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TEACHER'S GUIDE I: TRACKING THE SUN

Chapter 12 ('Beyond Earth') of the Grade VI science textbook (NCERT, 2024-2025) introduces students to concepts of stars, planets, satellites, and constellations.[1] While many students may enjoy watching the sky, these textbook concepts can seem abstract, distant, and irrelevant to their everyday experience. That the objects they can see in the sky with their eyes seem nothing like the 3-D images they see in their textbooks can increase this disconnection. How do we address this? One approach may be to offer students the opportunity to make observations of celestial objects that have relevance in their real-world.

What can our students observe that have relevance in their world?

To observe details of many celestial objects, students and teachers may require expensive equipment. But many patterns of the movement of these objects across our sky are visible to the naked eye. In a section titled 'Stars and Constellations', Chapter 12 of the Grade VI science textbook shares that: *"Some groups of stars appear to form patterns which are like shapes of familiar things. Long ago, when watching stars in the night sky was a favourite pastime of our ancestors, they identified these star patterns with animals, things, or characters in stories. Many cultures had names for patterns based on their own stories. These imaginary shapes helped them in recognising stars in the sky"*.[1] One of the activities suggested by the 'Learning Further' section at the end of this chapter is: "*Try to find out the names of planets in your local language. Also, find out the stories associated with stars and constellations in your region. Present these stories in a pictorial form*".[1] Encourage your students to share what they learn from this exercise in class. This chapter also offers a response to the question that many students may hold: "*Do we find patterns among the stars just for fun or is there some use of these patterns?... Recognising stars and their patterns was a useful skill for navigation in the olden times. Before the arrival of modern technology or even before the invention of the magnetic compass, it helped people, particularly sailors and travellers, in finding directions at sea or on land. It is still used in emergencies as a backup method*".[1]

(A) Observing the night sky: In the same textbook chapter, the section titled 'Night Sky Watching' shares ideas for two activities (Activity 12.2 and 12.3) that students can use to observe some such patterns themselves. Since both activities can only be done outside regular school hours, students may need to do it on their own. This may pose the following challenges:

- Finding a good location: As Chapter 12 of the Grade VI textbook shares: "*If you stay in a big city, you may find that the sky is rarely clear and only a few stars are seen in the night sky. This is due to light pollution, smoke, and dust... In villages or areas where there is less light pollution, a larger number of stars can be seen. Also, your house may be surrounded by tall buildings and trees, which may block your view...*".[1]
- Identifying what they are observing: "*Not all stars and constellations are visible from all places on Earth and on all nights in a year... To identify a star or a*

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constellation, you need to know what a particular constellation looks like and where to look for it in the night sky... To find out when and in which portion of the sky a star or a constellation will be visible from your location, you may take the help of sky mapping apps that can be downloaded on a mobile phone, or other online resources".[1] Not all students have access to online resources or mobile phones that can support such apps. Even students who have access to these resources may need some support from an adult till they become confident about using them on their own.

(B) Observing the daytime sky: Is there a star that is visible in the day and that our students can identify without needing aid from parents or teachers? Yes, the Sun. This is also what the astronomer Prajval Shastri points out in her article titled 'Daytime Astronomy with Self-constructed Equipment'.[2] Yet, most of what our students learn about the Sun is as facts from their textbooks. One reason for this could be that viewing the Sun directly can permanently damage the retina of our eyes. It is important for students to learn how to protect their eyes against the risk of such damage.[3] Prajval's article shares step-by-step guides that students can use to construct simple equipment (like a magic mirror and mounted solar ball projector) to safely track the Sun. Unlike the expensive instruments that students may need to inquire into other stars, the equipment in Prajval's article can be made from inexpensive and easily available material.

What can students learn from tracking the apparent motion of the Sun?

In his article titled 'Exploring the Sun's path using Stellarium', the astrophysicist Anand Narayanan highlights the fact that our concepts of time and direction have been shaped by observations of the Sun's predictable path.[4] Teachers can draw attention to the historical role this path has played in determining how we navigate the globe and design the time-keeping devices and calendars we use to structure our lives. In the same article, Anand shares three questions about the Sun's path that students learn as facts. He also shows how students can use Stellarium, a free virtual planetarium software, to explore these questions over long periods and across different latitudes.[4] But which aspects of these questions can students explore through real-world observations?

(A) Does the Sun always rise exactly due East and set exactly due West? Prepare your students for this exploration by introducing them to a compass. Show them how it can be used to determine due East (90 degrees to the right of the north on a compass) and due West (90 degrees to the left of the north on a compass).

Once your students are familiar with these concepts, ask if they can predict how many days in a week the Sun rises due East and sets due West. It can be useful to ask students to share observations or reasoning that support their guesses and open these to class discussion. You could record the guesses that students find most plausible on the board and invite them to share ways of testing them. One approach could be that students record the rising and setting positions of the Sun, relative to due East and due West, on each day of a week. How?

- Keep a compass at eye level.
- Mark the direction of the Sun (looking briefly, and not directly, towards it) the moment it appears above the horizon at sunrise or the moment it disappears below the horizon at sunset.
- Use the compass to estimate the

difference in the angle of sunrise from due East and the angle of sunset from due West.

Once the class agrees on an approach, you could give them a week to make their observations. Ask them to make note of any challenges they face in making precise observations. At the end of the week, invite them to share and discuss their observations in class. It can be helpful at this point to use the board to draw a sketch that shows the Earth revolving around the Sun. **Prompts for discussion:** *If the Earth revolves around the Sun, why does it look like the Sun is moving across our sky? The compass may have helped you get a broad sense of the direction of sunrise and sunset relative to you. But how helpful was it in getting the specific position of sunrise and sunset? Did your estimate of the difference in angle vary by much from one day to the other? Did it change by much over a week? Can you think of some way of making more precise observations of the rising and setting positions of the Sun? Based on what you have seen, do you think the positions of sunrise and sunset show any change in a year? Would you see any difference in these positions if you viewed them from a different latitude?* You could invite students to test their predictions for the last two questions using Stellarium.

