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Teaching and Learning

Teaching and Learning Astronomy

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Astronomy, pseudoscience and rational thinking

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Abstract: A strong case is made for including astronomy in the school science curriculum, as it encourages a scientific outlook. The realization that awesome natural phenomena can be explained in terms of known science can develop in students the habit of thinking rationally and help them counter superstitions that have traditionally taken root in society. A contrast with a pseudoscience like astrology will further help them to come to grips with the way real science functions.

12.1 Introduction

In 1944, three years before India became independent of British rule, Jawaharlal Nehru wrote in his now famous book *Discovery of India*:

The impact of science and the modern world have brought a greater appreciation of facts, a more critical faculty, a weighing of evidence, a refusal to accept tradition merely because it is tradition . . . But even today it is strange how we suddenly become overwhelmed by tradition, and the critical faculties of even intelligent men cease to function.

He then went on to express the hope that “Only when we are politically and economically free will the mind function normally and critically.” India became independent in 1947 with Nehru as the first Prime Minister, a post that he held for nearly 17 years. Ever an advocate of science and technology as the means of progress, he encouraged establishment of a good scientific infrastructure and also looked after achieving industrial growth. However, what has been the net outcome so far as human resources are concerned? Now we are well into the sixth decade after independence: where do we stand vis-à-vis Nehru’s expectations of rational thinking?

12.2 The present scenario

The picture is not very encouraging! Here are some pointers to how the social mind-set operates today, both collectively and individually:

- (1) Many marriages, even among educated graduates, are decided after the matching of horoscopes. In India, arranged marriages are still the norm, although the prospective bride and groom have greater say in the process. All the same, one condition that many families insist upon is that their horoscopes should be compatible! Many matches, otherwise suitable, are not allowed to take place if the planets disapprove.

- (2) Three years ago, the state of Uttar Pradesh was further subdivided to create another smaller state called Uttarakhand. The date and time of the ceremony for launching the new state was fixed after consulting astrologers. The ceremony was in fact postponed by a few days until an “auspicious period” approved by astrologers began. Likewise, it is not uncommon for state or union cabinets to be sworn in during auspicious periods.
- (3) In 2000, when several planets happened to be in the same part of the sky (i.e., close to, but not exactly in alignment), doomsday was predicted. It was claimed that all sorts of catastrophes, including volcanic eruptions, tidal waves, etc. would occur. This prediction led an entire seaside village in the state of Gujarat to go into a mind-set of panic, with people abandoning their homes and running away. Nothing untoward happened, of course, except that burglars made easy pickings from the abandoned houses.
- (4) During the last decade a new pseudoscience under the name of “*vastu-shastra*,” literally translated as “science of architecture,” is taking hold of the urban middle and upper classes. This subject lays down a series of rules for designing and constructing houses in relation to the ambience. While architects do have a set of rules that seek to relate the environmental factors to the siting of various rooms (e.g., in cold countries of the northern hemisphere, the south face is expected to capture the maximum sunlight and accordingly rooms with south-facing windows are planned), the dictates of *vastu-shastra* do not have any logical connection to environment. Here are some instances of what these rules recommend for the housing site:

If the boundary lines of the plot on which the house is built are not parallel to the magnetic axis, such land is poor for overall growth, peace and happiness.

If the land is high in the north or east directions, it causes financial losses or can damage the prospects of the owner’s male children.

Avoid sites shaped like a triangle as they will lead to government harassment, while a parallelogram can lead to quarrels in the family.

And so on and so forth! These suggestions are taken seriously, and the clients often make the architect change the plans, even demolishing what has already been built. *Editors’ Note:* The Asian practice of *feng shui*, apparently similar in nature, is unfortunately becoming popular in some circles in the USA.

- (5) In 1995, there was a miracle! The idols of Ganesha in several temples all over India began to drink milk if fed through their trunk. (Ganesha is the elephant god, who has the head of an elephant on a human body.) Believing the miracle, huge crowds gathered in these temples. The phenomenon was explained by scientists using the concepts of surface tension and capillary action. Yet many educated persons to date believe that the idol was permeated by a divine presence who drank the milk.
- (6) In the year 2001, the apex body of higher education in India, the University Grants Commission, declared astrology a science and offered funds for instituting its teaching in universities! After protests by scientists, the UGC withdrew the claim that astrology is a science and instead placed the subject in the humanities stream. It was claimed by the UGC circular that astrology provides understanding of time, and that it is useful in business as well as several other fields.

