PLUTO IN THE CLASSROOM

Chapter 1 ('The Wonderful World of Science') of the Grade VI science textbook (NCERT, 2024-2025) invites students to see science as: *"...a way of thinking, observing, and doing things to understand the world we live in and to uncover the secrets of the universe".* The story of the discovery of Pluto offers a concrete example of this process. Discussions around this story can help teachers meet two of the nine curricular goals that the National Curriculum Framework for School Education (NCF-SE) 2023 recommends for the middle stage:

1) 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 to: *"Illustrate how scientific knowledge and ideas have changed over time (description of motion of objects and planets, number of planets) and identify the scientific values that are inherent and common across the evolution of scientific knowledge (scientific temper, science as a collective endeavour...)".*
2) CG-9: *"Develop awareness of the most current discoveries, ideas, and frontiers in all areas of scientific knowledge in order to appreciate that Science is ever evolving and that there are still many unanswered questions".*

In addition to the aspects highlighted in these curricular goals, I would like to briefly touch upon two more:

3) Students often think of experiments as being the only or the most important approach that scientists use to investigate the natural world. Is this reinforced by the fact that many science textbooks focus on experiments? Or because many of us call all hands-on experiences in the classroom 'experiments' rather than 'activities'? The story of the discovery of Pluto may illustrate how experiments may not always be possible to do in fields like astronomy. It could also introduce students to the role that speculation, mathematical calculations, and careful observation play in developing scientific knowledge. **Prompt for students:** If your students show interest in this aspect of science, you could encourage them to think of and discuss examples where using an experiment to answer a question in science may be unnecessary, insufficient, or even unethical.
4) The story of the discovery of Pluto illustrates how our perception of the natural world is linked to and aided by the tools we use to explore it. We would know very little about Pluto (as well as Uranus and Neptune) without the powerful telescopes that are part of this story. It may also be important to point out to students that the efforts of many generations of people were involved in designing, building, and refining these tools. **Prompt for students:** If your students show interest in this aspect of science, you could:
    a) Encourage them to think of and discuss an example of at least one tool that allows them to observe, measure, or analyse some phenomenon in their immediate world in more detail and with more accuracy. You could use some of these questions for the discussion: *What aspects of your world would be invisible, inaudible, or unclear to you if you did not have this tool? Are there things you could not have known for yourself without this tool?*
    b) You could also download the **Planet Discovery Activity** on blink comparators designed by Dr Erica from Rosie Research: https://bit.ly/3VJgm2S. Invite your students to try it out. Page 4 of this activity displays images of the actual slides that Tombaugh compared to discover Pluto. If your students are unable to spot Pluto on these slides, show them what Tombaugh spotted by displaying this image on your mobile phone: https://www.planetary.org/space-images/the-pluto-discovery-plates. You could use this question for the discussion: *How important is it to have tools that make an investigation less time consuming? What kind of explorations would require such tools?*

The fact that Pluto is no longer considered a planet is linked to all these aspects of the nature of science. Because it is so far away from us (34 times the distance between us and the Sun), it is very difficult to observe. We have seen how Tombaugh and Lampland used a range of telescopes of increasing resolution to photograph it. But their images remained dim and unclear. As our tools to observe Pluto have become more refined, our knowledge of it has changed, and our definition of a planet has become clearer. For example, the first planet-like image of Pluto came in the 1990s, after the launch of the Hubble Space Telescope. The more astronomers observed this object, the smaller it appeared. By 2006, its mass was estimated as being 0.2% that of the Earth. These changes in our understanding have led to its reclassification as a dwarf planet. Returning to Chapter 1 of the Grade VI science textbook, this aspect of the story can be used as an example of how: *"Science is like a giant and unending jigsaw puzzle... Sometimes, we find that a piece of this puzzle has been put in the wrong place and needs to be moved. New discoveries often change our understanding of the world".* **Prompt for students:** If your students show interest in this aspect of science, you could encourage them to think of 1-2 statements about any aspects of their own world that are well-supported by evidence. These statements could be very simple in nature. For example, students could say that the bell for their lunch break always rings at 12 pm. Or that a certain kind of tree in their neighbourhood only starts flowering in a certain month of the year. Write these statements on the board. Ask them to share evidence to support these statements. You could then ask: *What if you found new evidence? For example, Buransh or Rhododendron, the state tree of Uttarakhand, is known to flower in March and April. But it was seen to bloom in January this year. How would you respond to new evidence of this kind? Would you dismiss it? Or would you be open to revising your earlier statement? What factors would help you choose your response?* Use this discussion to share how 'facts' in science are reliable, yet open to revision.


