article titled 'Does the Tumbler have Air?', I share my experience of using an inquiry-based approach with Grade VI students from a government school. For teachers who would like to try this approach in their own classrooms, here are some guidelines I have found useful:

- Cognitively challenging questions play an important role in encouraging inquiry into a phenomenon. In choosing what questions to use, it is important to understand the context, experiences, and observations that are likely to shape student ideas about the phenomenon. The questions we ask need to be adapted accordingly.
- When students respond to a fact that is 'told' to them or is read out from a textbook, there might be a gap between their and your understanding of it. But when you pose questions built around their observations and experiences, students are with you in the process of learning. Once this happens in a classroom, I have observed students demonstrating higher order thinking skills (like analysing, evaluating, and creating) in surprising ways.
- Students may not respond to our questions immediately. Rather than provide an answer, it is important to give them time to recollect any prior learning and think about any experiences that are relevant to the question. Also, when required, allow students to engage in discussion with their peers. This can help them confirm or validate their ideas. It can also give them the confidence to express these ideas in class.
- One of the most important aspects of an inquiry-based approach is hands-on experience. Some hands-on experiences are limited to organizing an opportunity for students to try a prescribed activity or make a model. Student learning from such experiences can remain limited to lower-order thinking skills. In contrast, trusting students and scaffolding inquiry around their experience allows better learning outcomes and more innovation. It also encourages students to use and show many higher-order thinking skills. For example, I have seen students make and test their own hypotheses, make models to explain a process or phenomenon, design and execute their own activity ideas, and identify and use their own materials for it.
- It is useful for students to have a hypothesis in mind before they start an activity. This gives them a clear idea about what to observe. This also allows students to make observations and inferences that are naturally related to the validation or invalidation of the hypothesis. Here, again, it is important to give students time to think about and build interrelations between their hypothesis, observations, and knowledge.

TEACHER'S GUIDE

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DOES AIR

ADD WEIGHT TO AN INFLATED BALLOON?

SAURAV SHOME & VIJETA RAGHURAM

Students are introduced to mass as a property of matter in the middle-stage science curriculum. But many students believe that air is massless. Can we use an inflated balloon to offer visual evidence that air has mass?

The introductory 'Probe and Ponder' section of Chapter 7 ('Particulate Nature of Matter') of the Grade VIII science textbook (NCERT, 2025-2026) poses this question: *"We cannot see air, so how does it add weight to an inflated balloon?"*[1]

This question offers students the opportunity to bring together some important science concepts that they learn about in different grades. For example, in Chapter 10 ('This World of Things') of the Grade III Environmental Studies (EVS) textbook (NCERT, 2025-2026), students learn that: "*...objects can be classified as solids, liquids, and gases.*"[2] They also learn that: *"Air does not stay in a cup; it just floats in and out. That is because air is a gas."*[2] In Chapter 7 of the Grade VIII science textbook, students learn that matter exists in three states: solids, liquids, and gases.[1] This would suggest that air is matter. In Chapter 6 ('Materials Around Us') of the Grade VI science textbook (Reprint 2024-2025), students learn that: *"Anything that occupies space and has mass is called matter."*[3] This would suggest that air, too, has mass. Yet, the idea that air is 'massless' is a widespread student misconception.[4] In Chapter 7 of the Grade VIII science textbook, students also learn that: *"...matter is composed of a large number of extremely small particles. These particles are so small that they cannot be seen even through an ordinary microscope."*[1] While students are able to associate the particulate nature of matter to solids and liquids, they find it difficult to think of air in the same way. So they may interpret steam rising from boiling water as one gram of water vapourising into massless vapour!

How do students arrive at the misconception that air is massless? We often tend to think of matter only in terms of human senses and capabilities. For example, how much of it can we see with our eyes? Can we feel its weight if we hold it in our hands? So students can think of even something as light as a feather or an eyelash as being made up of matter. But they may find it challenging to think of something invisible or transparent, like air, as matter. Especially because they do not experience its weight. If told that air does have mass, students ask if it can be measured and what its exact value is. In some cases, students express the interesting argument that, *"The mass of air cannot be measured because air does not push down, it rises."* On probing, students share the observation that party balloons rise into the air only when inflated with air (helium). Here, again, students are associating the concept of weight (and, therefore, mass) with objects that do not rise by themselves or can be used to keep an inflated balloon from floating away.

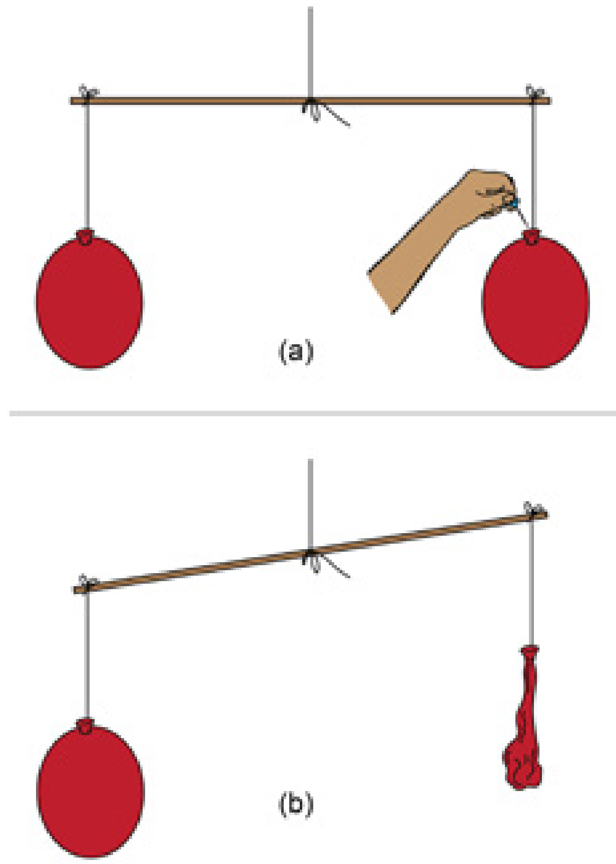

Fig. 1. Demonstrating that air has mass. In panel (a), the stick tied to two near-identical balloons inflated to the same size appears evenly balanced on both sides. In panel (b), one balloon is deflated, and the stick leans slightly towards the end with the inflated balloon.

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Demonstrating that air has mass

Chapter 6 of the Grade VI science textbook introduces the concept of mass through an activity idea (Activity 6.8: Let Us Measure). Students are asked to take three identical cups and fill them with water, sand, and pebbles, respectively. They are invited to predict which of these would be heavier and which lighter. Then, they are asked to test their prediction by weighing the three cups on a balance. This activity idea ends with the following words: *"... we can say that any object which is heavier or lighter can be measured in terms of a property called mass. The one which is heavier has more mass and the one which is lighter has less mass."*[3]

A similar activity can be used to give students visual evidence that air, too, has mass (see the **Activity Sheet**). In this activity, two nearly identical balloons are inflated to similar sizes. Each balloon is tied to one end of a long stick (like a one-metre scale). A string tied to the middle of the stick is used to suspend it from a hook on a wall or a door handle in such a way that it hangs freely. The position of the string on the stick is carefully adjusted to ensure that the stick is balanced (aligned parallel to the ground). Then, a pin is used to deflate one of the balloons. To do this without bursting the balloon, the pin is slowly inserted close to the mouth of the balloon. Once the balloon is fully deflated and the stick becomes steady again, the stick is seen to lean slightly towards the end with the inflated balloon (see **Fig. 1**). Since beam balances are common in their everyday world, students often associate this set-up with one. When asked why the stick leans towards the end with the inflated balloon, they tend to infer that the inflated balloon is heavier than the deflated one. Students know that the balloons are made of identical material and are of nearly similar size. So if asked, *"Why is the inflated balloon heavier?"*, most of them conclude that the difference in the weight of the two balloons is due to the mass of the air trapped in the inflated one. Students can be encouraged to test this conclusion by using a pin to

Box 1. Is the apparent weight of the inflated balloon different from its actual weight?

In comparing the weight of any two objects, like the two balloons in this activity, we are comparing the force that acts on their masses. One of these forces is gravity. The other is exerted by air. All objects on land, including humans, are immersed in atmospheric air. Air, like other fluids, exerts an upward force on objects immersed in it. In Chapter 5 ('Exploring Forces') of the Grade VIII science textbook (NCERT, 2025-2026), students learn that: "*The force applied by a liquid on an object in the upward direction is known as upthrust or buoyant force.*"[5] The magnitude of this buoyant force is equivalent to the weight of the volume of air displaced by the object. In other words,

- Buoyant force acting on an object immersed in air = weight of the volume of air displaced by the object.
- The apparent weight of an object immersed in air = Actual weight of the object – weight of the volume of air displaced by the object.

deflate the second balloon. Seeing the stick return to being parallel to the ground can help confirm to students that the difference in weight seen in the previous step was due to the air in the inflated balloon.

Factors that affect this activity

The air in the inflated balloon gives it more weight than the deflated one. But this also means that the inflated balloon occupies more space than the deflated one. So it displaces more surrounding air than the deflated balloon. Thus, the difference in weight that students can observe (~ apparent weight) between the inflated and deflated balloon is likely to be very small (see **Box 1**). What factors can help us observe this difference more clearly?

- **The density of air inside the inflated balloon:** In Chapter 9 ('The Amazing World of Solutes, Solvents, and Solutions') of the Grade VIII science textbook (NCERT, 2025-2026), students learn that: *"A wooden stick and an iron rod may be of the same size, yet the iron rod feels much heavier. When we say that iron is heavier than wood, we are referring to a special property known as density, which describes the heaviness of an object... Density is defined as the mass present in a unit volume of... [a] substance."*[6] When we use an air pump to 'push' air into a balloon, the air inside it is denser than the air outside it. In other words, there are 'more' air particles inside the balloon than in the same volume of space outside it. This helps ensure that the weight of air inside the inflated balloon is more than the weight of air displaced by it. Therefore, the difference in weight between the inflated and deflated balloons might be more noticeable. What if we were to inflate the balloons by blowing air into them with our mouth? The composition of air in a balloon inflated with a hand pump is the same as that of the air we inhale. But the composition of air in a balloon inflated with our mouth is the same as that of the air

Box 2. Curricular connections:

This activity and discussions around it can help meet the following curricular goals outlined in the NCF-SE (2023) for middle-stage science:

- CG-1: [The student] explores the world of matter and its constituents, properties, and behaviour. Specifically, they can support students in developing the competency to:
    - (C-1.1): *"Classify matter based on observable physical (solid, liquid, gas...) and chemical characteristics."*
    - (C-1.2): "*Describe changes in matter (physical and chemical) and use particulate nature to represent the properties of matter and the changes."*
- CG-6: [The student] explores the nature and processes of science through engaging with the evolution of scientific knowledge and conducting scientific inquiry. Specifically, they can support students in developing the competency (C-6.2) to: *"Formulate questions using scientific terminology (to identify possible causes for an event, patterns, or behaviour of objects) and collect data as evidence (through observation of the natural environment, design of simple experiments, or use of simple scientific instruments)."*
- CG-7: [The student] communicates questions, observations, and conclusions related to science. Specifically, they can support students in developing the competency (C-7.1) to: "*Use scientific vocabulary to communicate science accurately in oral and written form, and through visual representation.*"[7]

we exhale. Since students read about 'Respiration in Humans' in Chapter 9 ('Life Processes in Animals') of the Grade VII science textbook (NCERT, 2025-2026), you could share the fact that exhaled air has more carbon dioxide and water vapour and less oxygen than inhaled air.[8, 9] You could also tell students that oxygen is lighter than carbon dioxide and heavier than water vapour. How will the composition of exhaled air affect the difference in weights between the inflated and deflated balloon? Will this difference still be clearly visible to us? It may be useful to invite students to make predictions and test this. They could also compare the results of this method with those obtained by using balloons inflated with the air pump.

- **The sensitivity of the beam balance:** The beam balance that we use in this activity is made of a metre-long stick and a piece of string. It does not have the strength and stability that students may associate with the more common examples of such balances (like those used to weigh fruits and vegetables) that they see in their everyday world. But it has a remarkable sensitivity that allows detection of the small difference in weights between the two balloons. Based on our observations, a stick shorter than one metre can reduce the sensitivity of the balance. It may be useful to invite students to compare the results of using the balance recommended in the activity sheet against a traditional balance. They could also experiment with the effect that reducing or increasing the length of the stick (or the string used to suspend it or suspend the balloons from it) has on their ability to see a difference in weight between the two balloons.

Parting thoughts

Many observations and experiences of the properties of air in the real world may lead students to believe that it is massless. If not addressed early, this misconception can persist through higher stages and even adulthood. This simple activity that students can do by themselves provides concrete visual evidence that air contributes to the weight of an inflated balloon through its mass. It might also reduce the challenge that students experience in grasping the particulate nature of air (see **Box 2**).

The use of inexpensive and everyday objects (like balloons, sticks, and string) to set up the activity can help students become more resourceful and allow them the freedom to explore these materials in new and creative ways. For example, in their everyday world, students are familiar with beam balances being used to **measure** the absolute mass of objects against a standard mass. However, the model that students construct for themselves in this activity only allows them to **compare** the mass of an inflated balloon with that of a deflated one. On the other hand, students are frequently astonished by the sensitivity with which this model can detect even small differences in weight. Inviting students to try variations in setting up the activity, like using different ways of inflating balloons or using different lengths of sticks, can help them develop their prediction, observation, and experimentation skills. All of these are important science skills.

Key takeaways

- The middle-stage science curriculum introduces students to the particulate nature of matter, its different states, and its properties. Yet, students often show difficulty in relating these concepts to air.
- The idea that air is massless is a widespread student misconception. A simple activity with inexpensive everyday objects like two balloons, a metre-long stick, and some string can offer visual evidence that air has mass.
- Encouraging students to identify and experiment with factors that allow them to see the difference in weights between an inflated and deflated balloon can help them develop more familiarity with related concepts and practice important science skills.

Notes:

(a) Credits for the image (Balloon Floating in the Sky) used in the background of the article title: PickPik. URL: https://www.pickpik.com/balloon-sky-blue-green-fly-helium-70975. License: Royalty Free.

(b) This article includes one detachable classroom resource: **Activity Sheet: Does Air have Mass?**

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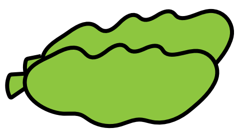
ACTIVITY SHEET: DOES AIR HAVE MASS?

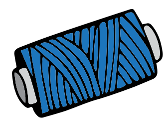
Aim: The air around us feels weightless. Does this mean that it does not have mass?

You will need:

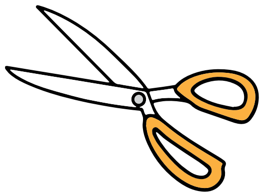


Two party balloons of the same size and material

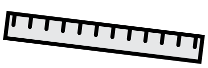
One air pump or a cycle pump (to fill the balloons with air)



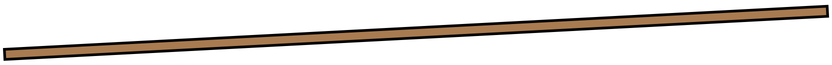
Some sewing thread



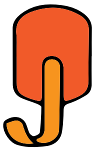
A pair of scissors



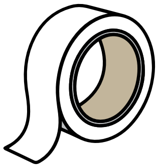
A 12-inch scale



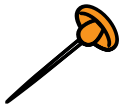
A one metre scale or a long (~at least one metre) stick



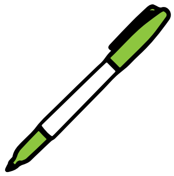
A hook on a wall or a door with a handle



Cello tape



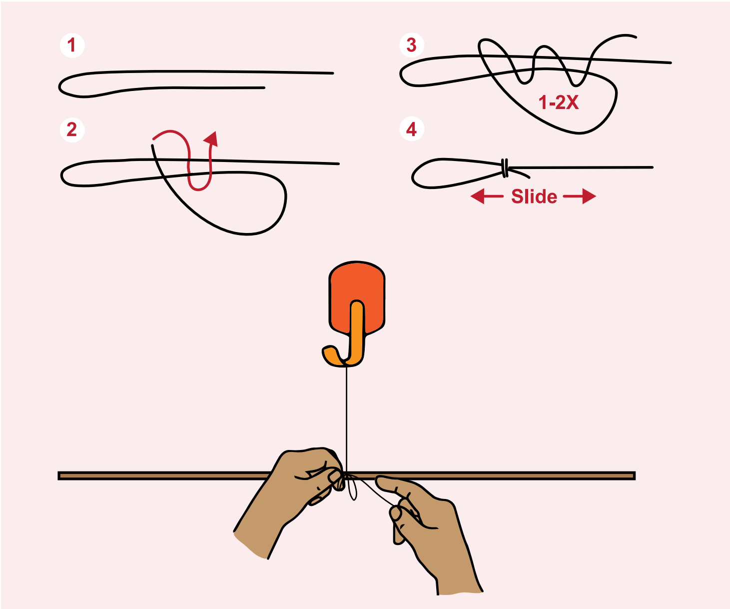
A pin



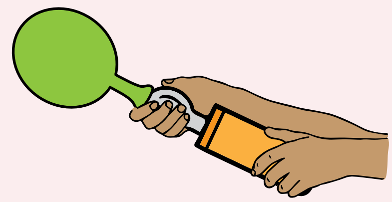
A sketch pen

What to do:

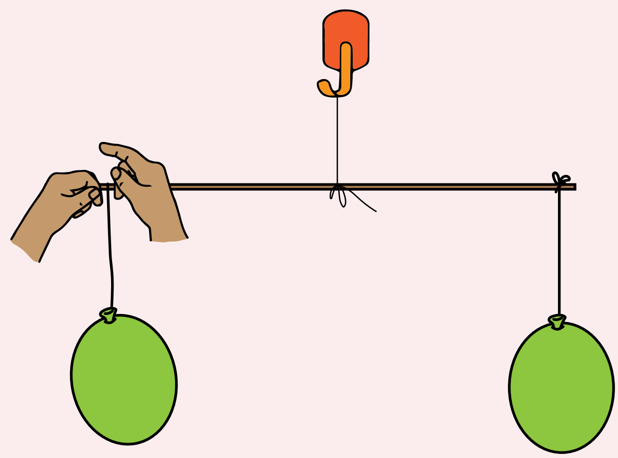
1. Find the midpoint (50 cm from any one end) of the stick (or scale). You could measure this length using a 12-inch scale. Attach one end of a 20-30 cm long piece of thread to the midpoint of the stick with a slip knot (see image). Tie the other end of this thread to a hook on a wall or a door handle so that the stick hangs freely from it.



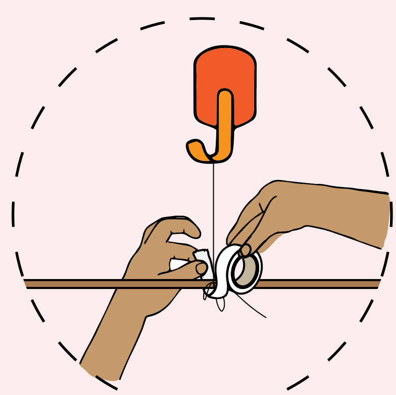
2. Use the air pump to inflate the two balloons to the same size. Close the mouth of each balloon with a knot or a piece of thread. If you need help in doing this, ask a friend.



3. Use the scissors to cut two 30 cm pieces of thread. Again, you could measure the length of the two pieces using the 12-inch scale. Use each piece of thread to attach a balloon to one end of the stick. The two balloons must hang freely from the stick at equal height from the ground.



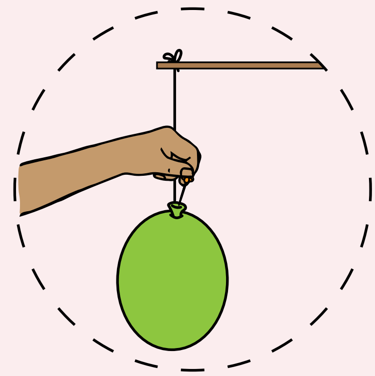
4. Check if the stick is still parallel to the ground. If it looks like it may be leaning to one side, gently adjust the position of the thread at the midpoint of the stick to make it parallel to the ground. Use a piece of cello tape to hold the central thread in its position.



Observe: The position of the stick when the two inflated balloons hang from it.

- Which materials contribute to the weight at the two ends of the stick?
- What do you think will happen if you were to prick one of the balloons? Would the stick remain parallel to the ground? Note down your prediction in the table in the Record section.

- Gently insert the pin near the mouth of one of the balloons. This will allow the air from it to escape slowly. Wait for the balloon to lose all its air and the stick to stop moving. Does the stick return to its previous position? Note down your observation in the table in the Record section.



Record:

	Your prediction	Your observation
What happens to the stick when you prick the balloon?		

Think about and discuss:

- Did you observe any change in the position of the stick after you pricked one of the balloons with a pin? Why (or why not)?
- Imagine you were to use a pin to prick the second balloon too. Would the position of the stick change? Why (or why not)?
- What does this activity tell you about the air inside the balloons?

Explore: Look at the stick and balloon set-up carefully.

1. Have you seen something like this in your everyday life? What is it used for? Discuss this with your friends and write it down.
2. Why do the two balloons in this activity need to be of the same size and material?
3. Why is it important to make sure that the stick is hanging parallel to the ground after fixing the balloons to its ends?

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THE DISAPPEARING VULTURES

RADHA GOPALAN

School textbooks tells students about the interdependence of different components in an ecosystem and the impacts of losing any of them. Can the story of the disappearance of vultures from the Indian subcontinent be used to illustrate these textbook concepts?

In Chapter 12 ('Forests: Our Lifeline') of the Grade VII science textbook (NCERT, 2024-2025), students read how the different living components (plants, animals, and microorganisms) of an ecosystem are interdependent: "*You have learnt how green plants produce food. All animals, whether herbivores or carnivores, depend ultimately on plants for food. Organisms which feed on plants often get eaten by other organisms, and so on. For example, grass is eaten by insects, which in turn, is taken by the frog. The frog is consumed by snakes. This is said to form a food chain: Grass→ insects→ frog→ snake→ eagle. Many food chains can be found in the forest. All food chains are linked. If any food chain is disturbed, it affects other food chains.*"[1] This is emphasized in Chapter 13 ('Our Home: Earth, a Unique Life Sustaining Planet') of the Grade VIII science textbook (NCERT, 2025-2026): *"...if grasses vanish, animals that feed on them, like deer or grasshoppers, struggle to survive. And, without herbivores, predators like tigers or foxes lose their food too. Every type of living thing has a role, and losing even a few weakens nature's ability to support life."*[2] In Chapter 5 ('Conservation of Plants and Animals') of the Grade VIII science textbook (NCERT, 2024-2025), students read that: *"At times, we kill snakes, frogs, lizards, bats, and owls ruthlessly without realising their importance in the ecosystem. By killing them we are harming ourselves. They might be small in size, but their role in the ecosystem cannot be ignored. They form part of food chains and food webs."*[3] One example of these textbook 'facts' can be seen in the case of the disappearing vultures.