(B) Does the length of day and night change over a year? Prepare your students for this exploration by sharing that a day is the duration of time between a sunrise and the sunset that follows it. Similarly, a night is the length of time between a sunset and the sunrise that follows it.

Once your students are familiar with these concepts, ask if they expect to see any differences in the length of day and night over a month. Again, it can be useful to ask students to share observations or reasoning that support their guesses and open these to class discussion. You could record the guesses that students find most plausible on the board and invite them to share ways of testing them. One approach could be that students record sunrise and sunset times at their location for a month. They could also get these details for the past month by looking at sunrise and sunset times in a local newspaper or calendar. Invite students to share and discuss their observations in class. **Prompts for discussion:** *Why do we use sunrise and sunset to define the length of day and night? Does this definition have any (practical) relevance in our real world? What if we decided that the length of day and night everywhere in the world and throughout the year is to be 12 hours each. What would it change about our lives? Did the timings of sunrise and sunset in the newspaper match your own observations? Can you think of some ways of making more precise observations? Do you expect to see any differences in the length of day and night over a year? Do you expect to see any changes in this pattern at other latitudes?* You could invite students to test their predictions for the last two questions using Stellarium.

(C) Is the length of a day-night cycle exactly 24 hours? Prepare your students for this exploration by sharing that the day-night cycle is defined as the duration of time that the Earth takes to make one complete turn around its own axis.

Ask students if they can think of a way:

(a) To measure this period: One approach is to choose an object in space as our reference and measure how long it takes for this object to appear at the same position in the sky. Let us suppose, for example, that the Sun appears to be directly above our heads at noon on a certain day. The day-night cycle would be the shortest amount of time it takes for us to see the Sun return to this position relative to us.

(b) To tell when it is noon at their location: Likely that students may find this question confusing. They may assume that noon is always at 12 PM IST. You could invite them to imagine that they have no clocks or watches. Is there some way they could tell when it is noon? If needed, share that noon is the time of the day when the Sun is at the highest point in the sky. Ask if they have noticed the length of their shadows at noon. If your students show interest in this aspect, invite them to try the outdoor (Activity 1: Shadow Tracing Over Time) and indoor (Activity 2: Shadow Tracing Indoors) activities that Sanda Roberts shares in her article '[The Science of Sunlight and Shadows]'.[5] Both activities can be done with inexpensive and readily available material. If needed, these activities can be made simpler. For example, students may find it easier to use an object rather than a person as a shadow maker. Once students arrive at the fact that noon is when their shadows are shortest, you could invite them to find out when this happens at their location. Discuss their observations in class. You could also share Alok Mandavgane and Varuni P's article '[When is noon?]' with them.[6]

Work with students to help them calculate the duration of time it takes for the Sun to return to its highest point in the sky. For this, students may need to find when it is noon on two consecutive school days. If students do not have access to mobile phones that allow the use of apps, encourage them to try the first two methods shared in Alok and Varuni's article and share their findings in class. You could use the 'Zero Shadow Day' (ZSD) app to find the exact timing of noon. **Prompts for discussion:** *Why do we use the Earth's rotation to define the length of our day-night cycle? Does this definition have any (practical) relevance in our real world? Can you think of a simpler and more useful way of defining our day-night cycle? Did the timing of noon that you found by measuring the length of your shadow match the exact timing in the ZSD app? How different was this from your calculation of noon as falling between sunrise and sunset? Can you think of some ways of making more precise observations? When viewed from the Earth, it takes 24 hours for the Sun to appear in the same position in the daytime sky. Do you expect it to take 24 hours for other stars to return to the same positions in the night sky?* You could invite students to test their predictions for the last question using Stellarium.

What can students learn from these exercises?

Doing these exercises in the real world first can help students appreciate the importance and the challenges of making precise observations and measurements in science. They will be able to see for themselves how difficult it is to find differences in the position of sunrise from one day to the next. Or how small the difference in length of day and night over a month can be. For example, the length of day in Bengaluru, Karnataka, on Mar 1, 2025 was 11 hours 53 minutes and 3 seconds. This steadily increased to a length of 12 hours 14 minutes and 31 seconds on Mar 31, 2025.[7] Some of them are likely to share what they did to make their measurements more precise. In this way, students may begin to practice what it means to observe the natural world like a scientist. Likely they will come back to class with more questions than you started this exercise with. They may, for example, want to know how scientists can tell when it is noon with such precision. Discussions around the relevance of how scientists define the day-night cycle, for example, can be connected to the many biological processes (including those related to our own health and well being) that are tightly linked to it in ways that we are just beginning to discover. For example, teachers could ask: Is the concept of day relevant only as a measure of the duration of time we have access to a source of illumination? You can point out that if this were true, we could extend the length of days by artificial illumination. Invite students to imagine what this would change about their life and the life of other organisms on the Earth. Amol Anandrao Kate's article 'Let there be Night' can be useful in preparing for this discussion.

In addition to helping students appreciate the relevance of textbook concepts in astronomy in their everyday world, these explorations can help meet two curricular goals recommended by the National Curriculum Framework for School Education (NCF-SE) 2023:

- CG-2: [The student] explores the physical world in scientific and mathematical terms.
- CG-6: [The student] explores the nature and processes of Science through engaging with the evolution of scientific knowledge and conducting scientific inquiry.[8]

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