(a)

Another reason this story may be important to tell in the science classroom is to ask students two questions that they may not ask you themselves, but are likely to think about a lot. Especially when they need to finish a lot of homework, prepare for examinations, or struggle with understanding a particularly abstract or complex concept in their textbook. The two questions are: *Why does science matter? Why do we study it?* This is how Chapter 1 of the Grade VI science textbook responds to these questions: *"As human beings, we have always been curious about our surroundings. We start exploring our surroundings and asking questions right from our childhood...science is all about joyful exploration. Enjoy your scientific journey, keep exploring and never stop wondering about the amazing mysteries of the universe and asking questions."* But many students may struggle to find opportunities to connect this curiosity and sense of joy with what they see in their textbooks. Some of our ways of teaching science may also play a role in this disconnection. In contrast, stories of discovery, like that of Pluto, can offer students many opportunities to relate to science as an exciting and creative pursuit rather than as a dry and uninteresting subject. Here are some aspects of this story that hooked our interest:

- Neptune was discovered within a degree of the position Verrier had predicted for it. And Galle spotted it on the same night that he received Verrier's prediction! **Prompt for students:** If your students show interest in this aspect of the story, invite them to imagine what influence the speed of this discovery may have had on Lowell's resolve to search for Planet X. Remind them that Lowell started his search for Pluto in 1906 and continued to search for it till his death ten years later. He used an approach that combined mathematical calculations (like Verrier) with observations of the night sky (like Galle). Yet, Lowell found no evidence for Pluto in his lifetime. You could use some of these questions for a discussion: *What does this tell us about the process of seeking answers*

for questions in science? What do you think may have helped Galle and Verrier? Was the search for Pluto harder to start with?

- To refine his search for Planet X, Lowell needed the answer to two questions: Where in the night sky would he be most likely to find such an object? And how big an object should he be looking for in photographs of the night sky? Making these predictions required some very complex mathematical calculations. Astronomers today could use some very advanced computers to do this. But this was at a time when even calculators (like the arithmometer) were only able to handle much simpler calculations. So, Lowell hired a team of 'human' computers! These were people who made complex, long, and often tedious calculations by hand. These calculations were particularly important in astronomy and navigation. About 50% of human computers were women. Many men saw this as a dull unglamorous job. It required long hours of precise work that was rarely acknowledged. Many astronomers could pay women computers half of what they paid the men. Lowell's team of human computers was headed by Elizabeth Langdon Williams. She was among the earliest women to graduate (with a degree in physics) from the Massachusetts Institute of Technology (MIT), US. Both Lowell and Tombaugh used Williams' calculations in their search for Pluto. **Prompt for students:** If your students show interest in this aspect, you could ask them to search for more details about Williams. Or to come up with a list of other such women whose calculations contributed to important discoveries in science. Depending on their interest and the resources available to you, this could become a year-long project. It may be helpful to keep in mind that there are very few records of the contributions women made to science during this period. Searching for material and even the names of scientists who were women may be particularly difficult. If neither of these ideas are possible to explore in your context, you could use some of these questions for a class discussion: *How was Williams' contribution to the discovery of Pluto different from Verrier's contribution to the discovery of Neptune? Why do you think Williams' role in this story is rarely spoken about? Do you think the girls in your class have a better chance (than Williams) of becoming and being known as scientists?* Even as science teachers, this may be the first time some of us may be participating in or facilitating such a discussion. You may find the freely available recording of an i wonder...webinar (Feb 2024) titled 'Dorothy Andersen: An Unsung Hero' (https://www.youtube.com/watch?v=GkKhdz8Wbe8) helpful in preparing for your role in the discussion.


(b)

- Lowell used his personal wealth to build the Lowell Observatory (it was one of a kind at the time) and willed most of his estate to it! We can guess how important this aspect is from the fact that the search for Pluto was put on hold for a 11-year period when the observatory did not have access to Lowell's wealth. **Prompt for students:** If your students show interest in this aspect, you could ask them how this may be related to the nature of Lowell's search. You could use some of these questions for a discussion: *Can you think of some things an astronomer would need to answer such a question? Do all questions in science need this kind of financial support? Can you think of 1-2 questions that can be explored with simple, inexpensive, and easily available materials?* You could also connect it to the next aspect included in this list!