The case of the disappearing vultures

What role do vultures play in an ecosystem? In Chapter 12 ('Forests:

Our Lifeline') of the Grade VII science textbook (NCERT, 2024-2025), students read this discussion between two children: *"What happens if an animal dies in the forest?" Sheila asked. Tibu replied: "The dead animals become food for vultures, crows, jackals, and insects." In this way, the nutrients are cycled. So, nothing goes waste in a forest."*[1] Animals that feed on the decaying flesh of dead animals (or carrion) are called scavengers. Among the examples of scavengers listed in the textbook, vultures are the only animals that are known to rely primarily on carrion for food. Because they are apex predators, Chapter 12 ('How Nature Works in Harmony') of the Grade VIII science textbook (NCERT, 2025-2026) groups these big birds and tigers under the category of 'large carnivores'.[4]

At one time, India was home to millions of vultures.[5] It was common to see these birds gathering in large groups, in open fields and near garbage dumps in cities and villages, around the bodies of dead animals (or carcasses), including those of cattle (see **Fig. 1**). Here is how Jamal Ara (India's first 'birdwoman') describes them in 'Watching Birds' (1970), a book she wrote for children: "*With his large heavy body, bald head, and bare scraggy neck, he is not a pretty sight, but he is unrivalled in the perfection of flight. He soars and wheels high up in the air, surveying the world below. With his allies, the kites, he patrols the streets, villages, and burning-ghats, clearing away refuse from garbage dumps and removing dead animals left lying on the ground.*"[6] Yet, it is unlikely that our students may have spotted one of these birds.

This is because vultures started disappearing from our villages and cities a little over 25 years ago. This disappearance was so rapid and severe that it is referred to as a 'collapse'. Vultures became endangered animals in the Indian subcontinent. As described in Chapter 5 of the Grade VIII science textbook (NCERT, 2024-2025), this meant that their numbers had diminished *"... to a level that they might face extinction."*[3]

Villagers first noticed the disappearance of these birds when carcasses of dead cattle began to pile up outside villages. This was concerning because many pathogens proliferate in carcasses. With their sharp beaks, talons, and grooved tongues, vultures are known to be very efficient at disposing dead bodies. A flock of vultures can pick a cattle carcass clean in less than an hour![7] In their absence, the rotting meat attracted rodents and feral dogs. Their numbers increased, increasing the transmission of diseases (like rabies) from these animals to the human population, particularly in villages where there were large numbers of cattle, sheep, goats, and fowl. Farmers started using chemicals to dispose carcasses. Tanks, ponds, and lakes became polluted with the pathogens from animal carcasses as

Fig. 1. **A flock of vultures spotted feeding on a carcass at Chhatarpur, Madhya Pradesh, in January 2016.**

Credits: Arindam Aditya, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:A_flock_of_Vultures_on_carcass.jpg.
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well as the chemicals that farmers used to dispose them.[8, 9] These impacts highlighted the critical role that vultures had played in keeping our communities healthy.

Scientists started investigating the reason for the collapse in the numbers of these birds. But this remained a mystery for close to eight years. Then, as students read in Chapter 2 ('Land, Soil, Water, Natural Vegetation and Wildlife Resources') of the Grade VIII geography textbook (NCERT, 2024-2025), scientists found that: *"Vultures in the Indian subcontinent were dying of kidney failure shortly after scavenging livestock treated with diclofenac, a painkiller that is similar to aspirin or ibuprofen."*[10] Since it was cheap and easily available, diclofenac was widely used by veterinarians (often called animal doctors) to treat cattle across India. When these cattle died, their bodies, like that of other dead animals, would be left at the outskirts of the village or in a garbage dump. If they had been treated with diclofenac anytime in the week before their death, some of this medicine would remain in the carcass. When vultures feasted on them, the medicine entered the bodies of the birds. Even a small amount of diclofenac caused the birds' kidneys to fail.[8, 11]

In 2006, the Government of India banned the manufacture, sale, and use of diclofenac for veterinary use.[12] Slowly, through many conservation efforts across the country, vulture populations have started recovering. Scientists have been monitoring the numbers of these birds. Their estimates suggest that only a few thousand vultures survive today and even their survival is at risk.[12, 13] Why is it taking so long for these birds to recover? After all, some of these birds did survive the collapse. Surely, they would have reproduced over time. You would think 18 years is long enough for these birds to return to their earlier numbers.

Scientists found that the slow recovery of vultures is linked to their breeding cycle. Many kinds of vultures breed only once a year. Like other birds, vultures are oviparous. In Chapter 6 ('Reproduction in Animals') of the Grade VIII science textbook (NCERT, 2024-2025), students read that fish and frogs can lay many eggs at one time while hens lay only one egg at a time.[14] Many kinds of female vultures lay only one egg per breeding season. And it takes 4-5 years for a chick to grow old enough to lay eggs of its own![15] Many eggs and chicks are eaten by predators. So you can see how long it may take for vulture numbers to return to what they were once! Then, just as these numbers seemed to be rising, scientists found six other drugs that are toxic to these birds. All of these medicines are used to treat cattle that have fever or are in pain. Their effect on vultures is similar to diclofenac—traces of each can cause death due to kidney failure.[16] In

Box 1. Curricular connections:

Discussions around this article and related activities (see **Activity Sheet I and II** and the **Teachers' Guide**) can help teachers meet the following curricular goals recommended by the National Curriculum Framework for School Education (NCF-SE) 2023 for:

A. Middle-stage science:

- CG-3: [The student] explores the living world in scientific terms. Specifically, students can develop the competency to:
  - (C-3.1): *"Describe the diversity of living things observed in the natural surroundings (... birds...), including at a smaller scale..."*
  - (C-3.3): *"Analyse patterns of relationships between living organisms and their environments in terms of dependence on and response to each other."*
- CG-5: [The student] understands the interface of science, technology, and society. Specifically, students can develop the competency (C-5.2) to: "*Share views on news and articles related to the impact that Science/Technology and society have on each other."*

B. Preparatory-stage Environmental Studies (EVS):

- CG-2: [The student] understands the interdependence in their environment through observation and experiences, developing the basis for appreciation of the idea of *'Vasudhaiva Kutumbakam'*. Specifically, students can develop the competency to:
  - (C-2.1): *"Identify natural and human made systems that support their lives (water supply... river flow systems... life cycle of plants and animals, food...)."*
  - (C-2.3): *"Connect changes in the environment and the lives of their family and community, as communicated by elders and through local stories..."*
- CG-4: [The student] develops sensitivity towards social and natural environment. Specifically, students can develop the competency (C-4.5) to: *"Identify needs of plants, birds, and animals, and how they can be supported (water, soil, food, care)."*[18]

January this year, the Government of India banned the manufacture, sale, and use of one of these drugs, known as nimesulide, for veterinary use. Also, scientists are developing other cattle medicines that are safer for vultures. These are now being recommended for use in veterinary medicine.[17]

Parting thoughts

Vultures have existed on Earth for almost 15 million years before humans. Yet, their vulnerability to a medicine that humans have developed brought them close to being wiped out from the Indian subcontinent![8, 11] The impact their disappearance had on humans can make us (students and teachers) pause, look around, and think of how closely our lives are intertwined with those of other living beings (see **Box 1**).

Through this story, students may begin to appreciate the importance of this fearsome-looking bird that Chapter 2 of the Grade VIII geography textbook (NCERT, 2024-2025) describes as: *"...a vital cleanser of the environment."*[10] But this story also offers something else for us to think about. It is through the process of science that medicines were developed to treat sick cattle. It is through the same process that we know of seven such medicines, including diclofenac and nimesulide, that can cause the death of vultures. Banning the veterinary use of diclofenac and nimesulide, developing vulture-safe medicines to treat cattle, and protecting these birds through a variety of conservation efforts are our seeds of hope.[19] They allow us to coexist with a new understanding.

Key takeaways

- The case of the disappearing vultures gives preparatory-stage EVS and middle-stage science students the opportunity to understand the interdependence of living organisms.
- Learning about the impacts that the disappearance of these fearsome-looking birds has had on human communities can help middle-stage science students appreciate the critical role that scavengers play in maintaining healthy ecosystems.
- Exploring the cause of the sudden collapse of these bird populations and the reasons for their gradual recovery can help students see the importance of conservation-related textbook concepts in the real world.
- The role of scientists in developing medicines to treat sick cattle, discovering their impacts on vultures, and protecting these birds through conservation efforts allows middle-stage students to examine the role of science in society.

Notes:

(a) Credits for the image (Indian Long-billed Vulture in Flight) used in the background of the article title: Chinmayisk, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Indian_long_billed_vulture_bottom_view_in_flight.jpeg. License: CC BY-SA 3.0 Unported Deed.

(b) This article includes three detachable classroom resources: **Activity Sheet I: Where are the Vultures?**, **Activity Sheet II: Ask about Vultures**, and **Teacher's Guide: Activity Sheets I & II**.

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ACTIVITY SHEET I: WHERE ARE THE VULTURES?

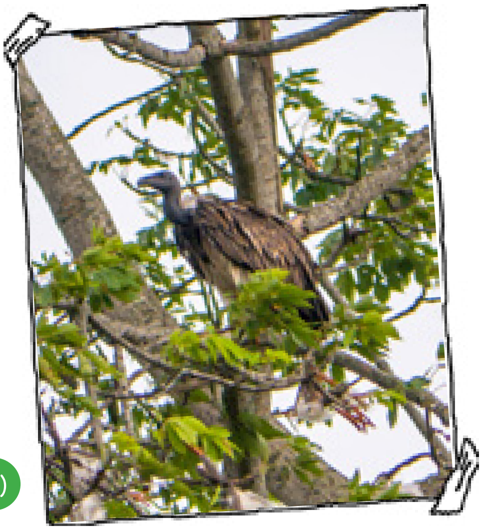
A) Listen carefully to the story 'The Disappearing Vultures.'

- Write down 2 things about vultures that you heard in the story that made you more curious about these birds. Why did these things make you more curious?
- Can you remember **one feeling** you had as you listened to the story? Write it down.
- Is there something you did not understand in the story? Or do you have any questions about the life of vultures that were not answered by the story? If yes, write them down. Discuss them with your friends and in class. If you need help, ask your teacher.

B) There are nine different kinds (species) of vultures found in India. Photographs of three of these kinds that nearly vanished are included below. These are called: (a) Long-billed vulture, (b) Slender-billed vulture, and (c) White-rumped or White-backed vulture. Take a few minutes to look carefully at these photos.

Use the table on the next page to record your observations of the birds in the photos:

(a)



(b)

(c)

	(a)	(b)	(c)
How would you describe the bird's surroundings?			
How would you describe its head and neck? What colour are they?			
What is the shape of the beak? What colour is it? Does it look heavy or light? Is it thick or thin? Is it straight or hooked?			
What is the colour of its eyes?			
Can you see its feet? How are the claws?			
Did you find any other interesting features in the vultures?			
Did you find anything else interesting in the photographs?			
Have you seen any of these vultures in your neighbourhood?			

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Life in your Backyard

ACTIVITY SHEET II: ASK ABOUT VULTURES

A) Talk to your parents, grandparents, and other elders in your community to find out what they can tell you about vultures. Record the details in the table below:

Questions to ask	Your notes
How many kinds of vultures have been seen in your neighbourhood? What are their local names?	
Are there any kinds of vultures in your neighbourhood now? If not, when were these birds last seen?	
What do they remember about these birds? For example, where did they usually see vultures? What have they seen vultures eating? Have they seen any vulture nests? If yes, where have they seen these nests?	
What do they think about these birds? How important do they think vultures are to humans? Can they share any anecdotes about these birds?	
Is there anything else they can share with you about vultures?	

B) If your family or your neighbours rear animals (like cows, buffaloes, sheep, and goats), talk to them about the kinds of medicines that are given to these animals. If possible, also talk to a veterinarian or animal health worker in your area. Record your findings in the table below:

Questions to ask	Your findings
What medicines are used to treat the animals when they have fever or are in pain?	
Have they used the medicine diclofenac to treat the animals? What do they use now?	
How are dead animals disposed in your neighbourhood now?	
How were dead animals disposed 15-20 years ago?	
Has there been any change in the way dead animals are disposed? If so, what was the reason for this change?	

Think about and discuss:

- You heard the story about the disappearing vultures. You also learnt about vultures from your elders. What are some impressions about these birds that you are taking away from this story and your conversations? Try and put all this together in a diagram to show the connections between vultures, what they feed on, why they vanished, and the effect this had on the local environment.
- Some people find vultures scary because of their appearance. Others think of these birds as being dirty because they feed on dead animals. In some cultures, vultures are viewed as being sacred. How are these birds thought of in your community?
- You collected some information about the medicines being used to heal sick animals in your area. Share it with your classmates and write down anything new that you learnt by listening to what your friends share.
- Did you learn something new about vultures from your elders? Or hear anything different from your elders from what you heard in the story? Note it down. Discuss it with your classmates and teacher.
- Do you have any additional questions about these birds? Try and find answers to these questions by talking to your elders or animal health workers or vets. You can also ask your teacher for help.

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Life in your Backyard

TEACHER'S GUIDE: ACTIVITY SHEETS I & II

- Activity sheets I and II are designed for Grade VI-VIII students.
- Each activity can be done over 2-3 days. Some tasks can be done in class. Others need to be done outside class.
- Introduce these activities in class by:

    a) Reading or narrating the story 'The Disappearing Vultures' to your students. Also, encourage students to discuss the story in their communities and think about how interdependent all living beings are on each other and the environment they are part of. This will help them become more deeply aware and sensitive to the vulnerabilities of all beings around them, even those that may appear fearsome. Empathy and compassion will emerge naturally.

    b) You could also show this 22-minute film (entirely or parts of it) 'Vulture Trilogy, Past, Present and Future' (URL: https://www.youtube.com/watch?v=LzgNe9uMgAs&t=49s) in class. This can be done on your mobile phone.

    c) For Activity Sheet I: If possible, show the images of the vultures on a computer screen. If this is not possible, you could print the images, paste them on a piece of cardboard or any other firm surface, and display them in class.

    d) For Activity Sheet II: Share any anecdotes, local cultural practices, or beliefs about vultures that you know of with your students. Remind them to listen with attention to what the elders and others in their community tell them about vultures and carefully record these details in their notebooks. If possible, invite an animal health worker and/or the local vet to the class for a discussion.

Connections to the middle-stage science textbooks:

These activities, and discussions around them, can be connected to the following textbook chapters from the middle-stage science curriculum:

- **Chapter 2 ('Diversity in the Living World') of the Grade VI science textbook (NCERT, Reprint 2024-2025)**: Here, students are introduced to habitats (places where animals and plants live, feed, and shelter). They also learn about how animals have special features (adaptations) that help them live and survive in these habitats. In Activity 10 in the 'Let us enhance our learning' section at the end of the chapter, students are invited to observe the feet of a duck and think about which activity these feet may help ducks perform. Activity Sheet I may allow teachers to extend this to vultures. In the 'Learning Further' section of the same chapter, students are invited to interact with elders in their family or neighbourhood to find out about animals that they saw earlier, but do not see now. Activity Sheet II may allow teachers to extend this to vultures.[1]
- **Chapter 5 ('Conservation of Plants and Animals') of the Grade VIII science textbook (NCERT, 2024-2025)**: Here, students are introduced to concepts related to conservation. This includes the extinction of animals (and plants) due to

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changing conditions (like deforestation due to human activities) in their habitats. The story of 'The Disappearing Vultures' and Activity Sheet II can highlight factors other than deforestation that can endanger the lives of animals. Students also read about how wildlife sanctuaries can help conserve large animals such as tigers, lions, and elephants. Teachers could extend this to discuss why vultures need to be conserved and the role vulture sanctuaries can play in this.[2]

- **Chapter 2 ('The Invisible Living World: Beyond Our Naked Eye') of the Grade VIII science textbook (NCERT, 2025-2026)**: Here, students are introduced to pathogens, the spread of disease, and the role of microorganisms as decomposers and recyclers of dead organic matter in decaying plants and dead animals. Teachers can invite students to compare the roles that vultures and microbes play in decomposition. They can also extend this to discuss the role vultures play in preventing the spread of disease.[3]

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CLASSIFYING
EVERYDAY MATERIALS AS METALS AND NONMETALS

SHIFA KHAN

Students read about the properties of metals and nonmetals in different grades in the preparatory-stage EVS and middle-stage science curricula. Can they apply these textbook facts in classifying everyday materials into these categories?

In Chapter 6 ('Materials Around Us') of the Grade VI science textbook (NCERT, Reprint 2025-2026), students read that all "*objects are made up of various materials*", and that all materials *"... possess different properties that determine their use."*[1] They also learn that materials can be classified based on *"... similarities and differences in their properties."*[1] Students are encouraged to classify materials in their surroundings based on properties like lustre, hardness, and transparency. This is not the first time students read about metals. They are introduced to this class of materials in Chapter 10 ('This World of Things') of the Grade III Environmental Studies (EVS) textbook (NCERT, 2025-2026).[2] An activity idea in this chapter encourages students to identify objects (like hinges, nails, and latches) in their classroom that are made of metals. Metals appear again in Chapter 3 ('Electricity: Circuits and their Components') of the Grade VII science textbook (NCERT, 2025-2026). Here, students read that, "*...metals are conductors of electricity and, thus, are used for making wires.*"[3] But students are formally introduced to the properties of metals and nonmetals in Chapter 4 ('The World of Metals and Nonmetals') of the Grade VII science textbook (NCERT, 2025-2026). Through ideas for a series of hands-on activities, students learn that: *"... metals are generally hard, lustrous, malleable, ductile, and good conductors of heat and electricity."*[4] What do students learn from this introduction?

What do students learn?

I was in a Grade IX science class in a government school. Chapter 2 ('Is Matter Around Us Pure?') of the Grade IX science textbook (NCERT, Reprint 2025-2026) lists properties and examples of metals, nonmetals, and metalloids.[5] Since students are expected to develop the competency to classify materials into these categories in the middle stage, I decided to start a discussion around this theme (see **Box 1**).

I asked the students, "*What are metals?*" Almost all the students raised their hands. Some listed the properties of metals ("*hard*", "*malleable*", "*ductile*", "*good conductors of electricity*"), while others shared examples ("*like gold and silver*"). I saw a piece of marble near the window of the classroom. Pointing to it, I asked: *"Is marble a metal?"* Many students said, "*Yes.*" Curious, I asked, "*Why do you think marble is a metal*?" The students shared this reasoning: "*Marble is hard. Metals are hard. So marble must be a metal.*" I replied, *"Yes, one property of metals is that they are hard. But metals have other properties too. All of you listed these properties. Metals are shiny, malleable, ductile, and good conductors of heat and electricity. Does marble show any of these other properties?"* The students took a few minutes to think about my question. One of them said, "*It will not conduct electricity."* Another said: *"It is not ductile."* A third student said: *"It is shiny."* I asked the rest of the students if they agreed with the last statement. Many of them did. Another student said: *"Marble is malleable."* Surprised, I asked, "*Why do you say that*?" They explained that they had seen houses with marble floors. The marble in these floors were in the form of sheets. The textbook defines malleable materials as materials that can be beaten into sheets. So marble was malleable. Some of the other students shared that they too had seen sheets of marble being used for flooring. One of the students said: *"Marble can conduct heat."* When I asked how they knew this, the student explained that they had observed that marble becomes warm to touch when it is exposed to direct sunlight or kept near a source of heat. Since the students had applied many of the properties of metals listed in their textbook to marble, I asked, *"You have heard what your classmates think. What do you all think? Is marble a metal?"* Most of the class replied that it was.

I posed similar questions to Grade IX students of the other government schools that I visited. They showed a similar understanding. To probe this more deeply, I compiled a list of 15 everyday objects that were made of materials listed as examples of metals or nonmetals in the Grade VI and Grade VII science textbooks. I shared this list with 56 Grade IX students from three government senior secondary schools. The students were asked to sort the materials into one of the following categories: Metal, nonmetal, or neither. To help the students with this exercise, I created a display of some of these objects on the teacher's table (see **Fig. 1**). I also kept an electrical circuit on the table. The students were invited to examine any of the objects in the display or test their electrical conductivity before marking their choices in the sheets provided to them. Once the students had submitted their responses, I read out the name of each object in the list and invited the students to share and justify their answers (see **Table I**).

Box 1. Curricular connections:

Discussions and activities around the classification of materials into metals and nonmetals can help teachers meet the following:

A. Curricular goals for middle-stage science:

- CG-1: Explore the world of matter and its constituents, properties, and behaviour. Specifically, it can help students develop the competency (C-1.1) to: *"Classify matter based on observable physical (solid, liquid, gas... translucent... conducting, non-conducting) and chemical (pure, impure; acid, base; metal, non-metal; element, compound) characteristics."*
- CG-6: Explore the nature and processes of science through engaging with the evolution of scientific knowledge and conducting scientific inquiry. Specifically, it can help students develop the competency (C-6.2) to: *"Formulate questions using scientific terminology... and collect data as evidence (through observation of the natural environment, design of simple experiments, or use of simple scientific instruments)."*[6]

B. Learning objectives for middle-stage students for the chapter on this theme:

- Differentiate between the commonly known materials based on their ability to be bent and formed into sheets, be drawn into wires, ability to produce ringing sound, ability to conduct electricity, and ability to conduct heat in order to define various properties of metals.
- Categorise the commonly known materials as metals and nonmetals in order to explain their physical properties.
- Predict the utility of a given material for a specific task to reinforce the physical and chemical properties of metals and non-metals.[7]

Fig. 1. A display of everyday objects for students to classify. My display had a piece of hard plastic, some sulphur, the graphite rod from a pencil, some coins, a piece of marble, a gold ring, a steel spoon, a piece of brick, a mercury thermometer, and some aluminium foil. Students were invited to observe and handle these objects before classifying the material they were made up of as metals or nonmetals.

Reflections from the exercise

I observed that the students were most confident about classifying materials that they could identify as examples of metals or nonmetals in one of their textbooks. For example, this was the **only** criterion used by those students who classified gold, iron, and mercury as metals. None of these students seemed to use what they could observe of the properties of these materials in their classification. In contrast, the students showed hesitation and reluctance to share their reasoning for classifying materials (like aluminium, mercury, and sulphur) that they could not identify in the real world and, therefore, could not connect to the examples listed in their textbooks. It was in classifying these materials that the students relied on an analysis of their observable properties.

My initial discussions showed that most students could recite all the properties of metals listed in their textbook. But rather than base their classification on an analysis of all of them, the students seemed to prioritize 1-2 of these properties over others. In many cases, the first property they looked for was hardness. Chapter 6 of the Grade VI science textbook (NCERT, Reprint 2025-2026) suggests that students: "*Take a metal key and use it to scratch the surface of a piece of wood, aluminium, stone, iron, candle, chalk, and any other material or object. Can some materials be scratched more easily than others? Materials which can be compressed or scratched easily are soft, while other materials which are difficult to compress or scratch are hard.*"[1] While none of the students tried this exercise, many of them classified the material of the wooden chair, hard plastic, graphite rod, diamond, coins, steel spoon, iron rod, and marble as metals **only** because they were hard. The other property that students looked for was shine. In Chapter 6 of the Grade VI science textbook (NCERT, Reprint 2025-2026), students read that: "*Materials that typically have shiny surfaces are said to have a lustrous appearance. Such materials with lustre are usually metals. Examples of metals include iron, copper, zinc, aluminium, gold, etc.*"[1] For the students, this property was an important criterion in classifying the material of the steel spoon and aluminium under metals and that of wood and plastic as nonmetals. They seemed to infer that if shiny materials were metals, materials that were not shiny were nonmetals. Similarly, the students who classified diamond as a metal based this mainly on the fact that it was shiny and hard. Overall, the properties that students seemed to give the least importance to in this classification were conductivity to electricity and heat. In Chapter 4 of the Grade VII science textbook (NCERT, 2025-2026), students read that: "*Have you ever noticed the sound produced when a metal spoon, or a metal plate, or a metal coin is dropped on the floor? How is it different from the sound produced when a piece of coal or wood is dropped on the floor?*"[4] None of the students mentioned or used this property in their classification.