These examples suffice to demonstrate that the goal of rational thinking is still some way away from the mental make-up of the average Indian. The question is whether something can be done to address this dismal situation.

12.3 The teaching of astronomy as an antidote

The disturbing fact about present symptoms is that the trend towards superstitions and beliefs in pseudosciences is growing and the younger generation is getting more and more attracted to pseudosciences. One way to start rectifying the situation is to demonstrate at the school level the way real science works and to contrast it with pseudoscience. Take the following example of chemistry:

In India, non-governmental organizations devoted to eradication of superstitions have two visiting teams doing the rounds of various schools. The first team performs “miracles” like producing sudden changes of colour, fire eating, etc., which the second team, following it, explains by the demonstrations of on-site chemistry experiments. When the unexpected or the unusual gets demonstrated as a known fact of science, the belief in miracles crumbles. Such direct demonstrations have proved to be very useful and effective. The Ganesha phenomenon was likewise demonstrated and clarified by scientific experiments. Although some die-hard believers were unmoved, schoolchildren at least found the debunking effective. I believe education in astronomy right from the school level can play a similar role in this enterprise. For astronomy provides similar instances that distinguish it as a science from pseudoscience. These instances come through several channels, which can be incorporated into school science curricula. Before discussing some examples, I wish to mention that normally astronomy appears in school texts as an extra chapter in geography! The planetary system, the Milky Way galaxy, and the universe are tucked in as the last lesson after pupils have taken in the different geographical aspects of the countries and regions on the Earth. Thus the lesson hardly presents astronomy as a science.

- (1) **Solar and lunar eclipses.** These are relatively rare phenomena but are spectacular (especially solar eclipses) when they do take place. An eclipse may not be visible directly at a given location, but thanks to information technology it can still be seen, on a computer screen, as occurring at another part of the globe. Traditionally, in India eclipses have been considered sinister, with demons swallowing the sun and the moon. At the solar eclipses of 1980 and 1995, for example, cities like Bombay wore a deserted look, since it was considered dangerous to venture out when the sun is being swallowed! Today, a secondary-school student can appreciate that eclipses are mere shadow play. The students can see how it is possible to calculate and predict when an eclipse will occur. One should explain the precautions to be observed while viewing a partially covered sun. One can also take this opportunity to debunk some long-standing superstitions, for example, the belief that it is dangerous for an expectant mother to be out under the eclipsed sun.
- (2) **Transits and occultations.** School students have a passing knowledge of Newton’s law of gravitation. They can appreciate how the law not only governs the fall of an apple but also the motions of planets and satellites. A transit of Venus across the solar disc (June 8, 2004 and June 5/6, 2012) can therefore be exactly timed, which can be demonstrated as a scientific experiment.
- (3) **Tides.** Students living in seaside places are familiar with tides. They can be made to time high and low tides and relate them to the position and phase of the moon. Again the law of gravitation can be brought up to explain the phenomenon.

Indeed the message that can be clearly communicated is that astronomy is a branch of science that epitomizes humanity’s attempt to understand the universe in terms of the