- Tombaugh was so determined to observe markings on the surface of Jupiter that he built his own telescopes from scratch. He ground his own mirrors and lenses for it. And used discarded automobile parts and farm equipment to build its mount. He had no formal training in any of this! **Prompt for students:** If your students have had the opportunity to 'make' a scientific model or instrument themselves, you could invite them to share their experience. Here are some questions you could use for this discussion: *What did you make? What kind of help did you need from your classmates and/or teacher? What did*

you use this instrument for? What did you learn from this experience? Did you enjoy it?
To offer students more of these opportunities, you could refer to the articles titled:

a) 'The Pedagogy of Making: Pinhole Camera' in this issue of i wonder... (Dec 2023-Dec 2024). In this article, Shiv Pandey (a teacher) shares his experience of inviting students to construct their own pinhole cameras.
b) 'Doing Science without Labs' in this issue of i wonder... (Dec 2023-Dec 2024). In this article, Satish Bhaskar (a teacher educator) shares his observations of how offering a space for '*jugaad* from junk' can encourage students to experiment with constructing new things using discarded objects.
c) 'Daytime Astronomy with Self-constructed Equipment' in the previous issue of i wonder... (Jun 2023). In this article, Prajval Shastri (an astronomer) shares how students can construct their own magic mirrors and mounted solar ball projectors to observe celestial objects in the daytime sky.

- Dr Slipher saw some of Tombaugh's drawings of Jupiter and offered him a chance to work as an astronomer at the Lowell Observatory. Tombaugh had completed only a high school degree at the time! **Prompt for students:** If your students show interest in this aspect, encourage them to record their observations of any object or feature in their immediate world by drawing it. Invite them to choose a subject that is related to something they are studying in science. You could use this question as a prompt: *What about this object or feature would be interesting to discuss in the science class?* Display their drawings in the class. Give each drawing a number. Allow your students enough time to view this display. Ask them to guess what object or feature is captured in each drawing. Then invite each student to present the subject of their drawing to the class. At the end of each sharing, ask how many students had guessed the subject of the drawing correctly. You could use some these questions for a discussion: *What would you need to see in a drawing to make a more accurate guess about its subject? Did any of the drawings help you see something that you had not noticed before? How easy or difficult did you find it to record your observations as drawings? Did it have any effect on what you observed or the way you observed it? How important do you think drawings are in science? What scientist-like skills could Dr Slipher have seen in Tombaugh's drawings?*

- Tombaugh first observed Pluto in February, 1930. This was the evidence that the Lowell Observatory had been seeking for about 24 years. The most immediate effect it had was that the entire staff at the observatory became involved in verifying this observation. They announced this discovery only about a month later! **Prompt for students:** If your students show interest in this aspect, ask them to imagine: *If you were in Tombaugh's shoes or on that team, what would that month have seemed like? Why was it so important to verify this observation? What do you think this process of verification involved? What if the team at the Lowell Observatory had reported this observation as soon as Tombaugh made it and it turned out to be wrong? We have seen that science is open to revision. How is this different from the kind of revision we spoke about?*

We wrote this story specifically for school teachers preparing to introduce their students to the solar system. While Pluto was seen as a planet for only 76 years, it has made a mark on many of us. It is likely that your students will question how matter-of-factly their textbook addresses this 'demotion.' We hope our telling of this story allows you to answer their questions without taking away from the wonder that this example of science as a human endeavour can inspire. We also invite you to choose parts of this story and ways of retelling it that you think will be most engaging to your students.

Curious about the images in this Guide? Here are some details:

Figure (a): Lowell using the 24-inch telescope at Lowell Observatory to observe the sky. Later, Tombaugh used this telescope to photograph Pluto. Both would likely sit in this position for hours. Credits: Lowell Observatory, Wikimedia Commons. URL: https://en.wikipedia.org/wiki/File:Percival_Lowell_observing_Venus_from_the_Lowell_Observatory_in_1914.jpg. License: Public Domain.
Figure (b): Perhaps the only photograph we have of Elizabeth Langdon Williams. What about the other women on her team? Who were they? Credits: Lowell Observatory, Wikimedia Commons. URL: https://commons.wikimedia.org/wiki/File:Elizabeth_Langdon_Williams.jpg. License: Public Domain.

i wonder... Rediscovering school science

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