Most of the students were able to accurately define malleability and ductility. Students who classified mercury under nonmetals and the material of the coins under metals used these two properties as supporting reasons. But many of the students had also classified marble as a metal because of its 'malleability'. This suggests that they may not have seen it break into pieces when beaten with a hammer. Chapter 4 of the Grade VII science textbook (NCERT, 2025-2026) introduces students to this property with an idea for a simple

Objects	Number of student responses				Main reasons for the most common answer
	Metals	Nonmetals	Neither	Blank	
Wooden chair and table	33	23	–	–	Classified as a metal for its hardness. Classified as a nonmetal because it was not shiny, malleable, or ductile. Some students shared that it was a poor conductor of heat and electricity.
Piece of hard plastic	34	22	–	–	Most students classified it as a metal for its hardness. Some of them had seen plastic sheets (malleable) and wires (ductile). Classified as a nonmetal because it was not shiny and was a poor conductor of electricity.
Iron rod	55	–	–	1	Students remembered it being listed as an example of metals in one of their textbooks.
Sulphur	29	24	–	3	Classified as a metal because students examined crystals in the sample in the display and found them shiny and hard as stones. Classified as a nonmetal because it was not very hard, seemed like a poor conductor of heat, and did not look as if it could be made into sheets or wires.
Diamond	45	6	–	5	Classified as a metal because of its hardness and shine. Classified as a nonmetal because it could not be converted into a sheet or a wire. Students did not know if it could conduct heat or electricity.
Graphite rod in pencil	43	12	–	1	Classified as a metal because of its hardness and shine. When used in the electrical circuit, students found that it could conduct electricity. Classified as a nonmetal because it was not hard enough for a metal. Students could chew it. Also, it did not look like it could be used to make wires or sheets.
Coins	55	–	–	1	Classified as a metal because of its hardness and conductivity to heat and electricity. Students used the circuit to check the last of these properties. Also, students had seen wires or sheets prepared from the same/similar material.
Chalk	–	35	11	10	Classified as a nonmetal because it was neither hard nor shiny.
Piece of marble	41	–	–	15	Classified as a metal because of its hardness and shine. Some students thought it was malleable because they had seen (flat) marble floors. Some had observed that it became warmer on heating (conducts heat). Left blank mainly because students were not sure if they should place it under metals or nonmetals.
Gold	55	–	–	1	Students remembered it being mentioned as an example of a metal in one of their textbooks.
Steel spoon	55	–	–	1	Classified as a metal because it was hard, shiny, and could conduct heat and electricity.
Brick	4	22	10	20	Students were not sure where to place it.
Mercury	12	43	–	1	Classified as a nonmetal by a majority because it was not hard and could not be used to make sheets or wires. Some students remembered that textbooks mentioned it as an example of a metal that was not hard.
Green board	2	21	10	23	Students were not sure where to place it.
Aluminium	24	11	–	21	Classified as a metal because of its shine. Some students remembered seeing it used as an example of a metal in one of their textbooks. Classified as a nonmetal or left blank when students were not sure which category it belonged to.

Table I. An analysis of the responses I received from the students. This is compiled from both individual answers to the exercise of classifying everyday objects as metals or nonmetals and the follow-up class discussions.

hands-on activity (see **Fig. 2**). It also tells students how they can use this property to differentiate between metals and nonmetals: "*You must have observed that objects such as a piece of copper, an iron nail, and a piece of aluminium become flat when beaten; whereas other objects or materials behave differently.* ***This property by which materials can be beaten into thin sheets is called malleability****. Most metals possess this property... A piece of coal or a lump of sulphur does not show this behaviour.* **They break**

Fig. 2. Many of the students decided that marble was malleable because they had seen floors made of this material. A simple activity to test the malleability of different materials is described in Chapter 4 of the Grade VII science textbook (NCERT, 2025-2026): "*...place each of the items one by one on any hard surface and beat them with a hammer. What do you think will happen? Do the objects become slightly flattened or do they break into pieces?*"[4] Some of the 56 Grade IX students remembered this activity idea being read aloud to them. It requires materials as readily available as a hammer and a flat surface. Yet, none of the students had seen a demonstration of this activity or tried it for themselves.

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into pieces and are said to be brittle*. On the other hand, wood neither gets flattened into a sheet nor breaks into pieces. Therefore, wood is neither malleable nor brittle.*"[4] I described the activity in the textbook and asked the students if they had used this to test if marble was malleable. While the students remembered that the activity idea had been read aloud to them in class, they had not seen a demonstration or tried it for themselves.

The classification of the graphite rod led to the most debate. Most students had classified it under metals. When I asked why, these students pointed out that it was hard and shiny. The students who had classified it under nonmetals argued that it was not hard enough to be a metal. They recognized that this was the same material that was inside their pencils and knew from experience that it could be chewed. Some students responded by stating that it was a metal because it was shiny and a good conductor of electricity. They had experienced a mild shock when they had tried to insert their pencils into electrical sockets. A couple of other students decided to test its conductivity to electricity. They inserted the rod in the circuit I had kept on the table and found that the bulb glowed. In this case, the students had the opportunity to base their classification on an analysis of multiple properties. This was confusing to many students. Which of these properties must they prioritize? Were there any properties that all metals showed, but nonmetals never showed? On the other hand, carbon is listed as an example of a nonmetal in Chapter 4 of the Grade VII science textbook (NCERT, 2025-2026).[4] Students read that: "*Carbon is essential in everyday life because it is the building block of all life forms. It is a key component of proteins, fats, and carbohydrates, which are necessary for growth and energy.*"[4] But the students did not seem to know that something as common as the graphite rod in their pencils is also composed of carbon.

While the students recognized that the coins and spoon in the display were composed of steel, they placed these under the metal category because of their hardness and shine. Also, the students knew that steel became warm to touch when exposed to heat. They used the circuit to confirm that it could conduct electricity (see **Fig. 3**). Since the coins were flat, the students reasoned that steel was malleable, too. What is interesting is that steel is mentioned in more than one chapter in middle-stage science textbooks and, in at least some of these cases, it is clearly referred to as an alloy of a metal and nonmetal. For example, Chapter 4 of the Grade VII science textbook (NCERT, 2025-2026) tells students that: "*Do you know that ropes made of steel [a mixture*

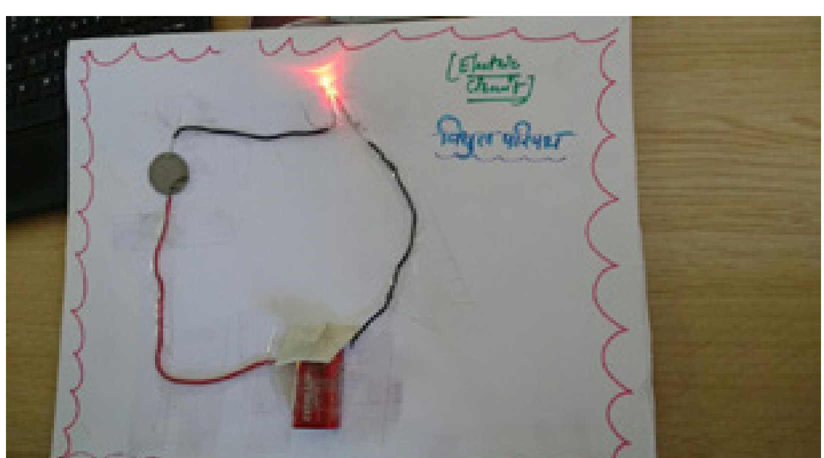

Fig. 3. Students used the circuit I had provided to check if one of the coins in the display was able to conduct electricity.

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Table 3.3

Article	Material with which the article is made of	Does the other end get hot Yes/No
Steel spoon	Metal	Yes

Fig. 4. Students classified the material of a steel spoon as a metal. I noticed that steel spoons appear as examples in different chapters of the middle-stage science textbooks. Some of these mentions, like in the table here, could imply that steel is made of 'a' metal.

Credits: This image is a screenshot of a table shared in Activity 3.7 in Chapter 3 ('Heat') of the Grade VII science textbook (NCERT, 2024-2025).[8] License: Copyrighted by NCERT. Used here for educational purposes.

of metal (iron) and nonmetal (carbon)] wires can support heavy loads? Therefore, they are used in suspension bridges and in cranes to lift heavy objects."[4] If this information on its composition was used to classify the material of the spoon, for example, it would be placed under both metals and nonmetals. Since this was not the case, it is most likely that the students did not remember the composition of steel. It is also possible that some mentions of steel may have been misleading to students. For example, Activity 3.7 in Chapter 3 ('Heat') of the Grade VII science textbook (NCERT, 2024-2025) invites students to: "*Collect some articles such as a steel spoon, plastic scale, pencil, and divider. Dip one end of each of these articles in hot water. Wait for a few minutes. Touch the other end. Enter your observation in Table 3.3.*"[8] Looking at the second column of the table, students may assume that a steel spoon is made up of only 'a' metal (see **Fig. 4**). Similarly, Chapter 10 of the Grade III EVS textbook (NCERT, 2025-2026), includes this 'Note to the Teacher': "*Show the children some common metals around you such as iron, copper, aluminium, gold, silver, mercury in a thermometer; or alloys such as steel, brass, and bronze. Alloys are mixtures of metals.*"[2] This, too, can be confusing to students because, for example, the gold that they commonly see in their everyday world is an alloy. Another possibility is that the students may not have understood the concept of a mixture. Or did not know what properties a mixture of a metal and nonmetal would show. At the time I tried this exercise, students were introduced to this concept in Chapter 2 of the Grade IX science textbook (NCERT, Reprint 2025-2026).[5] This year, students are introduced to it in Chapter 8 ('Nature of Matter: Elements, Compounds, and Mixtures') of the Grade VIII science textbook (NCERT, 2025-2026).[9] This chapter tells them that: "*When* ***two or more substances are mixed, where each substance retains its properties****, it is called a mixture. The individual substances that make up a mixture are called its components. The components of a mixture do not react chemically with each other.*"[9]

The material in six of the objects in the list I had shared with the students are neither metals nor nonmetals: Wood, plastic, chalk, marble, brick, and the green board. Yet, many students had not classified these materials under the 'neither' category. For example, plastic was classified either as a metal or a nonmetal. Some students decided that it was a metal mainly because, "*It was hard*." Other students added that they had seen sheets and wires made of plastic. Therefore, they reasoned, plastic was malleable and ductile, too.

Parting thoughts

One of the goals of the middle-stage science curriculum is to help students develop the ability to classify materials as metals or nonmetals.[6, 7] From my discussions with Grade IX students, it was clear that they were able to answer direct and rote-based questions (like, what are the properties of metals, what is malleability, etc.) accurately. But they struggled to answer questions that were not from their textbooks. Giving them the opportunity to apply the properties they remembered to sort materials in everyday objects into metals and nonmetals revealed important gaps in their understanding of this and related concepts from the middle-stage science curriculum. These gaps may not be visible in formal assessments. Instead, using a simple classroom exercise, like the one I designed, with middle-stage science students may help teachers identify and address such gaps more effectively.

Key takeaways

- Multiple chapters of the preparatory-stage EVS and middle-stage science textbooks describe the properties of metals and nonmetals.
- Students are, often, able to accurately list and define these properties. They are also able to share accurate examples from their textbooks.
- But students may struggle to use memorized textbook facts to classify the material in objects from their everyday world as metals and nonmetals.
- Student responses to a practical classification exercise can help reveal important gaps in their understanding of this and related concepts.

Notes:

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(b) The author used her analysis from the exercise described in this article to design a teaching plan. The editors hope to publish this plan and the author's experience of using it in class in the Dec 2025 issue of i wonder...

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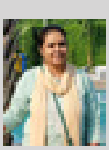

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EXPERIENCING
HOW THINGS WORK

ANSHIKA SHARMA

Children observe many examples of objects spinning, floating, and sinking in their everyday world. What scientific concepts and skills do they learn when given the opportunity to explore these phenomena through hands-on classroom activities?

A 'Note to the Teacher' in Unit 4 of the Grade IV Environmental Studies (EVS) textbook (NCERT, 2025-2026) shares that Chapter 7 ('How Things Work') aims to nurture: *"... student's natural curiosity to try out and observe common phenomena around them, including spinning, floating, and sinking. Through hands-on activities with toys, papers, and other materials used in day-to-day life, they will discover the patterns, and develop a sense of wonder about how things work."*[1] It does this by suggesting a series of simple hands-on activities that are designed to: *"...enable students to observe what happens and how things work in different situations. In this process, they will discover various common patterns, which gives them new learning about the materials. These new discoveries will raise their interest and curiosity in things further..."*[1] Despite the guidance that the textbook offers to teachers, this chapter, like the rest of the EVS curriculum, is frequently taught through rote learning and worksheets that assess textbook recall.

I designed a four-day summer camp around the experiential and child-centric approach recommended by the National Education Policy (NEP) 2020 and the National Curriculum Framework for Foundational Stage (NCF-FS) 2022.[2,3] Thirty-four Grade III-V students from government schools in the Rahatgarh block of Sagar district in Madhya Pradesh participated in the camp. This offered the students a multigrade and multilevel learning environment. What did children learn from my approach?

Which objects spin?

Chapter 7 of the Grade IV EVS textbook (NCERT, 2025-2026) starts with ideas for an investigation into spinning.[4] I started this investigation by asking the students: *"Can you* *name some things that can be made to spin?"* The students were initially quiet. But once I shared examples like that of a bangle, they began to respond with examples like *chakri (wheel),* ball, *kada* (bangle), *lattu* (top), and *chakriwala jhula* (Ferris wheel). I noticed that many students could not name more than one spinning object. Then, I invited the students to explore the classroom and its surroundings and collect objects that they thought could spin. The students brought items like erasers, bangles, tape, and bottle caps. And we spun them. I asked the students to observe the spinning objects. Connecting what they were doing in class with what they had observed outside it, one of the students exclaimed, *"Ma'am, the tape is spinning like a matka (pot)!"*

In the next part of the exercise, I invited the students to design their own spinners using cardboard and toothpicks (see **Box 1**). Once their spinners were ready, I encouraged them to observe what effect spinning had on the different shapes they had chosen for their models (see **Fig. 1**). When an oval-shaped spinner was spun, one student initially described its motion simply as *"ghuma"* (it spun). As they observed it more carefully, they noted that the spinner resembled a fan in motion and that it formed a circular shape while spinning. A circular spinner prompted comments like, *"It is spinning like a ball"* or *"It's like a lattu (top)."* When a square-shaped spinner was spun, the students noted that even though its shape was angular, it still appeared circular while spinning. One of them remarked that they could no longer see the sides of the square, recognising how motion can change our perception of shape. A star-shaped spinner fascinated many students. One student noticed, *"Its centre becomes round when it is spinning fast."* Another student pointed out that they could not count the number of sides this spinner had while it was spinning. A third student remarked that, *"It looks like a fan."* When asked to elaborate, they shared that when it was spinning rapidly, the edges of the star-shaped spinner seemed to blur or disappear like the blades of a ceiling fan moving at high speed.

These spontaneous and thoughtful observations showed that the students were actively processing the physical phenomena in front of them. Their ability to notice motion patterns, compare speeds, and connect classroom experiences with familiar real-world objects (like fans, balls, or tops) is a powerful example of learning driven by curiosity and guided observation.

Box 1. Designing spinners:

While observing different objects spin, one student said, *"Mere bhaiya ke paas lattu hai jo aise hi ghumta hai (My brother has a top that spins exactly like this)."* I asked him, *"What shape is your brother's top?"* He replied, *"Gol (Circular)."* I took out a cardboard piece and a pencil. Together, we drew a circular spinner on a piece of cardboard. Then, I asked the class to suggest other possible shapes. One student said, *"Andakar (Like an egg)."* So, I invited him to come forward and draw an oval shape on the cardboard. Inspired by this, another student added, *"Ma'am, we can make a star-shaped spinner!"* She too came forward and drew a star on the cardboard. In this way, the design process became a one-to-one interaction. My role was limited to offering a simple prompt: *"Observe your surroundings. Think of a different shape. And come forward to draw it on the cardboard."* This open-ended prompt allowed the students to exercise their creativity and observational skills. Some looked around the classroom and drew inspiration from charts, posters, or objects they were familiar with. Others imagined shapes on their own and brought them into the activity. By the end of this exercise, there were many different shapes drawn on the piece of cardboard, including that of a circle, square, rectangle, half-moon, star, cloud, balloon, triangle, and water droplet. I divided the students into pairs in such a way that each Grade V student was paired with a student from Grade III or Grade IV. This pairing allowed the younger students to receive help from the older students. Each pair was assigned the task of cutting out the different shapes from the cardboard. Then, we inserted toothpicks into these shapes and our spinners were ready.

By refraining from giving step-by-step instructions for this activity, I allowed the students to take ownership of the learning process. The activity became not just about making spinners, but about visualizing, initiating, and expressing ideas freely. I made a conscious effort to ensure that every student had the opportunity to participate. Even if a student suggested a shape that had already been drawn, they were encouraged to come forward and draw it themselves. The emphasis was not on the uniqueness of the shapes they came up with, but on ensuring that each child had a hands-on experience and felt included in the design process. Some students chose to make spinners in multiple (2-3) shapes, while others made only one model. Regardless of how many shapes they attempted, every child had at least one opportunity to create a spinner and see their design come to life. This approach helped ensure that the classroom became a space of equal engagement and creative exploration, where every learner's contribution was valued and visible.

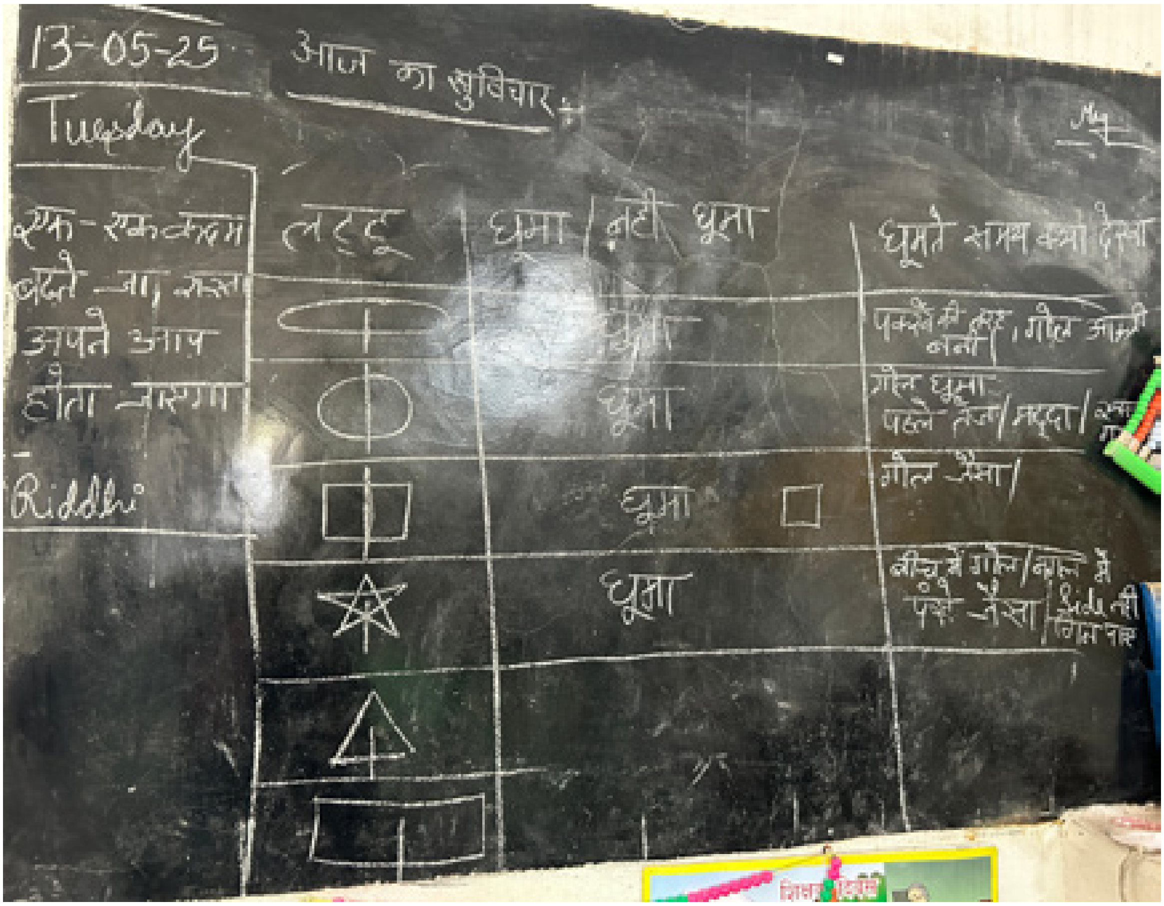

Fig. 1. **A record of the students' initial observations on the differently-shaped spinners they had constructed.**

The students also observed that the motion of their spinners was fast to start with, but gradually slowed down before coming to a stop. One student asked: *"Ma'am why does it fall in the end?"* A Grade IV student made a particularly thoughtful observation: *"It falls in the end because the speed becomes slow. First, it spins very fast, then the speed reduces and, finally, when the speed is almost nothing, it falls."* Connecting this with the *chakka* (tyre) with which children play with in villages, he said, *"As long as we push the tyre, it runs. When the speed of the tyre is almost zero, it falls."* What stood out was not just the accuracy of the observation, but the fact that the student was connecting a hands-on activity to the abstract concept of speed. While this concept is formally introduced to students at a later stage, this student was able to intuitively explain the slowing down of motion using real-world logic. For him to do this without knowing the technical vocabulary associated with speed reflects an emerging ability to reason beyond the surface level. It shows how students, when encouraged to observe closely and explain phenomena in their own words, naturally begin to engage with higher-order concepts—even those that have not yet been taught explicitly. In explaining what they see in ways that make sense to them, they begin to build the foundations for a more complex scientific understanding in the future.

The students also experimented with the position and size of the toothpick, which acted as the axis of rotation for their spinners. For example, a student who had created a star-shaped spinner inserted his toothpick at the edge of one of the star's wings instead of at the centre. When he tried to spin it, the spinner did not rotate properly. It wobbled and fell quickly. He observed: *"The weight of my spinner is not balanced; the toothpick is not in the centre."* On being questioned about his reasoning, the student connected the imbalance of his spinner to a real-life observation, saying: *"It's like when we wear a heel on one foot, but not on the other—we* *cannot walk properly because one side is higher than the other."* He related the side of the star with the toothpick to the heeled shoe in his example, *"This side is heavier."* Like both feet need equal support to maintain balance, he reasoned, the toothpick needed to be inserted at the centre of his spinner. After adjusting the position of the toothpick, the student tried spinning his spinner three more times. Having failed at this, he observed, *"The sides of the spinner are touching the ground, so it is not able to spin properly."* A little later, the same student wondered if the length of the toothpick might be disrupting the balance of the spinner. He asked, *"Can we just reduce the size of the toothpick?"* This showed that the student was beginning to think in a more open-ended, exploratory manner about the relationship between size, symmetry, and movement. This experience demonstrates the value of letting students explore, make mistakes, and reflect on their own experience. It also highlights the importance of inviting students to explain their understanding using language in their own way, as this often leads to richer and more relatable insights than technical terms alone can provide.

Some students tried this activity at home again, and shared their experience in class the next day. For example, a student had created a half-moon-shaped spinner and shared how it had moved when spun, *"When it was spinning, it looked like a knife."* What made this moment especially significant was that the student documented this observation in writing on a piece of paper—an early and self-initiated form of scientific recording. This demonstrates that learning from the classroom need not be limited to a structured activity; it can spark curiosity that continues beyond school hours.

Why do some objects float?

The next part of Chapter 7 of the Grade IV EVS textbook (NCERT, 2025-2026) shares ideas for an investigation into floating and sinking.[4] I started this exercise by asking the students: *"Which objects have you seen float on water and which ones have you seen sink in water?"* The students said that they had seen light objects, like leaves, float and heavy objects, like stones, sink. Then, I gave the students 8-10 minutes to explore the school surroundings and collect any things that they thought were likely to float or sink in water. These objects—leaves, rubber bands, stones, rope, rubber, stick, hairpins—were gathered in one pile. I invited the students to sit in a semicircle to increase visibility and interaction. I listed the objects in the pile on the board. The students were invited to come forward, one by one, choose an object and predict whether it would float or sink and why. As the students expressed their predictions, I recorded them on the board for the entire class to see (see **Fig. 2**). This allowed the class to collectively revisit, reflect on, and revise their thinking. I noticed that even the youngest learners demonstrated curiosity, initiative, and a willingness to participate in this exercise. For example, many Grade III students were actively listening to the logic shared by their older peers. When their turn came, they often tried to respond using similar reasoning. What stood out most was that students at this grade level were not hesitant to respond, even when asked higher-order thinking questions. Although their logic was not always accurate, they made genuine attempts to explain their thinking—an encouraging sign of growing confidence and conceptual engagement. This experience reaffirms that when students, regardless of grade level, are given voice, time, and support in a respectful and inclusive space, they can rise to a challenge.

The first predictions that students made were based on weight alone. For example, one of the students confidently predicted that a stone he had collected, *"will sink."* When asked why, the response was, *"Because it is heavy,"* and *"It is a big stone."* I then asked the student to bring a smaller and lighter stone for comparison. Once both stones were in hand, I asked: *"Will both these stones sink?"* The student examined them carefully and said, *"Yes, both will sink. They are heavy."* We tested the prediction by dropping both stones into water. As expected, both sank, but not before leading to an interesting observation. As the stones entered the water, the students noticed that bubbles formed around them. These bubbles were visible only while the stones were still descending, and disappeared once the stones settled at the bottom of the container. I pointed to a tumbler and asked, *"Will this tumbler float or sink?"* Most of the students felt that it would sink. Their reason was again related to weight. Some of the students felt that it may float. One of the students said, *"If there is water inside the glass, it will sink. If there is no water in the glass, it will float."*

Turning to the students who were confident that the tumbler would sink because of its heaviness, I asked, *"If heavier objects sink, then why does a boat—which is heavy—float on water?"* This sparked a deeper discussion (see **Fig. 3**). One student expressed the idea

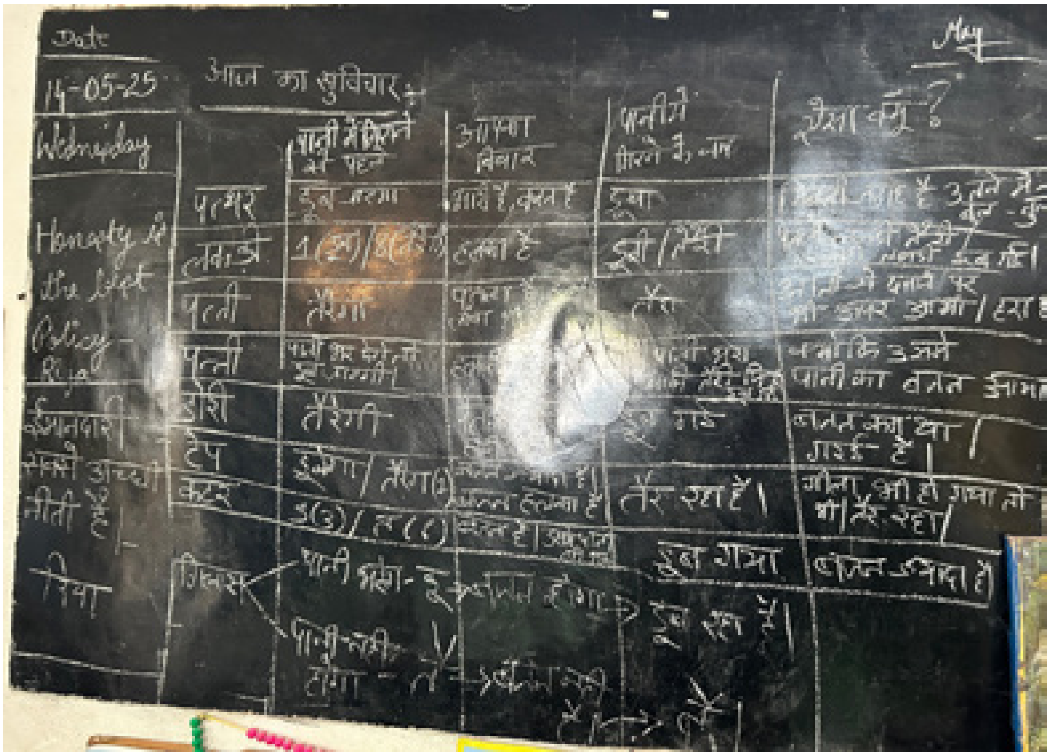

Fig. 2. **A record of the students' predictions on whether the everyday objects they had collected would float or sink in water.**
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that a boat would float because: "*It has wheels.*" Since this did not seem directly relevant to floating, I waited for her to elaborate. The student added that she has seen a boat on television that had wheels on it, and the wheels were helping it cut through the water. I wondered if the student was describing a turbine in action. A second student explained that: *"Pani aage badhta jata hai, isliye nav tairti hai (The boat floats because the water keeps moving forward)."* This explanation shows an attempt to relate the movement of water to the boat's buoyancy. A Grade V student suggested this explanation: *"Pani ka wajan uper le jata hai, isliye nav nahi doobhti (The weight of the water moves it up, that is why the boat does not sink).*" Another student said, *"Hum bhi toh tairte hain na pani mein (We also float on water)."* This discussion allowed students to consider the role of the weight of the water displaced by an object on its tendency to float or sink in this medium. It also encouraged them to think more critically about the factors that influence the floating and sinking properties of objects and explore these concepts more deeply (see **Box 2**).

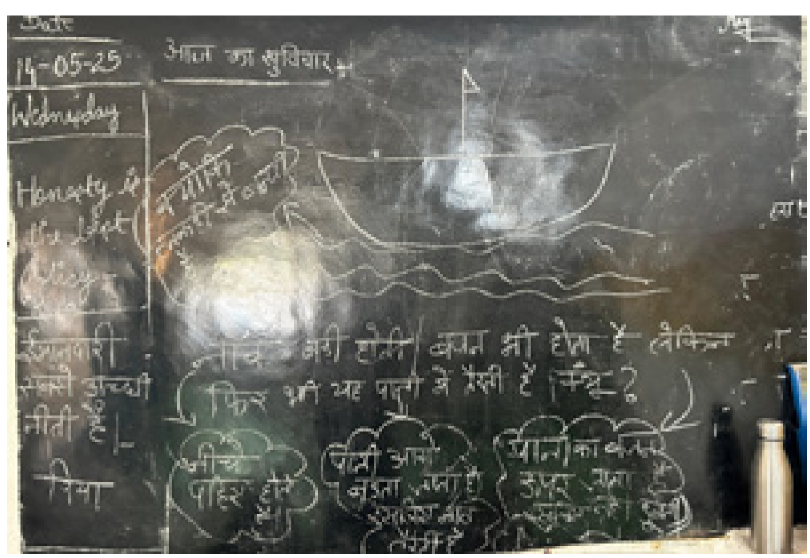

Fig. 3. The students shared three different hypotheses about why boats float on water.
Credits: Anshika Sharma. License: CC BY-NC.

We tested the predictions the students had made by putting each of the objects in water and observing them. One particularly engaging moment involved a *dori* (a thin piece of rope) that the students had collected. Almost every student predicted that it would float in water. When asked why, they replied, *"It is very light,"* and *"It doesn't have any weight."* Some also added that it was *"patli (thin)"*, which reinforced their assumption. However, when the rope was placed in water, it unexpectedly sank. The students were surprised and said, *"Ma'am, we predicted one thing, but something else happened!"* I asked them to think about why this might have occurred. One student observed the rope closely and said, *"It has a wire in it. That is why it sank."* Upon closer inspection, we found that the rope had been coated with a thick layer of black paint, giving it a stiff, wire-like appearance that added to its weight. The student concluded that it was this heavy outer layer that caused it to sink; not the rope itself. To take their learning further, I gave the students an assignment: Search for any rope-like objects they could find in their homes and check if they floated or sank in water. The students came to class the next day excited to share their findings. Some said, *"Ma'am, our rope floated,"* while others said, *"Ours sank."* When I asked about the material of their ropes, one student shared, *"It was jute...bore wali (from*

Box 2. Designing boats that float:

Chapter 7 of the Grade IV EVS textbook (NCERT, 2025-2026) ends with inviting students to design their own models of boats.[4] I asked students to bring any inexpensive materials from home that they could use to design a working model of a boat in the classroom. I gave them some hints and prompts. For example, they were told that they could use items like coconut shells to make a boat. In addition to these, the students brought materials like thermocol, empty bottles, ice cream sticks, and cardboard. I provided basic supplies like Fevicol and scissors. Students were asked to work in groups to design and build floating boats. I grouped them in a way that not only ensured resource-sharing and collaboration, but also helped create an inclusive, cooperative learning environment. For instance, if two students brought similar materials, they were paired together. Older students (Grade V) were paired with younger ones (Grade IV). Students who brought ample materials were paired with those who had limited supplies.

In total, there were 17 pairs of students. The students in each group worked together to build and test their models. They were asked to record the materials and process they used for construction and how they fixed challenges (see **Fig. 4**). One group, for example, documented how they had tried to build a model by sticking two pieces of thermocol together. At first, they tried using Fevicol to do this. But this did not work. So, the students looked around the classroom, searching for other material that they could use for this purpose. They found some toothpicks. But these, too, were not very effective in holding the two pieces together. Finally, they inserted some paper pins, obtained from the headmaster's office, between the two pieces of thermocol. This approach worked, and their thermocol model was successfully completed.

At the end of this exercise, we had 17 different designs. I asked each pair to compare their model with that of another group. They were asked to mention the strengths of both models, ways in which one model was better than the other, and predict if the two models would float or sink in water. One design in particular stood out for me. A student noticed some disposable cups in the classroom and ingeniously joined two of them. She then cut both from the middle to form a boat-like structure. I believe that such creativity might not have emerged if I had followed the more traditional approach of delivering a lecture on the content of the chapter. The learning environment, in this case, played a key role in bringing out this student's ability to think innovatively.

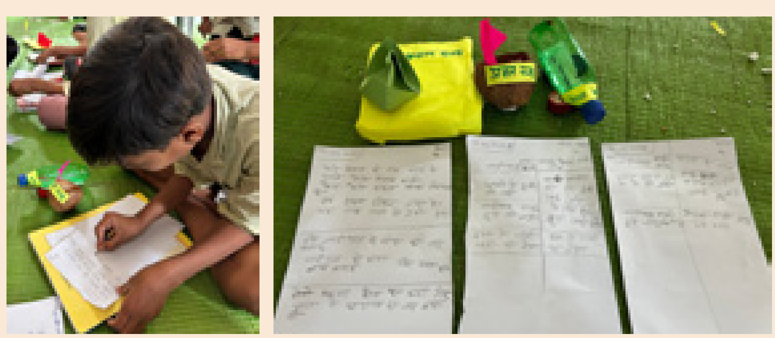

Fig. 4. The students recorded the materials and process they used for constructing their boat models.

a gunny bag)," while another said, *"Hamare ghar mein patli si thi, wo dubi nahi (The one in my house was thin; it did not sink)."* Through this discussion, the class collectively reached an important conclusion: Weight may not be the only factor that decides whether an object floats or sinks in water.

This exercise helped students make assumptions, build logical arguments to support them, test those assumptions, and revise their understanding when necessary. Their misconceptions were gently dismantled through engagement, not lectures.

Parting thoughts

The preparatory-stage EVS curriculum is designed less as a subject and more as a way to connect children to their surroundings. To help them observe, question, and understand their world. Recognising this, many EVS textbooks provide ideas for activities that are aimed at encouraging students to explore their surroundings. For example, Chapter 7 of the Grade IV EVS textbook (NCERT, 2025-2026) invites students to test if everyday objects (like erasers, bangles, and bottle caps) will float or sink in water, and share reasons to support their answers.[4] Doing this activity in class will give students the opportunity to observe and reason for themselves. But many teachers approach EVS as another subject to be memorised and questions related to activities as assessments. So, they may tell their students the 'correct answers' to these questions. For example, a teacher may state, *"The eraser will sink because it is heavy."* Students are then expected to memorise these answers, stripping their engagement with the activity of inquiry and reflection.

Box 3. Curricular connections:

This pedagogical approach can help teachers meet the following:

A. Curricular goals for the foundational stage:

- CG-7: Children make sense of the world around through observation and logical thinking. Specifically, it helps children develop the competency to:
    - (C-7.1): *"Observe and understand different categories of objects and relationships between them."*
    - (C-7.2): *"Observe and understand cause and effect relationships in nature by forming simple hypothesis and use observations to explain their hypothesis."*
    - (C-7.3): *"Use appropriate tools and technology in daily life situations and for learning."*
- CG-8: Children develop mathematical understanding and abilities to recognize the world through quantities, shapes, and measures. Specifically, it helps children develop the competency to:
    - (C-8.1): *"Sort objects into groups and sub-groups based on more than one property."*
    - (C-8.2): *"Identify and extend simple patterns in their surroundings, shapes, and numbers."*
    - (C-8.8): *"Recognise basic geometric shapes and their observable properties."*
    - (C-8.12): *"Develop adequate and appropriate vocabulary for comprehending and expressing concepts and procedures related to quantities, shapes, space, and measurements."*[3]

B. Curricular goals for preparatory-stage EVS:

- CG-1: [The student] explores and engages with the natural and socio-cultural environment in their surroundings. Specifically, it helps students develop the competency to:
    - (C-1.3): *"Ask questions and make predictions about simple patterns... observed in the immediate environment."*
    - (C-1.5): *"Use local materials to create simple objects... on their own for display or use in classroom processes."*
- CG-6: [The student] uses data and information from various sources to investigate questions related to their immediate environment. Specifically, it helps students develop the competency to:
    - (C-6.1): *"Perform simple inquiry related to specific questions independently or in groups."*
- CG-7: [The student] gains foundational familiarity with basic concepts and methods from the natural sciences (life sciences, physical sciences, and earth and space sciences) and engineering. Specifically, it helps students develop the competency to:
    - (C-7.1): *"Gain familiarity with using the scientific method in investigations, as well as familiarity with other crosscutting concepts such as energy, matter, and systems that apply across the domains of science and engineering."*
    - (C-7.2): *"Gain familiarity with disciplinary core ideas in the natural sciences, as well as in engineering, technology, and applications of science, which reflect the content that will be learned across subject areas in later grades."*[5]

The camp that I organized was not a deviation from the curriculum. In fact, all the activities that students worked with were drawn from the Grade IV EVS textbook (NCERT, 2025-2026). What made it different from many EVS classrooms was my pedagogical approach. For example, none of the Grade V students could recall constructing boat models in a classroom setting. The camp offered them the opportunity to do this using household materials. According to the NCF-FS (2022), connecting classroom learning to the child's real-world context enhances comprehension.[3] We saw this in action. Hands-on experiences with everyday materials changed the camp to a living laboratory. Each of the models that the students had designed reflected their capacity for creativity, experimentation, and teamwork. These explorations showed how familiar tactile experiences can unlock students' curiosity.

This experience demonstrates the kind of pedagogy needed in EVS classrooms. By shifting from rote to reflection, from memorisation to making, and from fear to freedom, the classroom can become a space where children's natural curiosity is respected and nurtured. When children are given the freedom to experiment with materials from their surroundings, they began to think beyond the textbook. They build their own logic, test their assumptions, and deepen their understanding through direct experience (see **Box 3**). When teachers act as facilitators—encouraging observation, questioning, and hands-on work—students feel connected to the subject. It becomes their world, not just a chapter to memorise. So, let us move away from telling students, for example, what will float or sink. Instead, let us trust them to find out. Because when children explore, they do not just learn the answer; they learn how to think. Such an approach not only builds scientific thinking, it fosters curiosity, ownership, and joy in learning. Let EVS become a 'subject' that allows a child to learn to love learning.

Key takeaways

- The preparatory-stage EVS curriculum invites students to explore how things spin, float, or sink through ideas for many activities.
- Despite the guidance that the textbook offers to teachers, EVS continues to be taught in many schools through rote learning and worksheets that assess textbook recall.
- Using an experiential, child-led approach to teaching EVS helps students move beyond rote learning to curiosity, questioning, and real-world understanding.
- Allowing students to engage in hands-on activities on spinning, floating, and sinking can help them develop stronger observation and prediction skills.
- Involving students in the collaborative process of designing their own models of spinners and boats can help them build skills in communication, creativity, and teamwork.
- Observing how their models of spinners and boats work can help students develop and express an early understanding of scientific concepts that are formally introduced to them at later stages of schooling.

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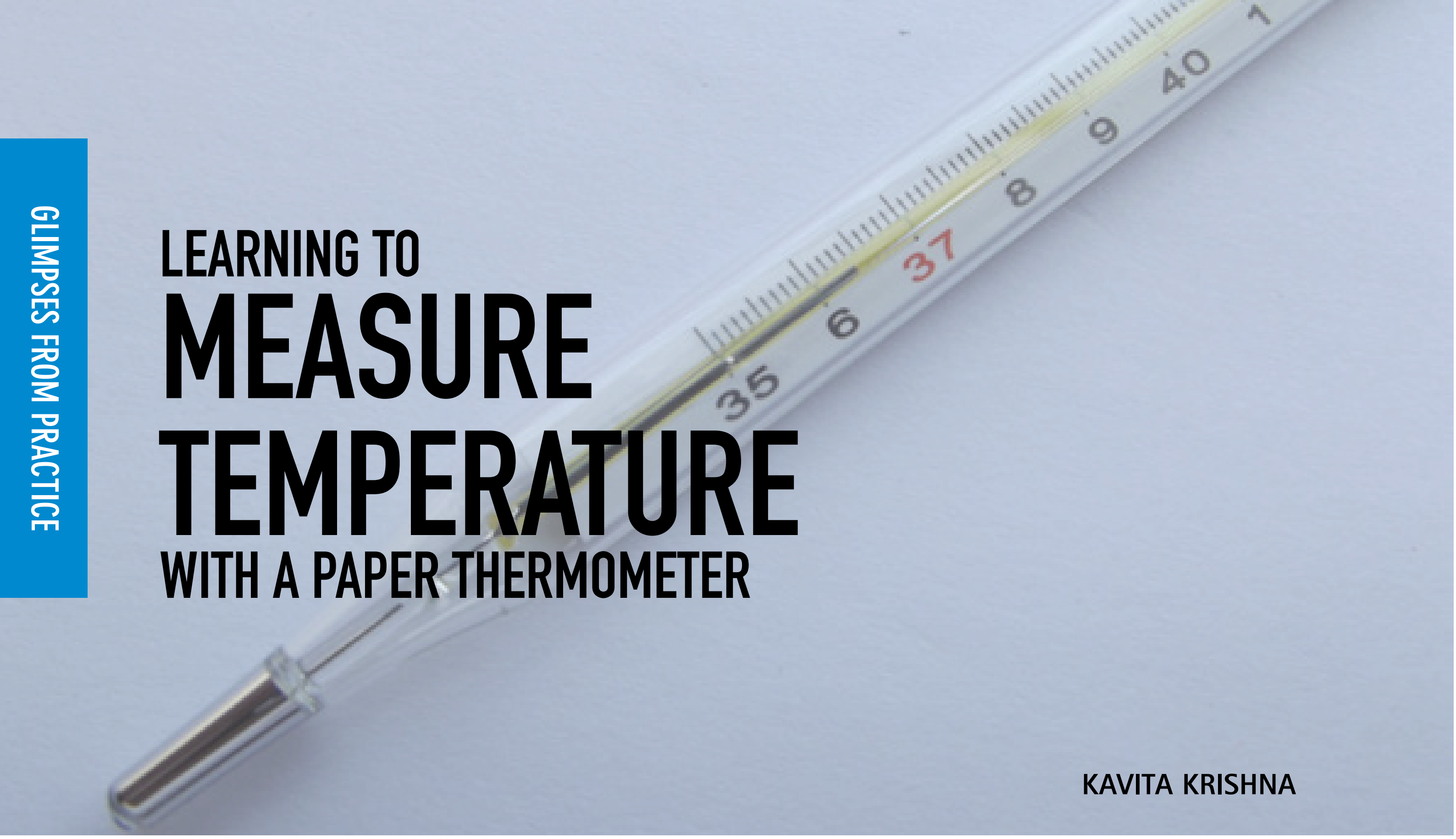

LEARNING TO MEASURE TEMPERATURE WITH A PAPER THERMOMETER

KAVITA KRISHNA

Learning to use a thermometer to make accurate temperature measurements is an important skill for middle-stage science students. How do we use a paper model of a thermometer to help them develop this skill?

Temperature is a word that children tend to be familiar with in their everyday life. In school, they are first introduced to it in Chapter 15 ('Blow Hot, Blow Cold') of the Grade V Environmental Studies (EVS) textbook (NCERT, 2024-2025).[1] At this stage, students may not realize that the sense of touch is not a reliable way to estimate temperature. They may also not be aware that temperature can be measured and used to describe the condition of materials (including the air that surrounds them).[2] But learning to quantify and measure physical quantities, like temperature, with accuracy is a fundamental skill in science. As shared in the National Curriculum Framework for School Education (NCF-SE) 2023, science education in the middle stage needs to provide students with the opportunity to: "*...identify and measure physical properties and determine the mathematical relationship between physical properties...*"[3]

It is in Chapter 7 ('Temperature and its Measurement') of the Grade VI science textbook (NCERT, Reprint 2025-2026) that students are formally introduced to the process of measuring temperature using clinical and laboratory thermometers.[4] While this process may seem straightforward, it involves a complex combination of concepts and skills that develop over years.[5] Research indicates that the principles of measurement are difficult for many students and require more attention in school than is usually given.[6] For example, I have observed that students find it difficult, initially, to identify the liquid column, locate the meniscus (the curved upper surface of the liquid in the glass tube), and read the temperature (see **Fig. 1**). Or, they may struggle with recording the temperature accurately because they are not sure what the smaller subdivisions on the scale represent. They may also report measurements taken on the Celsius scale and Fahrenheit scale interchangeably

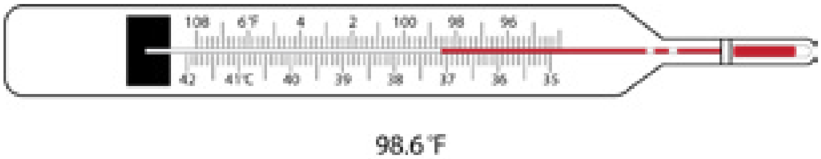

Fig. 1. Reading the temperature in a thermometer. Students may initially find it difficult to identify the liquid column in a thermometer, locate the meniscus (the curved upper surface of the liquid in the glass tube), and read the temperature. Paper models of thermometers can help them practice this skill.

Credits: Adapted for i wonder... from an image shared by Nationwide Children's in the article 'Temperature: Digital and Glass Thermometers'. URL: https://www.nationwidechildrens.org/family-resources-education/health-wellness-and-safety-resources/helping-hands/temperature-digital-and-glass-thermometers. License: CC BY-NC-ND.

because they do not recognise the importance of consistent standard units in measurement.

For these reasons, it may be necessary to ensure that each student is given the opportunity to handle thermometers themselves and practice making accurate measurements with them. But this may not be feasible in some classrooms due to safety and cost considerations. In such cases, a paper model of a thermometer can act as an inexpensive and useful teaching aid.

Using paper models in class

Paper models of thermometers can be used:

(a) For demonstrations: I have found these models very useful in classroom demonstrations. The liquid column in a glass thermometer moves with variations in the surrounding temperature. Also, the meniscus may not be visible to students. In contrast, the reading in a paper model is static. Models can be constructed in different sizes. I use large ones for demonstrations. The markings on these models are clearly visible to students, even those sitting at a distance. Also, paper models can be easily manipulated by the teacher.

(b) For hands-on experiences: Students enjoy making their own paper models (see the **Activity Sheet**). The process of construction is simple and the materials required for it are inexpensive. Working in pairs or small groups, students can practise taking multiple readings of the temperature marking on these models before they handle a glass thermometer (see the **Worksheet**). This can also help them develop more confidence in making temperature measurements (see **Box 1**).

Learning measurement concepts

A paper model of a thermometer can be used to introduce or reinforce the following measurement concepts:

- **Units of measurement:** The units that a thermometer is calibrated in is marked on it. You could use different thermometers (or their photographs) calibrated in Celsius and Fahrenheit units, respectively, to show students how to locate this information. You could also construct paper models with one or the other scale, distribute them among students, and ask them to read out the temperature marked on the model they have picked (see **Fig. 2**). Students will need to be reminded that a measurement is more than a number. The numerical value has no meaning unless the units of measurement have also been noted and recorded. For example, you could ask students whether they would feel hot or cold if the temperature was 40° outside, without mentioning the units of measurement. Students in India, where weather reports

Box 1. Curricular connections:

Activities and discussions around a paper model of a thermometer can help meet the following:

A. Curricular goal for middle stage science: CG-1: [The student] explores the world of matter and its constituents, properties, and behaviour. Specifically, it helps students develop the competency (C-1.3) to: *"Explain the importance of measurement and measure physical properties of matter (such as volume, weight,* ***temperature****, density) in indigenous, non-standard and standard units using simple instruments."*[3]

B. Learning outcomes for:

- Grade VI science: [The student] measures physical quantities and expresses in SI units, e.g., length; and constructs models using materials from surroundings and explains their working...
- Grade VII science: Measures and calculates, e.g., **temperature**; pulse rate; speed of moving objects; time-period of a simple pendulum, etc.[7]

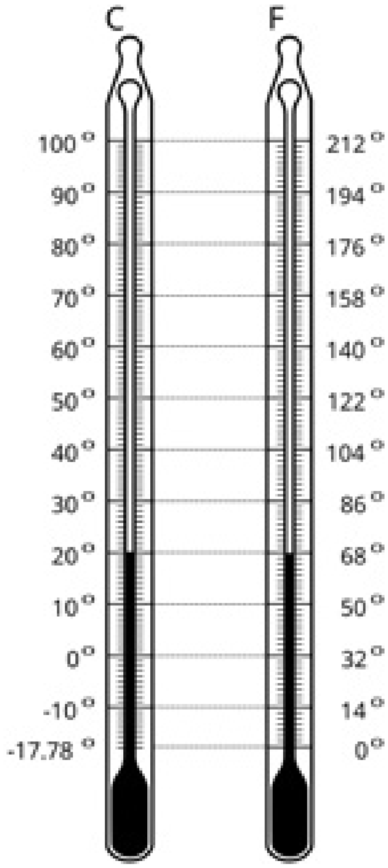

Fig. 2. Comparing temperature readings on a Celsius scale with that on a Fahrenheit scale. You could use thermometers, paper models, or an illustration like this one to show students that while the height of the liquid in the two instruments is the same, it corresponds to different values (20°C versus 68°F) in the two scales.

Credits: TheVovaNik, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:Fahrenheit_Celsius_scales.svg. License: CC BY-SA 4.0 International Deed.

usually use the Celsius scale, are likely to say *"hot"*. You could point out that 40° would be very cold weather if the units of this temperature measurement are in Fahrenheit (since 40°F is equal to 4.4°C), but it would be hot weather if the units are in Celsius. Thus, the phrase *"40 degrees"* is not meaningful unless the units are specified.

- **Range of the thermometer:** This is the span of values for which an instrument is designed to provide accurate and reliable measurements. Students can determine the range of a thermometer or a paper model of it using the steps outlined in Activity 7.3 in Chapter 7 of the Grade VI science textbook (NCERT, Reprint 2025-2026).[4] Knowing the range of different thermometers can help in selecting the right instrument for an application. For example, a clinical mercury thermometer is designed to measure human body temperatures, which remain within a few degrees of 37°C. Therefore, it has a narrow range of 35°C to 42°C. In contrast, a weather thermometer has a larger range of –30°C to 50°C. This is because it is designed to measure atmospheric temperature, which shows much greater variation than the human body temperature. You could create paper models of both kinds of thermometers, invite students to determine their range, and discuss applications where they would be most effective.
- **Least count:** This is the smallest value that can be measured with a thermometer. It is the smallest division on the measuring scale. Students can determine the least count of a thermometer or a paper model of it using the steps outlined in Activity 7.4 in Chapter 7 of the Grade VI science textbook (NCERT, Reprint 2025-2026).[4] This value determines the precision and reliability of the measurements we make with a thermometer. So if the smallest difference between the markings on a thermometer is 1°C (its least count), the value being recorded should be rounded to the nearest degree for a precise scientific measurement. Again, teachers could use paper models with different least counts to give students the opportunity to determine this value by themselves.

Practising measurement skills

Handling a glass thermometer can be very different from handling a paper model of it. But you could use a paper model to introduce students to parallax errors.

Parallax is the apparent displacement of an object against the background when seen from two different perspectives. Here is a quick way to demonstrate the parallax effect to students: Ask them to look around and find an object with a vertical edge (like a window frame). Then, ask students to close their right eye and align their index finger with the edge. Next, without moving their finger, ask them to open their right eye and close their left one. Ask them if their index finger still looks aligned to the edge. The edge will appear to have moved sideways. This is because the position of our right eye is different from our left one.

A parallax error occurs when a measurement is not taken at eye level. The reading can then end up being higher or lower than the actual one. Students are introduced to parallax errors in Chapter 5 ('Measurement of Length and Motion') of the Grade VI science textbook (NCERT, Reprint 2025-2026).[8] You could connect what they learn in this chapter to the process of measuring temperature by asking: "*What do you think is the correct position of the eye while reading the scale on the thermometer?*" Emphasize the fact that students will need to position their eyes correctly to read the temperature scale accurately. Discuss how even small changes in this position can cause parallax errors. To demonstrate this, you could ask students to read a specific marking on the temperature scale of their paper models, while keeping the model at eye level. They could then change the angle at which the model is held in relation to their eyes and read the marking again. Is there a difference in the readings they record? Can they think of a way to reduce this difference?

Moving to a glass thermometer

Once students are able to read the temperature scale on their paper models with accuracy and confidence, they can be given the opportunity to handle and read the temperature on a glass (clinical or laboratory) thermometer. I ensure that the units, range, and least count in the paper model I use for class demonstrations are identical to those in the laboratory thermometer available in the classroom. This makes it easier for students to transfer their learning from a paper model to a glass one. However, students might still need additional support in making this transition, especially with aspects that cannot be practised with a paper model. For example, students may have some difficulty identifying the liquid column in a laboratory thermometer. Teachers may need to demonstrate how to hold and rotate the thermometer from side to side to identify the thread of mercury (or alcohol) in the thin tube. This skill can be developed with practice. Students will also need to:

- Ensure adequate contact between the liquid bulb and the the material whose temperature is being measured.
- Allow time for the liquid column to stop moving before recording a reading.
- Take multiple readings at a time of the temperature of the same material.

Parting thoughts

The ability to think in precise and quantitative ways about physical phenomena is a fundamental skill in the development of scientific thinking. Thus, as students progress through different stages of schooling, their ability to measure and calculate becomes increasingly important in 'doing' science. According to the NCF-SE (2023): "*... from verifying similar properties at earlier stages,... [students] progress to making quantitative predictions and measurements to arrive at theories...*"[3] This includes the ability to select the appropriate instrument for a specific application, handle the instrument correctly, and make accurate measurements using standard units.

Measurement-related concepts and skills are systematically included in different topics in the school curriculum. For example, Chapter 7 of the Grade VI science textbook (NCERT, Reprint 2025-2026) shares ideas for a series of activities that can be used to introduce students to the basic concepts and skills involved in making accurate temperature measurements. A paper model of a thermometer allows students to have hands-on experience of working with some of these concepts and skills. This can help students transition to using a glass thermometer correctly both in the science classroom and in the real world. What students learn through this experience can also provide a sound basis for learning more advanced measurement concepts at higher stages of schooling.

Key takeaways

- Grade VI students are expected to learn to measure temperature using clinical and lab thermometers.
- Making accurate measurements requires a complex combination of concepts and skills that students are expected to develop as they progress through different stages of schooling.
- Involving students in constructing their own inexpensive paper models of thermometers can help them develop the skill to manipulate materials and become more familiar with these instruments.
- Paper models of thermometers also act as useful teaching aids in the science classroom. They can be used to help students develop an understanding of some important measurement concepts and practice some basic measurement-related skills.
- While practicing with a paper model of a thermometer can prepare students to use a glass thermometer more skillfully, they will need support in learning the additional skills needed to make this transition.

Notes:

(a) Credits for the image ('Reading a thermometer') used in the background of the article title: saulhm. URL: https://pixabay.com/photos/thermometer-temperature-instrument-106380/. License: Public Domain.

(b) This article includes two detachable classroom resources: **Activity Sheet: Make Your Own Paper Thermometer Model** and **Worksheet: What Can You Learn From a Paper Thermometer Model?**.

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ACTIVITY SHEET: MAKE YOUR OWN PAPER THERMOMETER MODEL

You will need:

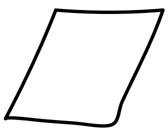
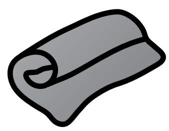
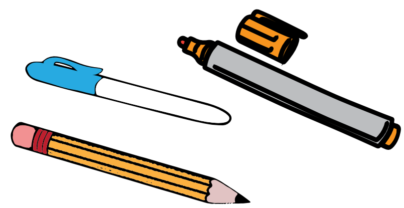


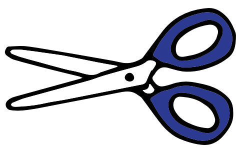
Chart paper or thick card



Some silver coloured paper or aluminum foil



Pencils, sketch pens, or marker pens for writing



Scissors or a craft knife

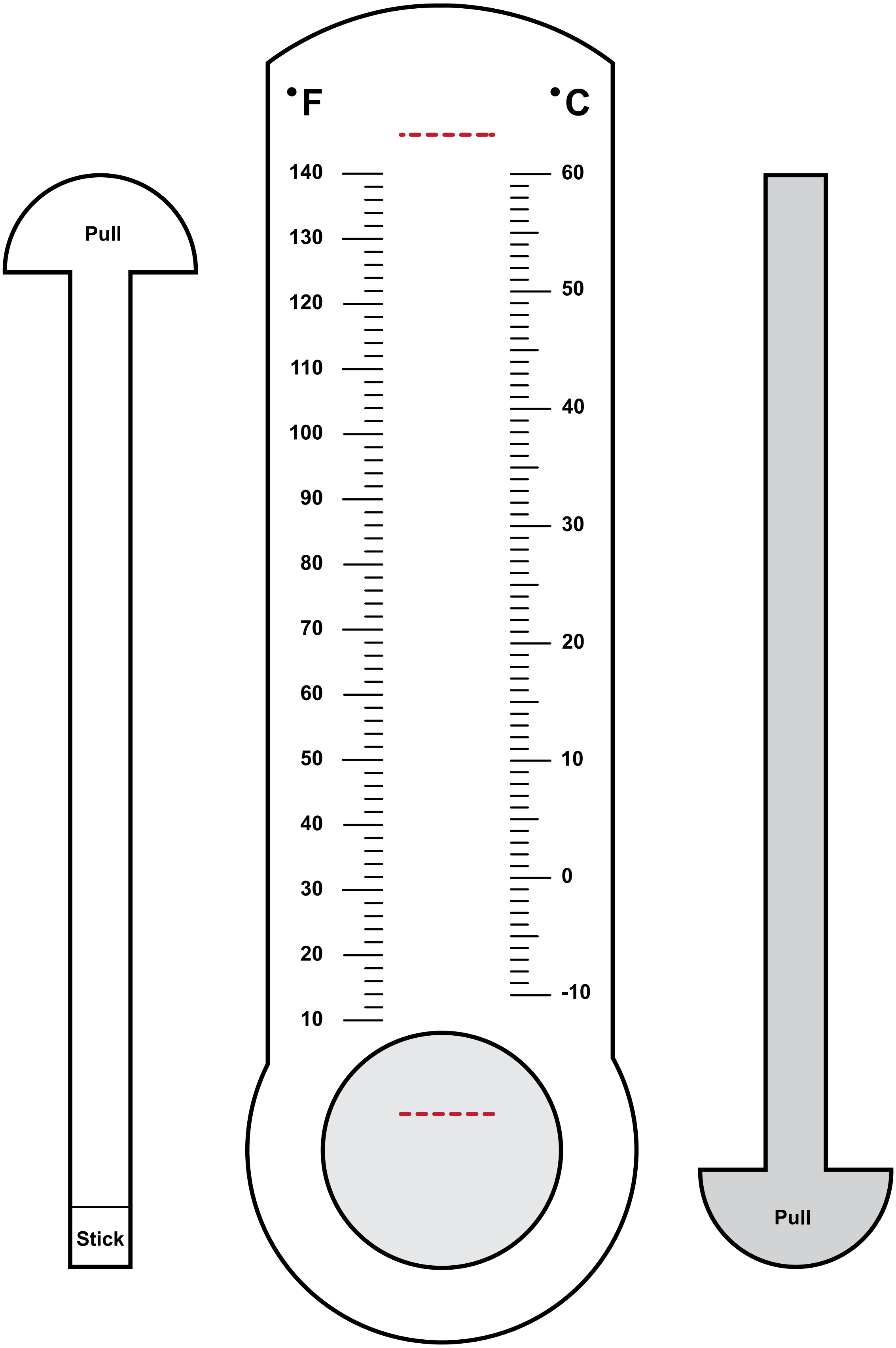
What to do:

1. Copy the drawing of the thermometer on the other side of this sheet onto the chart paper. Make it as big as you want.
2. The drawing has three components: The thermometer and two sliders. Use the scissors or craft knife to cut these components out.
3. The grey slider will act as the mercury column. You can cover it with silver paper or aluminum foil.
4. There are two dashed red lines in the thermometer component. Make cuts along these lines.
5. Insert the flat end of the grey slider piece from the back of the thermometer up into its bottom incision.
6. Insert the flat end of the white slider piece from the back of the thermometer down into its top incision.
7. Glue the tab on the white piece to the grey piece to join them together.
8. Use the pulling handles on the ends of the slider to move the grey bar to mark the temperature.

i wonder... Rediscovering school science

Contributed by:

Kavita Krishna, who has worked for two decades as a Science, Technology, Engineering, and Mathematics (STEM) educator in rural India and the UK. She can be contacted at: kavitak2006@gmail.com.


Pull
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WORKSHEET: WHAT CAN YOU LEARN FROM A PAPER THERMOMETER MODEL?

Aim:

To become familiar with temperature scales on a liquid thermometer by learning how to:

- Find the range of a thermometer.
- Read the thermometer scale correctly.
- Find the smallest temperature difference that can be read on the scale.
- Note the correct units used for the reading.

What you need:

Your paper thermometer model

What to do:

A) Learn about scales of a thermometer: Observe the thermometer. You will see two scales marked on it. Can you name them?

- The scale shown with °F is called the .... scale.
- The scale shown with °C is called the .... scale.

B) Learn about the range of a thermometer: Observe the Celsius scale:

- What is the lowest temperature shown on this scale?
- What is the highest temperature shown on this scale?
- What is the range of this thermometer in degrees Celsius?

Can you find the range of this thermometer in degrees Fahrenheit?

C) Learn about the smallest value that the thermometer can show: On the Celsius scale:

- You will see some evenly spaced bigger marks with numbers. What is the temperature difference between any two consecutive bigger marks?
- You will see many divisions (shown by smaller marks) between any two consecutive bigger marks. How many such divisions can you see?
- How many degrees does each small division show?
- The smallest value that this thermometer can read in degrees Celsius is ....

Can you find the smallest value that this thermometer can read in degrees Fahrenheit?

D) Practice reading the scale:

Some temperatures are given in the table on the next page.

1. Move the thermometer strip to show the given temperature on your paper model. Remember to pay attention to the units and use the appropriate scale.
2. Read the same temperature on the second scale and enter your reading in the table below. Remember to read the scale with your eye directly in line with the mark you are reading.
3. Take turns with your friend. One of you can set the temperature with the strip on the first scale and the other can read the second scale.

	Temperature in °Celsius	Temperature in °Fahrenheit
Average normal temperature of the human body		98.6°F
Normal body temperature for a chicken	41°C	
Temperature of melting ice	0°C	
Maximum temperature in your town/village yesterday		
Normal body temperature for a dog		102°F

Think about and discuss:

1. Can you use a thermometer which has the same range as your paper model to measure the following? Why or why not?
    a. 100 °C, the temperature of boiling water?
    b. 102 °F, the body temperature of a dog?
    c. The temperature at your school on a hot summer day?
2. Set the slider of your paper model at a particular marking on the scale. Then, look at the marking from different positions (above and below the position at which your eye would be directly in line with the mark) and write down your reading. Do you get the same reading? Why or why not?

i wonder...
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GLIMPSES FROM PRACTICE

PERCEIVING SIZE

AVANISH SINGH

Objects can appear to be smaller or bigger than their actual size. What ideas do students hold about actual and apparent sizes? How do we use the outdoors and simple tools to explore these ideas?

Many exploratory and hands-on activities in the preschool curriculum (NCERT, 2020) are designed to help children develop a range of learning skills. These include visual perception skills like size constancy.[1] This skill: *"...involves the ability to perceive and recognise the actual size of an object regardless of factors that may change its apparent size."*[1] One of these factors is distance. The more the distance between us and an object, the smaller the image captured by the retina of the eye is. But, with size constancy, children understand, for example, that the school building is of the same size whether they are close to it or far away. Providing opportunities for children to develop this skill is important in enabling them to accurately observe and compare objects in their surroundings (see **Box 1**).

Perceiving size

I was visiting a small government primary school (with Grades I-V) in a remote village in Hoshangabad district in Madhya Pradesh. While interacting with one of the teachers, I expressed interest in engaging with the Grade V students. He was generous enough to offer me the opportunity. Rather than interact with the students within the confines of the classroom, I invited them to join me in exploring the open school grounds. I often carry a frugal microscope (called Foldscope) with me. Whenever I have the opportunity, I use it with students to discover the unseen in our surroundings—from tiny microorganisms to the cells in plants. To set the stage for such an exploration, I began with some relatable, yet thought-provoking, questions: "*How do things look when they are far away? How do they look when they are close? Have you observed any difference?*"

Since we were gathered under the open sky, I asked the students to consider the stars that shine at night: *"Those stars glittering in*

Box 1. Curricular connections:

Opportunities that allow students to develop size constancy can help meet the following curricular goals for the foundational stage:

- CG-2: Children develop sharpness in sensorial perceptions. Specifically, it helps children develop the competency (C-2.6) to: *"Begin integrating sensorial perceptions to get a holistic awareness of their experiences."*
- CG-7: Children make sense of the world around through observation and logical thinking. Specifically, it helps children develop the competency (C-7.1) to: *"Observe and understand different categories of objects and relationships between them."*
- CG-13: Children develop habits of learning that allow them to engage actively in formal learning environments like a school classroom. Specifically, it helps children develop the competency (C-13.3) to: *"Observe minute details of objects, wonder, and explore using various senses, tinker with objects, ask questions."*[2]

the sky—how large do you think they are?" Some students promptly responded with confident hand gestures, suggesting that the stars were only as small as little balls. Their reasoning was clear: Stars **look** tiny. So, in their minds, they **were** tiny. I was intrigued (and a bit concerned) by this common misconception—the idea that distant objects are small because they 'appear' small to our eyes.

To probe further, I pointed to a tall tree at the far end of the ground and asked, *"Look at the tree there. How tall does it appear to us from here? If you were to walk up to it, would its actual size be the same as it appears from here, or would it be more than that?"* Again, the students asserted that the tree's actual size would be exactly as it appeared to them from this distance. I tried a different example. We were standing near some plants. I pointed to a flower and asked, *"How big is this flower? If I moved this pot to the far end of the ground, would it look smaller or bigger?"* The students expressed the view that the flower would look as big as it looked to them now, irrespective of where the pot was placed.

The problem was clear to me now. The students were conflating the apparent sizes of objects with their actual sizes.

Bridging perception with theory

Chapter 11 ('Sunita in Space') of the Grade V Environmental Studies (EVS) textbook (NCERT, 2024-2025) draws attention to the relationship between distance and size. Two fictional characters, Shahmir and Uzaira, compare the apparent size of the Moon as perceived from the Earth with that of a coin. The textbook invites students to try this activity themselves: *"How many centimetres away from the eye did you keep the coin to hide the moon?"*[3] While the students may have tried this activity in class, it was clear that they had not connected it to their lived experience. I tried thinking of a simple activity to bridge this gap that could be done, right there, on the playground. Looking around, I noticed some grass and plucked a blade of it. Holding it up for the students to see, I asked, *"Can everyone see the blade of grass in my hand?"* The students nodded their yeses. Standing just a few feet away from me, the blade was clearly visible to them. Then, I asked the students to walk **backward**, one step at a time, and to stop

Fig. 1. Experiencing the effect of distance on perception of size. I asked the students, standing in a line, to start walking backward, one step at a time, and stop when they could no longer see the blade of grass in my hands.

Credits: Dinesh Yadav. License: CC BY-NC-ND.

the moment the blade seemed to disappear from their view (see **Fig. 1**). There was a buzz of excitement as the students shuffled backward, eyes fixed on the blade of grass in my hand. One by one, they halted at various distances. Soon, most had reached a point where they could no longer see the blade of grass.

I now moved to the second part of the activity. I asked the students to start walking **forward** slowly, one small step at a time, until the blade came back into sight. They were to stop and call out when it reappeared. They eagerly complied. Soon we had a rough boundary of visibility, with the positions of the students indicating how distance had made the straw vanish from sight. We gathered in a circle to discuss this. I asked: *"Did the blade* ***suddenly*** *blink out of existence at a certain distance? Or did it appear to* ***gradually*** *become smaller and fainter till it was too small to see?"* The students shared that the farther they moved from me, the smaller the blade had looked until, finally, it was no longer visible. This was an aha moment for them. I could almost see the shift in their understanding.

I brought their attention back to the size of distant stars and of the tree at the other end of the ground, *"Are they actually as small as they appear to us from here?"* This time, I saw the students pause. I waited for the experience with the blade of grass to sink in. Some of the students broke into smiles of realisation, but hesitated to state their new understanding. One of the students stretched her hands wide apart to communicate that the actual size of a star was likely to be much bigger than it appeared to be in the night sky. Some of the other students said that the actual size of the tree on the other side of the ground must be more than what it appeared to be from this side of it.

In each of the examples we had explored till this point, the apparent size of the object was smaller than its actual size. To provide some contrast, I introduced them to a magnifying lens and invited them to use it to observe anything that caught their interest. Still sitting in a circle, they started with looking at a single letter on a piece of paper; then, at some pebbles; and, finally, at some crystals of sand. They could see how the magnifying lens made these objects appear much larger than their actual size. At this point, I showed them the Foldscope. Working together, we prepared a paper slide for the sand crystals that had caught their interest. Taking turns to observe the sand crystals through the Foldscope, they were amazed at the amount of detail that was visible to them (see **Fig. 2**). I ended our discussion by encouraging students to use drawing as a way to record how the sand crystals had looked from under the Foldscope.

Parting thoughts

Rabindranath Tagore emphasized the need for education to unfold in harmony with nature, with the child learning through direct engagement with the world.[4, 5] My experience reaffirmed that stepping outside the classroom has the potential to transform not just the scenery, but our pedagogical approach in powerful ways. Under the open sky, traditional roles blurred. I was no longer the sole bearer of knowledge, and the students were no longer passive listeners. Instead, we became co-explorers in the unfolding investigation. This change in environment encouraged the students to participate more freely—they moved around, pointed at objects, and looked more comfortable with asking questions. In essence, stepping outside turned the lesson into a **shared adventure.** A simple shift in setting had made learning feel organic and alive,

Fig. 2. Observing how a microscope (Foldscope) can make an object appear larger than it actually is. Students were amazed at the amount of detail this tool revealed in a sand crystal.

illustrating how a small tweak in our pedagogical approach can greatly boost student engagement. It was a reminder that, sometimes, the most effective 'classroom' is not a room, but the world just beyond its door. Tagore also believed that pedagogical approaches need not emerge from books. They can come as a result of the interplay of observation and experience. For example, the students did not just hear about size and distance; they saw, tested, and **felt** the reality of these concepts through their own inquiry.

Jiddu Krishnamurti saw education as a means to awaken the mind—to free it from fear, conformity, and passive acceptance.[6] Being outdoors offered an experience of freedom that fueled student curiosity. I noticed the students did not wait for me to explain everything; they became active investigators in this exploration. Some of the students tried their own little variations of the blade test, giggling as they waved at a friend to see how far apart they could move before their features were no longer visible to each other. I handed them the magnifying lens after less than half a minute of demonstration. Without much prompting, they started to examine everything from the texture of pebbles to the print of their books, driven purely by their own wonder. The lesson had turned into an open-ended exploration. It was a joy to see students who had held a common misconception until a few minutes ago **chase new questions** on their own. Moments like this affirm that giving learners space to explore lets them ride on their innate curious instincts.

There is enormous potential in children when they are given the chance to discover things for themselves. Their questions become deeper, their observations keener, and their confidence in finding answers grows. By stepping back slightly, I saw them step forward and take charge of their learning. In those few minutes, they were occupied in **creating** knowledge for themselves and each other. By stepping away from structured instruction, the students experienced the joy of questioning, the power of seeing with their own eyes, and the confidence to revise their own assumptions. Their hesitation in reconsidering the size of stars was not just a cognitive shift; it was a glimpse into the deeper process of liberation and acceptance, an act of courage in breaking free from conditioned thinking.

Key takeaways

- The foundational-stage curriculum has many exploratory and hands-on activities that invite children to observe and compare the sizes of different objects in their environment. But children may continue to conflate the apparent sizes of objects with their actual sizes.
- Activities that allow students to make observations of the role of distance in shaping their perception of size can help address this challenge.
- Using the outdoors as a classroom and offering students the opportunity to use simple tools (like a magnifying lens or a frugal microscope) themselves can expand the scope of these observations and foster deeper engagement with learning.

Notes:

(a) Credits for the image (Field with trees in the distance) used in the background of the article title: sarangib. URL: https://pixabay.com/photos/rice-fields-gangavati-karnataka-204128/. License: Public Domain.

(b) The facial features of the children in Fig. 1 and Fig. 2 have been blurred to protect their privacy.

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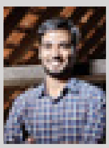

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HOW ARE THUNDER AND LIGHTNING RELATED?

SAURABH DEKA & ANURAG TIWARI

Many students observe that thunder follows lightning. But how are the two related? Can students use the gap between the two to estimate how far they are from a lightning strike?

Chapter 6 ('Pressure, Winds, Storms, and Cyclones') of the Grade VIII science textbook (NCERT, 2025-2026) tells students how lightning and thunder are caused: *"When land gets heated, the warm and moist air, being lighter, rises… As the rising air expands, it cools and moisture in it condenses to form water droplets, creating clouds. Under certain conditions, warm air rises to such great heights that the low temperature there converts water droplets into ice particles… Strong winds blowing upwards and downwards facilitate rubbing between water droplets and ice particles. You have learnt in the chapter 'Exploring Forces' that when two objects are rubbed against each other, they get charged. In this case, strong winds blowing upwards and downwards and rubbing against each other cause static electric charges to develop within the clouds. The positively charged lighter ice particles move upwards and occupy the upper part of the clouds. The negatively charged heavier water droplets occupy the lower part of the clouds. Thus, a charge separation within the cloud takes place. Also, when the negatively charged lower part of the cloud moves closer to the ground, it causes the ground and nearby objects, such as trees or buildings, to become positively charged. Normally, air acts as an electrical insulator and does not let opposite charges meet. But when the build-up of charges becomes very large, the insulating property of air breaks down. A sudden flow of charges takes place, producing a bright flash of light called lightning. Lightning can occur as opposite charges collide within a cloud, between clouds, or between clouds and the ground. Lightning rapidly heats up the air around it, causing the air to expand and produce a loud sound known as thunder."*[1]

But teachers may wonder: How are these facts useful to students in their everyday world? And students often ask questions that are not addressed in the textbook. For example: Why is lightning followed by a big booming sound? Why is thunder sometimes loud and sometimes soft?

A conversation on thunder

Thunderstorms are a common feature during the monsoon season in the hilly regions of Uttarakhand, especially in districts like Tehri and Chamoli, where the weather can change rapidly.

The teacher was in a Grade VIII classroom of a government school in this region. They started a discussion on thunderstorms with a question: *"Have you experienced a thunderstorm recently? What do you remember seeing or hearing?"* Students said that thunderstorms were common in July and August. They had observed flashes of lightning in the sky. This was followed by the sound of loud thunder.

The teacher asked: *"Does the sound of thunder always follow the flash of lightning?"* A student replied: *"Yes! I saw lightning in the sky. It lit up the whole sky. The thunder came a little later."* Other students expressed agreement with this observation. They had always heard thunder after they saw the flash of lightning.

The teacher asked: *"Why does this happen? Why do we not hear thunder while seeing lightning?"* A student replied: *"Maybe lightning happens first. Thunder happens later. So we hear it later."* Another student remarked, *"But isn't thunder the sound of lightning?"* The first student looked up from the open textbook on her desk, *"Here it says that lightning happens first. It heats up the air. The air expands and causes a loud sound."*[1]

Another student asked: *"Why does lightning heat up air? Is lightning hot?"* The teacher replied: *"Lightning is not hot. It is an electric discharge. So it releases a huge amount of energy. Some sources say that it releases so much energy that it can power more than 850,000 homes or a small town for a day."*[2, 3]

One of the students said, *"But the textbook says that air is an insulator. So how does it get heated up?"* The teacher asked, *"Why do we call air an insulator?"* The student replied, *"It is like clay. It will not let heat pass through it."*[4] Another student said, *"No, current will not pass through it."*[5] The teacher replied, *"Air **is** a poor conductor of **both** electricity and heat. Yet, during a lightning strike, a large amount of charge flows through the air in a very small amount of time. How this happens is a mystery. As this charge flows through the air, the air in contact with it gets very hot."*[2, 6]

One of the students asked, *"How hot?"* The teacher replied, *"A single lightning bolt can heat air to a temperature close to 30,000°C!"*[7] The student said, *"How hot is that?"* The teacher was thoughtful for a few minutes. They were thinking of an answer that would be relatable to the student. Then, they asked, *"Do you remember what our normal body temperature is on the Celsius scale?"* The student shook their head. Another student hesitantly said, *"37 degrees?"*[8] The teacher said, *"Correct. So imagine, you have a high fever. Your body temperature is 40°C. Wait. Let me write that on the board."*

The teacher wrote:

> Lightning causes air to heat up to: ~ 30,000°C
>
> Fever causes our body temperature to rise to: 40°C

The teacher asked: *"Can someone tell me how much hotter the air near a lightning bolt is than our body when we have a high fever?"* One of the students said, *"Thousand times more."* The teacher nodded, *"Close. It is actually about 750 times more. Lots of books will tell you that this is also about 5 times hotter than the surface of the Sun."*[7]

One of the students said, *"But hot air does not make sound."* The teacher said, *"You have not seen hot air make sound. Have you seen it change in any other way?"* Many of the students replied: *"It will expand."* The teacher asked, *"How do we know this?"* One of the students said, *"If you keep a balloon in the sun, it will get bigger."*[4] The teacher nodded: *"Like the air in the balloon, the air in contact with the electric discharge of lightning heats up and expands. This happens in a fraction of a second. The particulate matter in hot air collides against that in the surrounding air very quickly and forcefully."*[9] Then, they asked: *"What do you hear when two materials collide against each other with a lot of force?"* The teacher could hear answers like *"loud sound"* and *"bang"*.[10] Smiling, the teacher said, *"Yes, that loud sound is thunder."*

The class was quiet as students thought about this. Then, one of the students asked, *"If things happen so fast, why don't we hear thunder when we see lightning?"* The teacher smiled. *"Good question. Lightning produces light. And light travels incredibly fast—so fast that we see it almost instantly. Thunder is sound, and sound moves much slower."*

The teacher saw that some of the students had not understood. *"Imagine two students traveling from school to the stationary store in the market area. They start off at the same time. One of them is riding a bike. The other walks. Neither stops anywhere on the way. Who do you think will arrive at the stationary store first?"* The class replied, *"The student on the bike!"* The teacher said, *"Yes, light is like the bike. It zips ahead."*

One of the students asked, *"So we see lightning first because light travels faster than sound?"* The teacher confirmed this. *"How much faster?"* another student asked. The teacher replied, "*Light zooms through the sky at about 300,000 kilometres per second. Sound only moves at around 343 meters per second. Let me write this on the board."*

The teacher wrote:

In one second:

Light travels 300,000 kilometres.

Sound travels 0.343 kilometres.

After giving the students a few minutes to look at the two numbers on the board, the teacher asked: *"Can someone tell me how much faster light is than sound? Let us round the speed of sound to 0.300 kilometres in a second."* The class was quiet. Then, a student volunteered to write their answer on the board. They came to the board and wrote: 1000000. Turning to the class, the teacher said, *"So light travels almost a million times faster than sound."*

The teacher changed the conversation. They asked students: *"How do thunderstorms affect us?"* The students spoke of how these storms have damaged electricity lines or disrupted school schedules. Some students confessed that they feel anxious or scared of lightning and thunder. The teacher drew students' attention to these lines in Chapter 6 of their Grade VIII science textbook (2025-2026): *"Lightning can be dangerous! It can ignite fires, damage buildings, and cause severe burns or death in humans and animals. We must take necessary precautions and protect ourselves from lightning."*[1] They waited for the students to read this part of the textbook chapter themselves.

Seeing the students look up from their books, the teacher said, *"Here is the fun part about thunder! All of you have observed a short gap between seeing lightning and hearing thunder. How long is this gap?"* The students shared their guesses. Some said one second. Others said, a few seconds. The teacher waited. Once the students had shared their guesses, they asked, *"Does the length of the gap remain the same during a thunderstorm or does it change?"* Many students said it remained the same.

The teacher said, *"The gap changes based on the distance between the lightning and you. And we can use this gap to figure out how far away lightning is from us."* The students looked at the teacher expectantly.

The teacher turned to the board and wrote:

Speed = Total distance covered/
Total time taken.

Turning back towards the students, the teacher asked: "*Do you remember the formula on the board?"*[11] Some students nodded their heads. Some said yes. Some remained quiet. The teacher explained: *"We know the speed of sound is 0.343 kilometres per second."* The teacher repeated, *"This means that sound travels 0.343 kilometres in 1 second. So if it reaches us a second after we see lightning, how far is the lightning from us?"* Some students said, *"0.343 kilometres."* The teacher replied, *"Correct. Say lightning strikes 1 kilometre away from us. How long would it take for the sound of thunder to reach us?"* The class remained quiet.

The teacher turned to the board and wrote:

The sound of thunder travels:

0.343 kilometres = in 1 second

1.000 kilometre = in ? seconds

One of the students replied, *"1 divided by 0.343."* The teacher replied, *"Correct. This is about 3 seconds."*

They rubbed out the question mark in the last line and replaced it with this number. This is what students could see on the board:

The sound of thunder travels:

0.343 kilometres = in 1 second

1.000 kilometre = in 3 seconds

Turning to the students, the teacher asked: *"If you hear thunder 6 seconds after the flash, how far away has lightning struck?"* Some of the students said 2 kilometres. *"Correct,"* the teacher replied and invited one of them to write this on the board (see **Fig. 1**).

One of the students asked, *"But how will we know how many seconds if we are outside?"* The teacher replied, *"You do not have to be exact. The next time you see a flash of lightning, start counting. One... two... three... This is close to the number of seconds. Some people*

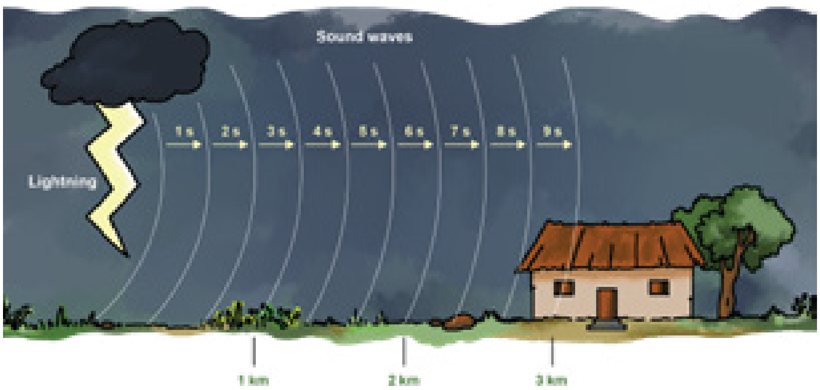

Fig. 1. Estimate your distance from a thunderstorm. Count the seconds between seeing lightning and hearing thunder. Divide by 3 to estimate how far you are (in kilometres) from where lightning strikes.

Credits: Adapted for i wonder... from an image on Science Notes (URL: https://sciencenotes.org/time-between-lightning-and-thunder-how-far-away-is-lightning/). License: CC BY-NC-ND.

suggest counting one hundred and one, one hundred and two, one hundred and three... The idea is that using more words will ensure we do not count too fast. Keep counting until you hear thunder. Then, what do you do?" One of the students replied, *"Divide the number of seconds by 3."* The teacher nodded, *"Yes. This will tell you how far the lightning is from you in kilometres. If the thunder comes just a second or two after the flash, it means the lightning is very close. You should head indoors immediately."*

The teacher ended the discussion by sharing precautions that students needed to take to keep themselves safe during a thunderstorm.

Parting thoughts

This conversation is based on our interactions with Grade VIII students (see **Box 1**). To engage meaningfully in these interactions, students are encouraged to draw on their prior knowledge from many chapters and concepts in the middle-stage science curriculum. These include electricity, temperature, heat transfer, the particulate nature of matter, sound, and linear motion. The exercise to estimate the distance between us and a lightning strike can give students the opportunity to understand and explore the relationship between light and sound (see the **Teacher's Guide**). It also allows students to see the practical relevance of these scientific concepts in

Box 1. Curricular connections:

This classroom conversation and estimation activity can encourage students to:

- Observe natural phenomena and ask scientific questions.
- Apply concepts like speed, motion, and energy to real situations.
- Use estimation and reasoning to make predictions.
- Develop scientific literacy that helps them stay safe and make informed decisions.

It can also help teachers meet the following curricular goals for middle-stage science:

- CG-1: [The student] explores the world of matter and its constituents, properties, and behaviour. Specifically, it can help students develop the competencies to:
    - (C-1.2): *"Describe changes in matter (physical and chemical) and use particulate nature to represent the properties of matter and the changes".*
    - (C-1.4): *"Observe and explain the phenomena caused due to the differences in pressure, temperature, and density."*
- CG-2: [The student] explores the physical world in scientific and mathematical terms. Specifically, it can help students develop the competency (C-2.1) to: *"Describe one-dimensional motion (uniform, nonuniform, horizontal, vertical) using physical measurements (position, speed, and changes in speed) through mathematical and diagrammatic representations."*
- CG-6: [The student] explores the nature and processes of science through engaging with the evolution of scientific knowledge and conducting scientific inquiry. Specifically, it can help students develop the competency (C-6.2) to: *"Formulate questions using scientific terminology (to identify possible causes for an event, patterns, or behaviour of objects) and collect data as evidence (through observation of the natural environment, design of simple experiments, or use of simple scientific instruments)."*[12]

They can also help meet the following learning outcomes for middle-stage science:

- [The student] relates processes and phenomena with causes...
- [The student] applies learning of scientific concepts in day-to-day life, like...taking measures during and after disasters.
- [The learner] explains processes and phenomenon, like production and propagation of sound...[13, 14]

ensuring their safety. This can be particularly useful in regions where thunderstorms are a seasonal reality.

Our conversations on this theme have happened on sunny days. So while students were curious, we could not try this exercise out practically. Our students assured us that they would try this exercise during the next thunderstorm. On our next visit, some students shared their observations of how long the gap between lightning and thunder was. A few of them also shared their estimates of the distance between them and the lightning strikes. If students struggle with this estimation, teachers can simulate this experience with audiovisual (AV) aids. We are yet to try this ourselves.

Key takeaways

- Students observe that thunder follows lightning. The Grade VIII science textbook tells students what we know about how lightning is caused. But their questions about thunder and its relationship with lightning may remain unaddressed.
- Discussions on how thunder is produced and why we hear it after we see lightning can be used to connect students' real-world observations and experiences with concepts on electricity, temperature, heat transfer, the particulate nature of matter, sound, and linear motion.
- An exercise on using the sound of thunder to estimate how far we are from a lightning strike equips students with knowledge that can help keep them safe during a thunderstorm.

Notes:

(a) Credits for the image (Big Lightning Strike) used in the background of the article title: Sunilvirus, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Big_Lightning_Strike.jpg. License: CC BY-SA 4.0 International Deed.

(b) This article includes one detachable classroom resource: **Teacher's Guide: Visualising Sound and Light as Waves and Comparing their Speeds.**

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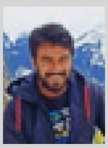

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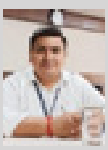

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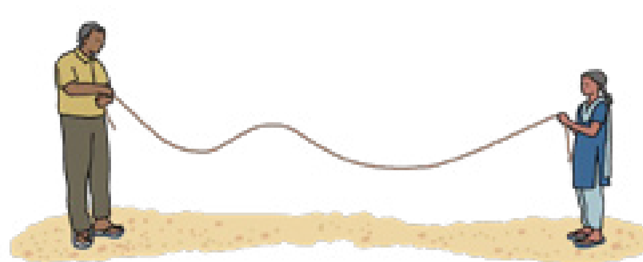
Ask a Question

TEACHER'S GUIDE: VISUALISING SOUND AND LIGHT AS WAVES AND COMPARING THEIR SPEEDS

Lightning and thunder evoke strong feelings, such as fear, awe, excitement, and mystery. Students are inherently curious about natural phenomena that are so dramatic. They also have many questions about how these two are related. Saurabh Deka and Anurag Tiwari explore this question in their article titled 'How are thunder and lightning related?'. In this article, they share how the sound of thunder can be used to estimate the distance of a lightning strike from our location. Students might understand this better if we help them:

(A) Visualise sound and light as waves:

- **Discussion:** We could start by asking students what they see when they throw a pebble into a pond or some other water body. Calling upon a few students to share their experiences, we could use the board to record some short phrases and terms that capture the essence of their observations. It is likely that students would have observed how the pebble produces waves or ripples on the surface of water. Draw the class's attention to the observation that while these waves are created at the point where the pebble hits the water surface, they spread outwards in all directions in a circular pattern. Reiterate that waves travel away from their source.



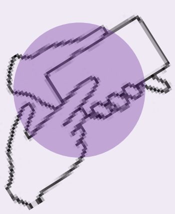
- **Demonstration:** To show that waves can travel at different speeds, take two very long ropes that can go from one end of the classroom to the other. If this is difficult to do indoors, it could be done on a field or playground. Ask a student to hold one end of the rope. Keeping the other end loose enough to sag a little, move it up and down once to create a wave that travels to the student's end of the rope. Repeat this, but start with keeping the rope tauter. Students will see that the wave that is created in the second case travels distinctly faster than that in the first case. Restate that a wave travels away from the place where it is created and that waves can have different speeds. **Tip:** If two such ropes are available, they can be held parallel to each other. One of them can be held more tautly than the other. A wave can be set up in both ropes simultaneously. This might make it easier to notice the difference in the speeds of the two waves.

TEACHER'S GUIDE

- **Summing up:** We could start by stating that both sound and light are waves, even though we cannot see these waves the way we can see waves on the surface of water or those created by moving a rope up and down. **Tips:** (a) Although light has properties of waves as well as particles, its wave nature is more prominent in our everyday experiences. Phenomena such as refraction, diffraction, and interference of light are properties of waves. The particle nature of light is seen only in very specific situations. So it need not be included in this discussion. (b) Sound is a different kind of wave than light. Students will learn about this difference in higher grades. Teachers interested in exploring it may find this module on sound (URL: https://clixplatform.tiss.edu/sound/course/content/) helpful.

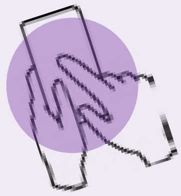
(B) Compare the speeds of light and sound:

- **Discussion:** We could start by telling students that light waves travel at a much higher speed than sound waves. For this reason, when light and sound waves are created in a lightning strike, we see the lightning before we hear the thundering sound. We could ask students if they can recall other such experiences from their everyday life. If they need prompts, we could ask, for example, if they have seen a firecracker go off (in the air or on the ground) from afar. Do we hear its sound at the same time as we see its light and smoke? Or, we could ask if they have seen an electrical transformer blow up at a distance. Do we not see the sparks and smoke first and hear the sound only later? Tell students that people have worked on estimating and measuring the speeds of sound and light since the past three to four centuries. They have found that the speed of light is extremely huge (3 lakh kilometres per second) as compared to the speed of sound (340 metres, or one third of a kilometre per second). Taking a ratio, we see that the speed of light is approximately 9 lakh times the speed of sound.
- **Demonstration:** The speed of light is difficult to visualise given its extremely large value. In comparison, the speed of sound is a much smaller value, although 340 meters per second happens to be quite large compared to our everyday speeds of walking, running, or even traveling in a

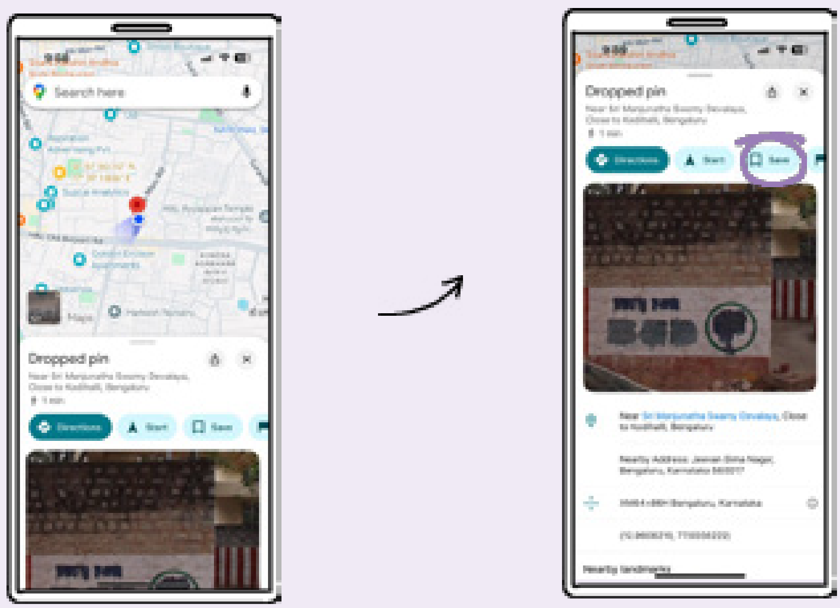


Exercise: Walking a Distance of 340 meters

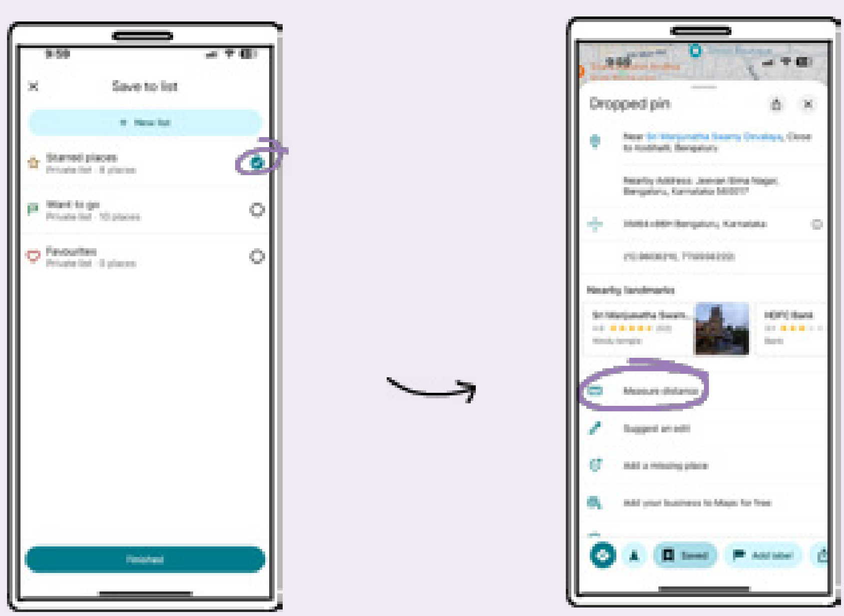
Turn on 'Location' on your phone and open the Google Maps app.



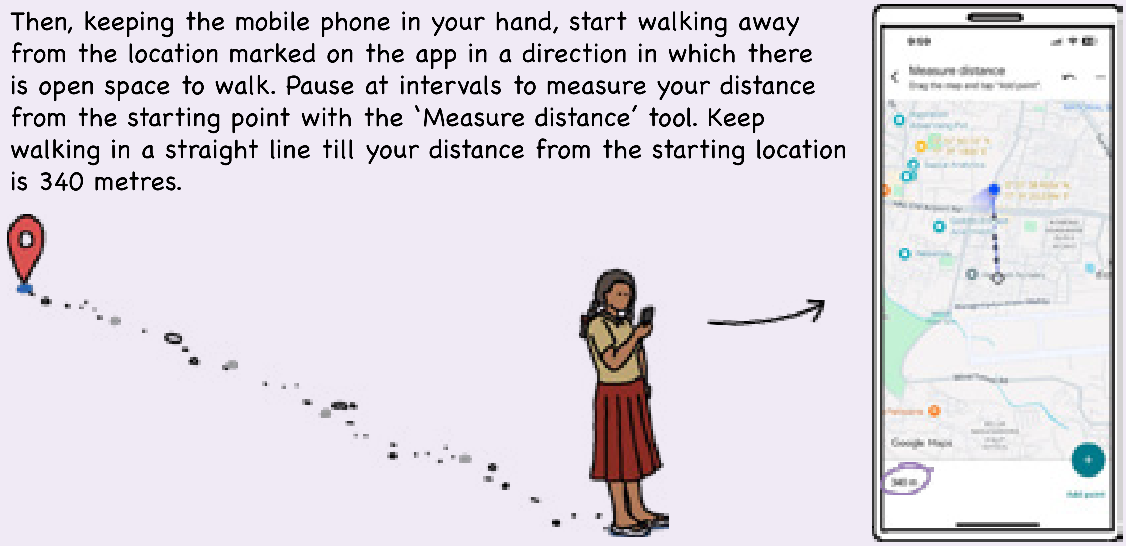
Press down with a finger on the screen on your current location for one to two seconds. A red icon will show up on the map that will be labelled as 'Dropped Pin'.



Click on 'Save' and select 'Starred places'. Now, scroll down and select the option to 'Measure distance'. Show the screen to students.



Then, keeping the mobile phone in your hand, start walking away from the location marked on the app in a direction in which there is open space to walk. Pause at intervals to measure your distance from the starting point with the 'Measure distance' tool. Keep walking in a straight line till your distance from the starting location is 340 metres.



vehicle. To help students get a tangible sense of the speed of sound, take them to a large open area like a field or playground. Use a stick or stone to mark your location. Then, walk 340 metres away from this location with your students (using the **exercise illustrated above** to measure this distance). Tell students to look back at the place where you started from and visualise that sound would take one second to travel to your current location. To help students appreciate the length of a second, you could ask them to look at the second hand of a watch or a mobile stopwatch and count out loud the number of seconds. If possible, you could ask students to remain at the current location, while you walk back to the starting position to light a firecracker. Ask students to observe the time lag between seeing the flash or smoke of the bursting firecracker and hearing the sound it makes. This should be about one second. At this point, it will be useful to remind students about the main idea from Saurabh and Anurag's article: If we hear thunder one second after seeing the lightning, it has struck a place 340 metres from us. If we hear it after two seconds, its distance from us is two times 340 metres, and so on.

- **Thought exercise:** We can make use of the idea of scaling. Remind students of the idea of scale in a map: We represent large distances in the real world with proportionate and smaller lengths on a map. Ask students to imagine a map with a scale of 1 millimetre corresponding to 1 kilometre. Here are two ways you could help students get a tangible sense of the distance sound travels in a second: (a) Give students a piece of card paper or a postcard. Ask them to consider the thickness of the paper. This is around 0.3 to 0.4 millimetres or 1/3rd of a millimetre. (b) You could ask students to look at the smallest marking on a scale (= 1 millimetre) and imagine making three equal pieces of it. What length would be covered by any one of these pieces? If we were to represent the distance that sound travels in a second on our map, it would equal the thickness of card paper or the length of one of the three pieces. Give students time to appreciate the smallness of this length. Then, tell them that on a map drawn with the same scale, the distance that light would travel in one second is about 300 metres. Ask them to think about how much more that distance is than that covered in the same amount of time by sound. Can they imagine how much bigger the map would have to be to mark the distance light travels in a second on it? Another way to express the difference in speeds could be to say that light travels 3/4th of the distance to the Moon in one second. The distance to the Moon is around 4 lakh kilometres. So, for all practical purposes, the light from a lightning strike reaches us in a really tiny amount of time. This amount is so tiny that it can be thought of as negligible.

i wonder... Rediscovering school science

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KAPILA BAIDEU:

HEARING STUDENT QUESTIONS

DEEPAK RAJPUT

On September 14, 2022, I watched the i wonder... webinar titled 'Asking Questions in Science'.[1] This webinar featured a conversation between Madhav Kelkar (from Eklavya, Bhopal) and Saurav Shome (from Azim Premji Foundation). Madhav Kelkar shared how the Eklavya team had created a fictional character called 'Sawaliram' to invite children to share any science questions that sparked their curiosity. It worked. Children from many different schools sent their questions on postcards addressed to Sawaliram. The Eklavya team sent back responses as handwritten letters signed by Sawaliram.[2] It was a beautiful idea, reflecting the value of both curiosity and the intimacy of handwritten communication. Inspired by this, I wondered, *"Why not try something like this in our school?"*

Inviting questions from students

Hummingbird School, located in the Majuli district of Assam, primarily serves children from the Mishing community on the island. We have always tried to nurture a culture of questioning and exploration in the school. Inspired by Sawaliram, we formally launched an initiative to invite questions from our students in 2023. Students were introduced to a fictional character called Kapila Baideu. This name was chosen with care. 'Kapila' means 'why' in the Mishing tribal language, and 'Baideu' means 'elder sister' in Assamese. Put together, 'Kapila Baideu' loosely translates to 'Why Didi'. The hope is that students think of her as a caring and inquisitive elder sister who will listen to and respond to their questions with thoughtfulness and depth. Knowing students would be curious about Kapila Baideu's life, we created a backstory. Belonging to a fictional country called Rationalia, she teaches at the University of Peace in the Department of Humanities. A polymath by nature, she seems to know a great deal about everything—be it science, society, or emotions. To receive our students' questions, we designed a special 'Kapila Baideu box' that is styled to look like a traditional letter box (see **Fig. 1**).

From the beginning, this initiative has thrived. Our students eagerly drop their questions into the box, and we are often joyfully overwhelmed by their volume and depth. A small group of 4-5 teachers, including me, works diligently to respond to each question. We try to send a response within 15 days of receiving it. Students get impatient with delays. The process of responding to these questions is deeply collaborative. Every question we receive is entered into a spreadsheet that is visible to

Fig. 1. The Kapila Baideu box. Students drop their questions into this box, specially designed to look like a traditional letter box.

Credits: Deepak Rajput. License: CC BY-NC-ND.

all members of the team. Teachers sign up to respond to questions that speak to them. We also read each other's drafts and offer suggestions. As a team, we often rely on discussion and internet research to understand topics well enough to offer thoughtful responses. Also, team members often consult other people. For instance, if a student asks about floods or natural disasters, we reach out to local teachers familiar with such experiences for their input. While we make no claims to expertise, we try to ensure that the voice of Kapila Baideu carries both care and credibility. When Kapila Baideu answers scientific questions like *"Why are leaves green?"*, she does not just state textbook definitions or facts. Instead, she invites students into a conversation. The answers often lead to a back-and-forth exchange of letters, nudging students to think more deeply. For example, the discussion may flow into what makes plants green, why that colour matters, and how plants live and grow (see **Fig. 2**). Through these thoughtful dialogues, Kapila Baideu becomes a one-on-one mentor, tuning her responses to each student's curiosity and understanding. This helps ensure that the process of inquiry is no longer about information sharing; it is about building relationships.

Initially, we thought Kapila Baideu would remain focused on generating curiosity around science-related questions. Indeed, many students ask, *"Why are leaves green?"* or *"How do stars shine?"* But to our surprise (and delight), the questions have quickly become more diverse. Some students share personal concerns: *"Why do I*

Child, you have asked a very intelligent question:
Why are leaves green?

Have you ever observed a newly growing plant? What color are its leaves?

Yes, you know — they are green.
But sometimes, we also see that some leaves turn yellow or dry up.
What happens to those? Do they grow nicely?

Which plant grows better — the one with green leaves or the one with yellow or dried leaves?

Look around your surroundings, observe, and write back to me.

Your question — "Why are leaves green?" — I will answer after you send me your observations.

Go and explore child

Your Kapila
Baidew

Fig. 2. An example of a response from Kapila Baideu. Rather than directly answer a question, Kapila's response nudges students to think more deeply about the natural phenomenon that triggers it. The name of the student it is addressed to has been scrubbed out here to protect their privacy.

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have no friends?"* or *"Why is my hair short?"* Others ask social or philosophical questions, like: *"Why does our school have a student union body?"* These letters are no longer just an expression of simple questions—they have become windows into the emotional and intellectual worlds of our students. One of our team members is the school counsellor. They respond to emotionally sensitive letters, particularly those related to fear, sadness, or low self-esteem. Students sometimes write things like: *"Why am I not good at Math?"* or *"I failed my test and feel ashamed"*. In such cases, the respective subject teacher steps in to respond, even if they are not part of the core Kapila team.

Our students believe that the responses they receive to their questions are written by Kapila Baideu. So, in writing our responses, we always keep the character of Kapila Baideu in mind. We try to ensure that all the team members stay on the same page. We cannot contradict each other. We cannot say different things in different letters. This is also the reason we abandoned the intention to respond with handwritten letters. Students might have recognised a teacher's handwriting. So, once our responses are finalised, we print them in a special 'Kapila' format. This is a delicate typewritten design that preserves anonymity, while still feeling personal. It is also less laborious. We are currently experimenting with ways to make the letter-receiving experience even more memorable. A new team member with an interest in design is helping us add small, personalised elements to each letter. For example, if a student writes about their admiration for a particular sports person, we might include a small card or token related to that interest. We even have a postman to deliver these letters! This is one of our beloved colleagues, who helps with school maintenance and tends to the school gate. Carrying letters from Kapila Baideu in his *jhola* (cloth bag), he steps into a class, calls out a student's name, and hands them their letters with a quiet smile (see **Fig. 3**). This has now become a treasured ritual.

Fig. 3. Each response from Kapila Baideu is sent out in a specially designed envelope. This adds a personal touch to 'her' response.

Parting thoughts

Our attempt to invite students to think of and ask questions has become a full-fledged initiative at Hummingbird School. Kapila Baideu has grown into a silent, yet powerful, presence in our school, fostering curiosity, empathy, and reflection.

Why has this initiative been so successful? Here are some reasons I can think of:

- The first is the mystery around Kapila Baideu. Students associate this character with the letter box in a quiet corner of the school and the letters that are delivered to them. This simple set-up builds curiosity and excitement. Who is writing these letters? This question plays an important role in keeping students' anticipation alive. Younger students believe that Kapila Baideu is a real character. This is reflected in some of the questions they send to her. For example, they often ask, *"Where do you live?"*, *"Who are your friends?"*, *"Will you be my friend?"*, *"When will you come to our school?"* The older or more rational students may suspect that someone from school is writing Kapila Baideu's replies.

But they, too, like the mystery. Especially because they do not know which teacher is behind this initiative or how they operate. On our part, we like the fact that the mystery around Kapila Baideu allows this initiative to remain spread out. Because it is not associated with any one teacher, multiple people from the school can come forward to speak in Kapila Baideu's voice. Sometimes, we actively encourage the mystery. For example, we recently observed that letters from many students asked questions without telling us their names or grades. Without these details, how would we send them personal responses?! We shared our challenge with students in a letter from Kapila Baideu. The letter was read out in the morning assembly. Not by a teacher, but by a student leader from the student council. This allowed us to send a message to students without revealing our identity. In other instances, this sense of mystery allows us to connect students to the larger world through their imagination. For example, as 2024 unfolded, changes in the school timetable disrupted the rhythm of our initiative. Several of our team members became too pressed for time to write responses. For about eight months, this initiative fell into a dormant phase. The questions from students kept coming, but the answers paused. Students began discussing the possibility that Kapila Baideu had died. This rumour started spreading in school. Some of our students even dropped letters to her, asking, *"What happened to you?"* Thankfully, new members joined the responding team of teachers. To explain the pause in a way that made sense to our students, we created a backstory: Kapila Baideu had travelled to Europe to cover the war between Ukraine and Russia. This is why she could not write back to our students. She expressed regret. This simple step allowed us to revive the initiative.


Kapila baideu - 2025 - July
kapila baideu thank you for give answer to me. I observe that the leaf are yellow because when the tree's are not getting nutrients and water properly so it became yellow. I know that you will give me before summer vication.

Fig. 4. An example of a student letter to Kapila Baideu. Students send their questions in any format and on any piece of paper they can find. The name of the student who sent this note has been scrubbed out from this image to protect their privacy.

- The second is that this initiative gives students the freedom to express their curiosity without hesitation. At first, we played with the idea of asking students to write 'proper' letters. Or insisting that they use a certain kind of paper for their questions. But, after some thought, we decided not to impose any rules. Students write to Kapila Baideu however they want. Whenever they find a moment, they drop in their questions. They send their questions on any paper they can find—hard, soft, or even strips torn from a notebook (see **Fig. 4**). Sometimes, they even put a small photograph of themselves inside the box. Maybe, they want to believe that Kapila will see these photos.
- The third is how students feel when they receive Kapila Baideu's letters. Each letter is delivered by hand to students in their class. The student opens the letter to hear a warm and gentle voice. The content of the letter is pitched at the level of the student receiving it. While personal, the letter does not lecture or make students feel uncomfortable. Students feel safe communicating with Kapila.

There may be many things that teachers can do to adapt this initiative to their schools and students. For us, this is just the beginning. We are still learning, and there is plenty of room for growth. We hope to try many more ways to let our students know that their questions are important and to feel that they are heard.

Notes: Credits for the image (The Kapila Baideu corner in school) used in the background of the article title: Deepak Rajput. License: CC BY-NC-ND.

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MAKING AND USING PINHOLE CAMERA MODELS

ANKITA CHATURVEDI

Earlier this year, on April 25 and 26, I was facilitating a workshop on the theme of 'Light' with middle-stage (Grade VI to VIII) government school science teachers. The workshop aimed to explore ways of making teaching learning materials (TLMs) that were different from those prescribed in the textbook. This included, for example, making a periscope using an empty *agarbatti* (incense sticks) box as a TLM for reflection and a Kaleidoscope to teach multiple image formation. We also wanted to make a pinhole camera. One method of construction of a pinhole camera model is described in Chapter 8 ('Light, Shadows and Reflections') of the Grade VI science textbook (NCERT, 2020-2021).[1] This method is also included in Chapter 11 ('Light: Shadows and Reflections') of the latest Grade VII science textbook (NCERT, 2025-2026).[2] I found this model bulky. While searching for a simpler method, I came across the article 'Pedagogy of Making: Pinhole Camera' by Shiv Pandey in the Dec 2024 issue of i wonder...[3] This article is accompanied by a classroom resource titled 'Activity Sheet: Make Your Own Pinhole Camera'.[4] This resource is divided into sections that provide instructions on how to make the model, how to use it, what teachers can observe and, most importantly, what is to be discussed with students. This can support teachers not only in making this TLM, but also in using it to build a grade-appropriate conceptual understanding of light. After I had made the model described in the Activity Sheet and confirmed that it worked, I decided to use this resource in the workshop.

Model making in the workshop

I started the session with the teachers by sharing an online version of the Hindi translation of the article.[5] None of the teachers had read the article. So I introduced it and briefly explained the main ideas presented in it. Then, I shared printouts of the Activity Sheet (one copy per participant), gave them 10-20 minutes to read their copies, and facilitated a discussion using questions like: What was the underlying concept of the activity? Is this concept part of the middle-stage science syllabus? How do you explain this concept in class? Would you like to make the model? What materials will you need to make it? Seeing the enthusiasm they showed for the idea of making their own models, I indicated that they could start work on it.

I provided materials like disposable cups, black marker pens, butter paper, tubes of glue and Fevicol, needles, and rubber bands for the model-building exercise. The teachers were divided into groups. The 4-5 teachers in each group shared the same material, but each teacher built their own model. To encourage the teachers to think creatively, this was the guidance I offered: "*The process shared in the*

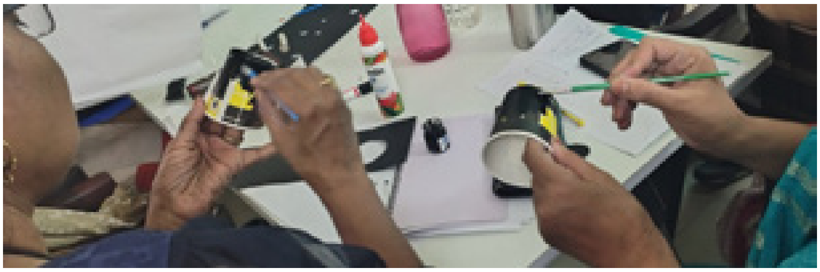

Fig. 1. Some teachers used poster colour to darken the outer surface of their paper cups.

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Activity Sheet is one way of making this model. If you wish to, you could choose other ways of making your models." Walking around the room, I noticed that some of the teachers had started introducing small variations in their models. For example, the sheet instructs teachers to blacken the sides and bottom of the paper cup using a black marker pen. But a couple of teachers asked for black poster colour and used a paintbrush to darken the surface of their cups (see **Fig. 1**). Another teacher saw a bottle of black ink in the room and tried using it. But they dropped the idea after seeing that the result was not dark enough to block light effectively. A third teacher used a strip of black sheet to cover the sides of the cup (see **Fig. 2**). The sheet also instructs teachers to use glue to fix a butter paper to the open mouth of their cups. This would act as a 'screen' to capture the image created by the pinhole camera. I asked one group of teachers to try using tracing paper instead. The idea for this variation had come to me while procuring materials for the workshop. The butter paper was kept near tracing paper. On examining the texture of the tracing paper, I wondered how it would affect the clarity of the image formed by the pinhole camera. One of the teachers used a bigger-than-usual piece of butter paper for the screen. It covered more than half the length of their cup. Similarly, while some teachers used glue or Fevicol to fix their screens to their cups, others used rubber bands. These variations led to active discussion on questions like, *"Will the size of the butter paper affect the clarity of the image?"*, or *"Why blacken the bottom and sides of the paper cup?" or "Will the image formed on tracing paper be as clear as the one formed on butter paper?"* These discussions not only made the session more interactive, but also increased the teachers' interest in related concepts of light.

Once all our models were ready, we lit some candles and tested them using the questions and prompts in the sheet to guide our observations (see **Fig. 3**). The teachers engaged in this process with enthusiasm.

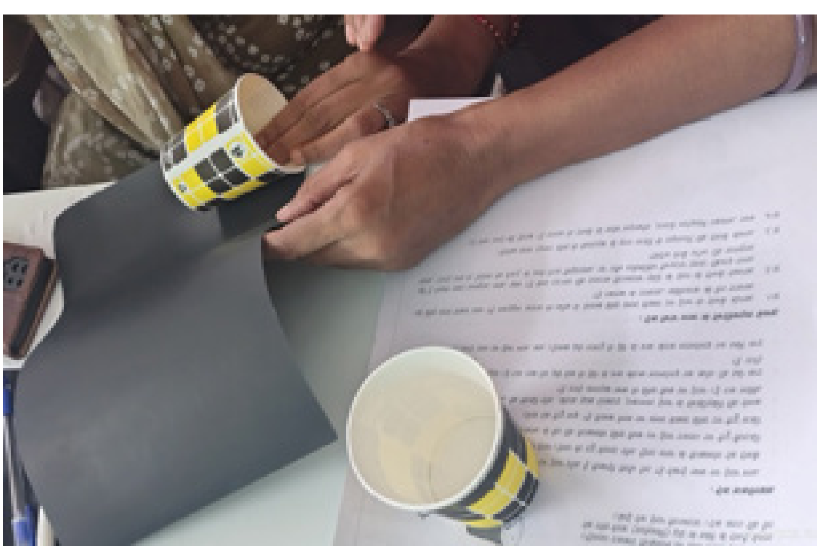

Fig. 2. A teacher used a strip of black sheet to darken the sides of their cup.

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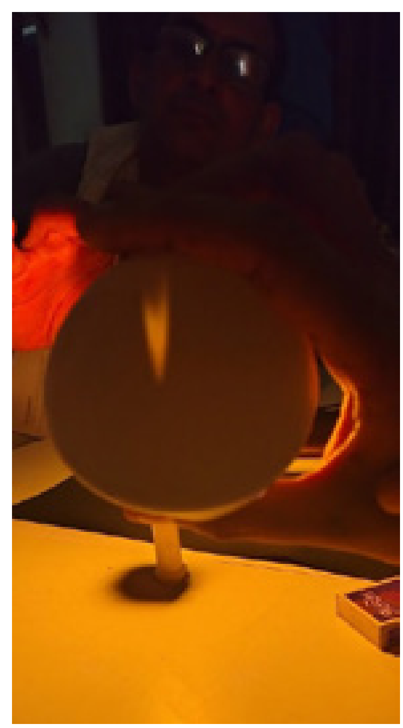

Fig. 3. Teachers tested the clarity of the images produced on the screens of their model pinhole cameras using a candle flame.

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I encouraged them to write their observations against each question to help maintain a record of what they did and observed. One interesting observation was that the image formed on a screen made of tracing paper was sharper compared to the one formed on butter paper.

Parting thoughts

Overall, it was a great experience for the teachers and me. Many of the teachers had used the method recommended in the textbook to **demonstrate** the making of a pinhole camera in class. But they found the method in Shiv Pandey's Activity Sheet simple enough to allow each of their students to use it to **construct** their own models. All of us found the language and articulation of the instructions in the Activity Sheet very simple and easy to follow. The prompts for observation and discussion shared in the sheet are fantastic! They are very specific and provide direction to help deepen observation skills. They helped teachers think about the kinds of discussions they could have while trying this activity with their students. The teachers also appreciated the collaborative approach we had used in the workshop: Sharing resources with a group, but making their own models; helping one another; and discussing their observations and experiences with each other. They expressed the intention of using a similar approach in their classrooms.

The article helped teachers think out of the box and look for alternative ways of doing this textbook activity. They participated in every stage of this session with zeal and enthusiasm, observing and discussing the effect that different factors (like switching off the lights in the room or adjusting the distance between the pinhole and the candle) had on the clarity of the image produced on the screens of their models. Many of the teachers asked questions about their observations and shared what they had learnt with their peers. Listening to them, I could see that this exercise had not only introduced them to a different way of making pinhole camera models, but had also increased their engagement with underlying concepts. The Activity Sheet had played a vital role in creating an environment that inspired their enthusiasm and supported their learning. This is the magic of using the right resource!

Notes: The image (Constructing a Pinhole Camera) used in the background of the article title was created for i wonder... using ChatGPT, under prompting by Vijeta Raghuram (Aug 2025). License: CC BY-NC-ND.

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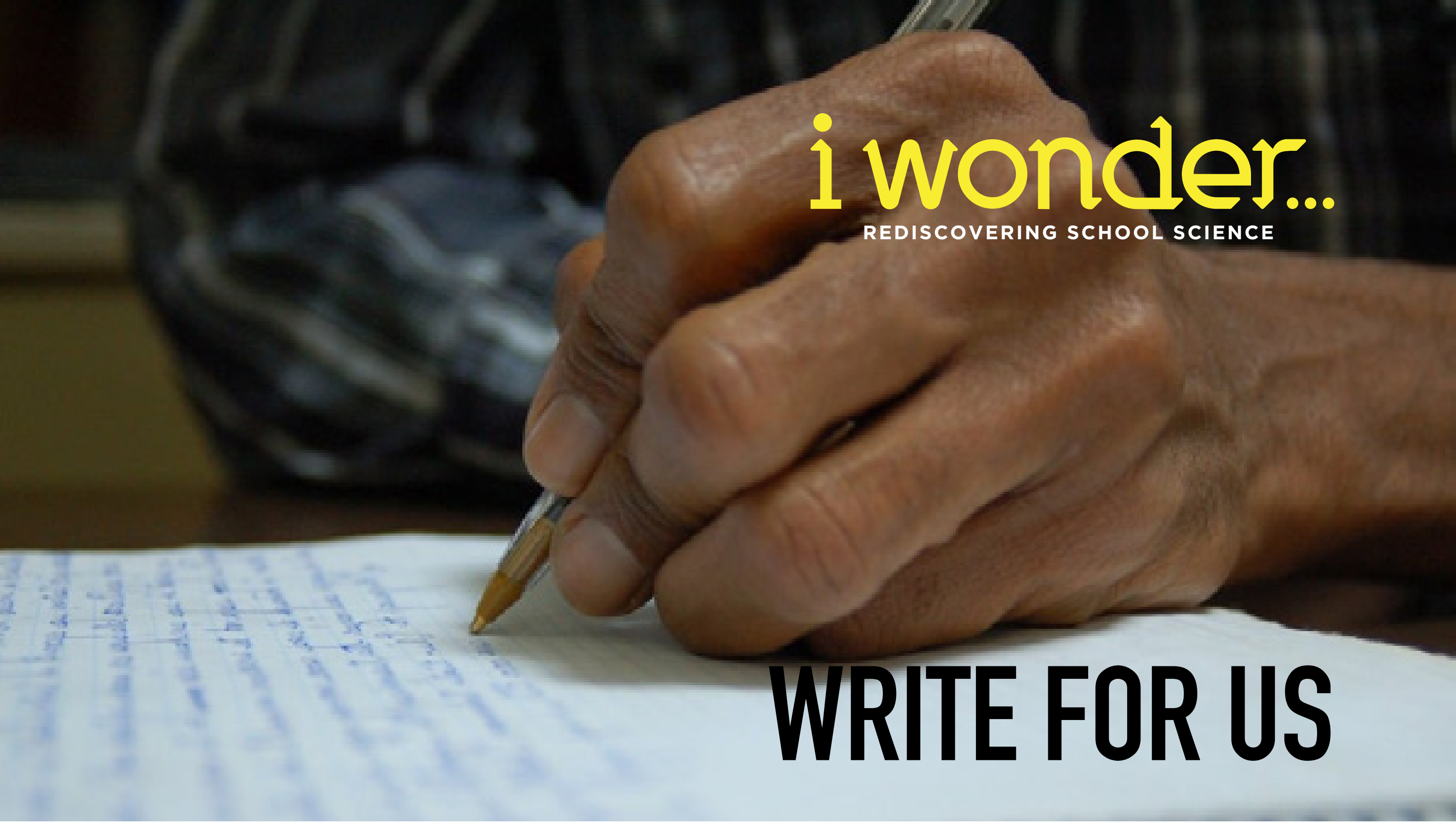

WRITE FOR US

i wonder... is a magazine for preparatory-stage (Grades III-V) Environmental Studies (EVS) and middle-stage (Grades VI-VIII) science teachers. Our aim is to share articles and resources that government school teachers can use in classroom instruction.

Requirements:

What kind of subject knowledge, pedagogical approaches, and perspectives to school education would teachers need to meet grade-appropriate curricular goals and build related competencies in their students? If you are a practicing science teacher, teacher educator, or researcher engaged in exploring this question, share your experience with us.

1. Choose a topic from the latest edition of the preparatory-stage EVS and middle-stage science textbooks (NCERT, 2024-2025). These are freely available here: https://ncert.nic.in/textbook.php. Highlight explicit connections to the content of these chapters. Allow the grade-appropriate learning outcomes for these subjects to guide the scope, complexity, and level of abstractness of your draft.
2. The National Curriculum Framework for School Education (NCF-SE) 2023 recommends specific curricular goals for preparatory-stage EVS and middle-stage science education. This document is freely available here: https://education.gov.in/sites/upload_files/mhrd/files/ncf_2023.pdf. Teachers are expected to meet these goals in ways that help their students develop and practice certain competencies in their real world. Present your article and/or resource from a perspective that supports teachers in this task.
3. Context plays an important role in what teachers can do in their class. Where possible, share how teachers can apply or adapt your article or classroom resource to meet the requirements and constraints of their own contexts. Design activity ideas and teaching guides with materials that government school teachers and students can find easily, locally, and inexpensively.

Your submissions:

- Need to be original. Include references and acknowledgements to indicate contributions from others.
- Need to be as concise as you can make them. They can be as short as 800 words. Try not to exceed 1500 words.
- Need to be written in simple non-academic language. Do show us why the ideas in your draft matter to you.

Share your pitch with us:

Write a brief outline that tells us what you want to write about and the key questions you intend to address. Also, tell us how your article:

- Supports the content of the grade-appropriate NCERT textbook.
- Aligns with the stage-appropriate curricular goals in the NCF-SE 2023.
- Can be used by teachers in their classroom instruction.

Include a brief bio (< 50 words) that tells us something about your background in science and/or science education, and areas of interest in school science.

Send your pitches and drafts to: iwonder@apu.edu.in. We accept submissions (in English, Hindi, or Kannada) throughout the year.

FEEDBACK FROM READERS

"*One of the most compelling and timely pieces in the Apr 2025 issue is 'Why Add Eggs to Midday Meals?'. The connected classroom resources are very good. The article bridges the gap between textbook science and real-world challenges, such as child nutrition, food taboos, and public health. The Teacher's Guide 'What Do We Do with Egg Shells?', by Radha M & Radha Gopalan, offers a delightful, hands-on activity blending waste management, composting, and soil science—perfect for preparatory-stage EVS and middle-stage science classrooms. The article 'Understanding GBS Outbreaks', by Satyajit Rath, connects infectious diseases and sanitation topics from textbooks to current public health events. 'Introducing an Indian Scientist: Janaki Ammal', by Lavanya Karthik, presents a powerful way to highlight Indian women scientists and explore the intersection of science, identity, and social justice. 'Exploring the Sun's Path with Stellarium', by Anand Narayanan, describes a useful tech-enabled astronomy teaching tool for understanding seasons, day/night cycles, and celestial movement. The activity sheets in the issue are mind blowing. We should use these resources well. It will definitely support teachers and children in their learning.*"—Haripriya J, Azim Premji Foundation, Mandya, Karnataka.

"*We discussed the article 'Doing Science Without Labs' during a workshop with science teachers. We also made some science models through waste material like empty plastic bottles, used tetra packs, empty shoe boxes, etc. Almost all things in the magazine are nice. But a small suggestion regarding the Hindi translation. Sometimes, very hard words are used.*"—Krishan Joshi, Azim Premji Foundation, Pithoragarh, Uttarakhand.

"*I have read the article 'Why Add Eggs to Midday Meals' in the Apr 2025 issue and the three related Teacher's Guides. The article is based on the common beliefs of people who tend to avoid eating eggs. These include the beliefs of not just vegetarians, but also those who consume fish or chicken, particularly around eating eggs in summers, gas formation in the stomach, and early start of puberty, etc. I had myself held the belief that consuming peanuts and milk, instead of eggs, can provide necessary nutrients. However, after carefully examining the table given in the article, I found that out of the 25 nutrients, milk and peanuts can offer 14 nutrients in higher amounts than eggs. But they cannot fill deficiencies in phytochemicals, like beta-carotene and lutein, vitamins B12 and B2, and minerals like choline. While there are other sources of these nutrients, they are unlikely to be more widely accessible or inexpensive than eggs.*"—Parmanand Sahu, Azim Premji Foundation, Raigarh, Chhattisgarh.

"*Magazine issues are strong in content and have practical and classroom linkages that increase their usability for resource persons and teachers. Some suggestions: (a) Include a 'Teacher's Voices' column to highlight classroom practices; (b) Add interdisciplinary connections; (c) Introduce a section for resource persons that features ideas for developing professional development modules.*"—Avneesh Shukla, Azim Premji Foundation, Barkot, Uttarakhand.

"*In the Apr 2025 issue, I liked the article 'Connecting Policy & Practice in the Science Classroom' the most. This is because it offers apt examples that can be used to have more effective conversations with teachers about the nature and purpose of science. It will be very useful in teachers' workshops. I have shared this article with my science team, so that it may help them in future workshops. I feel that articles around force and pressure need to be included in future issues.*"—Imran, Azim Premji Foundation, Chittorgarh, Rajasthan.

"*i wonder... has consistently proven to be a valuable and inspiring resource—whether we are designing workshops, school-based engagements, or planning team capacity-building efforts. The articles are pedagogically rich, contextual, and deeply aligned with the vision of NCF-SE (2023). I have used three articles from the Dec 2024 and Apr 2025 issues—'The Pedagogy of Making: Pinhole Camera', 'Exploring Acids & Bases with Natural Indicators', and 'Doing Science Without Labs'—across various domains of my work. During school visits, these articles helped me design and conduct hands-on demonstration sessions for both students and teachers. For example, the pinhole camera activity was used to explore light and image formation in Grades VI–VIII, sparking scientific curiosity using local materials. Similarly, the article on natural indicators guided students and teachers through experiments using turmeric and hibiscus to understand acids and bases, making chemistry* engaging and accessible even in resource-poor settings. These demonstrations also fed into the design of a District Resource Group (DRG) workshop on 'Doing Science Without Labs', where the third article served as a conceptual anchor. It helped teachers reimagine science education through observation-based, locally grounded activities. All three articles supported the development of contextual teaching-learning modules, provided excellent pedagogical examples for teacher workshops, and contributed to capacity building in the science team by demonstrating how meaningful science can be taught without sophisticated infrastructure. They also enhanced my own professional growth, helping me align field practice with the vision of NCF-SE (2023), promoting contextual relevance in science teaching. As we now begin extending our work into Grades IX to XII, I feel it is time to consider broadening the scope of the magazine to include articles that address senior secondary science topics. While current issues excellently cater to Grades VI-VIII science and preparatory-stage EVS, we often find ourselves looking for similarly engaging, inquiry-driven content for higher grades, especially in physics, chemistry, biology, and environmental science. This expansion would retain the magazine's existing strengths while making it even more relevant for the full range of school science education. It would also provide secondary-level teachers and resource persons with accessible, practice-oriented material rooted in real-world contexts—something that i wonder... already does so well for middle school."—Anurag Tiwari, Azim Premji Foundation, Chamoli, Uttarakhand.

"It is a bit difficult to use articles like 'Exploring The Sun's Path with Stellarium' regularly and keep a record of observations. I am unable to visualize the effectiveness of this in a government school set-up. I liked the teacher's guide as it shares step-by-step suggestions on conducting a related activity in a classroom."—Ram Vahil, Azim Premji Foundation, Banswara, Rajasthan.

"I used inputs from the approach in 'A Project-centred Approach to Biographies of Scientists' from the Dec 2024 issue to design an event for the science day celebration for students and teachers. I used the article 'Exploring Acids & Bases with Natural Indicators' from the Apr 2025 issue in this CRC meeting. I have also used 'The Importance of Asking for Questions in Different Ways' from the Dec 2024 issue in classrooms to ask students to write their questions."—Archana Dwivedi, Azim Premji Foundation, Haridwar, Uttarakhand.

"I tried the activity in 'The Pedagogy of Making: Pinhole Camera' from the Dec 2024 issue with students of Grades VI-VIII. I used 'The Importance of Asking for Questions in Different Ways' for a discussion with teachers during a CRC meeting. We explored how we can create opportunities in our classrooms so that the children can bring what they are seeing around them to the class in the form of questions."—Neelam Kunwar, Azim Premji Foundation, Champawat, Uttarakhand.

"I used some references from the articles 'The Importance of Asking for Questions in Different Ways' and 'The NCF-SE in Classroom Instruction' in CRC academic meetings with teachers. This has helped in my articulation during discussions around 2 things—how NCF-SE envisions a science classroom; and the assessment part of the teaching learning process. I used the articles 'The Pedagogy of Making: Pinhole Camera' and 'Exploring Acids & Bases with Natural Indicators' while working with students of grades VI and VII and to give suggestions to teachers. I used these two articles as supporting material in developing items and experiments using available low-cost materials. I used the article 'Doing Science Without Labs' for ideas and visualizing while developing teaching plans for demonstration in schools and for teachers in a summer workshop to use low-cost material for hands on and project centric approach of science teaching. I particularly like the 'Science Educator at Work' and 'Ask A Question' sections in the magazine. The first one gives really good insights into the combination of approaches used in classroom teaching of concepts and the second one addresses a very common question and explores ways to find its answer in a comprehensive way, which always appeals to my curiosity."—Saurabh Deka, Azim Premji Foundation, New Tehri, Uttarakhand.

"Articles like 'The Pedagogy of Making: Pinhole Camera', 'Doing Science Without Labs', or 'The Importance of Asking for Questions in Different Ways', especially when they are directly linked with textbook content, prove to be very effective, as they can be transacted in classrooms without much modification. My primary involvement has been with middle-grade teachers, and in this context, I have frequently used or referred to these articles during workshops. They not only provide practical strategies but also help teachers connect theory with classroom practice, making the learning process more meaningful and engaging for students. The magazine has gradually evolved into its present form after consistent efforts since its inception. One segment that could be added (if possible) is 'voice from field practitioners' such as teachers, internal members, or other readers about the magazine or specific articles. Including such reflections would not only provide valuable insights but also serve as a source of motivation for the team that works diligently to bring out the magazine."—Deepak Singh Rawat, Azim Premji Foundation, Chamoli, Uttarakhand.

Share your feedback

Would you like to share anything from your classroom experiences that would help other teachers use the articles and resources from our Apr 2025 issue more effectively in their classroom practice? Tell us.

You can share your feedback for the:

- English edition of our Apr 2025 issue here: https://forms.gle/Q9Sr6CMnjN998F9m9
- Hindi edition of our Apr 2025 issue here: https://forms.gle/aBqqm61rxYWpsDrv9
- Kannada edition of our Apr 2025 issue here: https://forms.gle/MLn9kSuXFugpAyHZA

You can also write to us at: iwonder@apu.edu.in.

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Read

We publish three issues (Aug, Dec, and Apr) a year. Every issue is available in **English, Hindi,** and **Kannada.** Each issue features a combination of articles and detachable classroom resources (like Activity Sheets, Concept Builders, Teacher's Guides, Booklets, Posters, or Field Guides). These are included under sections like: The Science Educator at Work, Life in Your Backyard, Annals of History, The Science Lab, Perspectives, Resource Review, Teaching as if the Earth Matters, and Ask a Question. All **our content is CC-licensed and freely available** on our website.

Ask and discuss

Share your questions with authors in our free, live, online discussions. Here are some examples:

- **How do children know the Earth is not flat?** (URL: https://www.youtube.com/watch?v=gMKyAZuu4tY) with Anand Narayanan and Amol Anandrao Kate.
- **Why science matters** (URL: https://www.youtube.com/watch?v=KeJIBY1IqpM) with Anil Kumar Challa, Reeteka Sud, and Vinay Suram.
- **Plants and pollinators: Let's explore** (URL: https://www.youtube.com/watch?v=cqYu1zwmLX0&t=9s) with Meenakshi and Radha Gopalan.
- **Exploring motion through a balloon's flight** (URL: https://www.youtube.com/watch?v=NgIRXGDpnfw) with Anish Mokashi and Vinay Suram.

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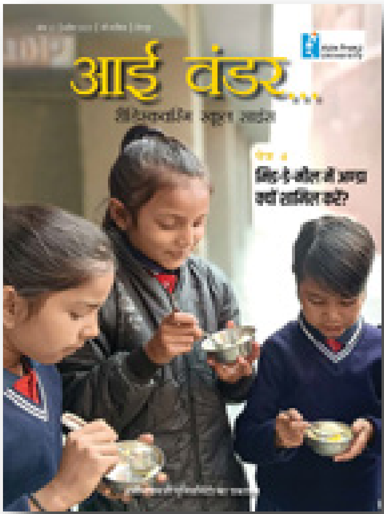

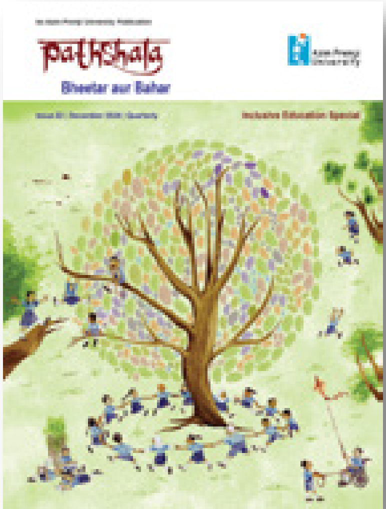

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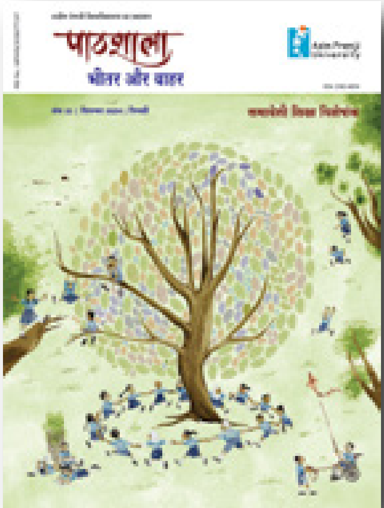

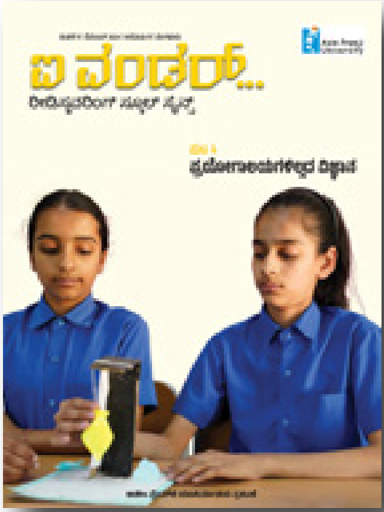

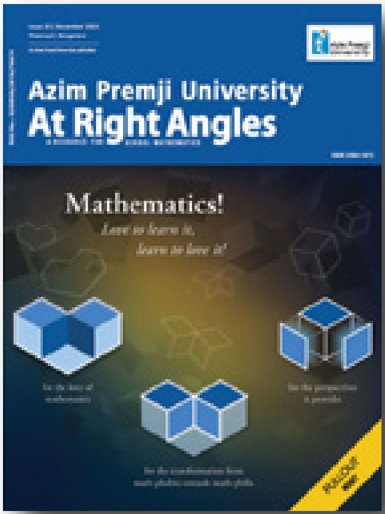

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