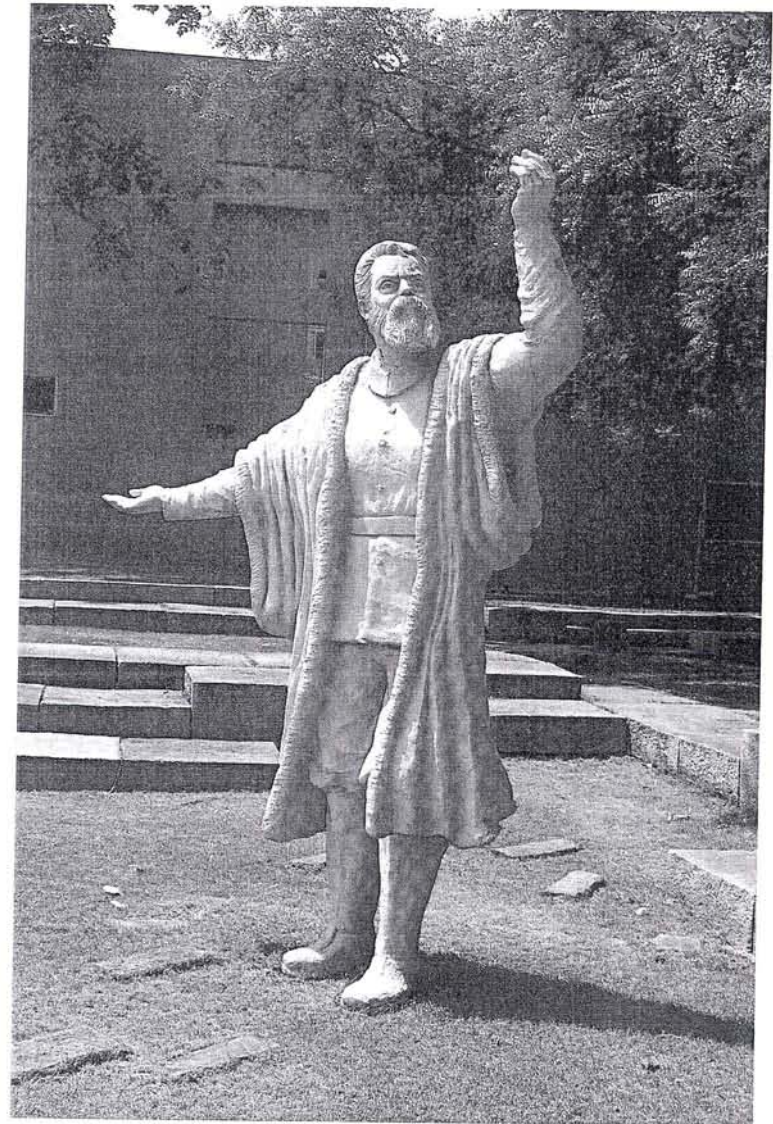


Fig. 12.1. A statue of Galileo Galilei (1564–1642) at Inter-University Centre for Astronomy and Astrophysics in Pune, India. Photo by Jay M. Pasachoff.

science studied here on the Earth. At a more sophisticated level, one can bring up discussions of why the sun shines, why different stars have different colors, how astronomers can study the universe with non-visual forms of light, and so on. But the bottom line should be that one must do one’s best to understand natural phenomena with the tools of science.

12.4 A critical look at astrology

In the Indian context, special efforts are needed to counteract the growing influence of astrology. To contrast a pseudoscience like astrology with hard science like astronomy, the above examples from astronomy may be put side by side with how astrology operates. Thus children could be asked to apply the following criteria to astrology:

- Scientific predictions are falsifiable and are therefore worded in a precise manner. Are astrological predictions so worded or are they vague and could be made consistent with any result? As an example, children may be asked to compare the forecasts for different zodiacal signs that appear in different newspapers and see if there is any consistency in them.
- Even if the astrological forecasts are tested for success or failure, how often are they successful and how often not? The example of coin-tossing may illustrate the circumstance that a prediction may turn out correct purely by chance. So if you correctly predict 50 times out of 100, are you able to claim any special knowledge or special predictive power? At the high-school level, some account of probability and statistics may be brought in to quantify the issues.
- Is the making of a prediction logical and based on some precisely stated assumptions? All too often astrologers are *ad hoc* in their approach, and change the premise *post facto* if the forecast does not tally with facts. It can be explained that science does not permit this luxury. Ideas of Karl Popper regarding falsifying a scientific theory can be explained.
- Do the successes/failures of a prediction depend on who makes them? That is, is there objectivity about them? When a particular astrological prediction fails, other astrologers point a finger at the person who made the prediction, stating that he is not competent. In short, one encounters here a subjective element which is not permitted in science. If a scientific experiment cannot be repeated by other labs, it loses credibility.
- Field tests on large samples and their overall success-evaluation have established the validity of empirical relationships in physics, which were subsequently explained by basic laws. What has been astrology's record with such field tests? It turns out that astrologers discourage such field tests. However, such tests as have been conducted by social scientists and statisticians show that the success rate of an astrological forecast is statistically insignificant.

Ample examples exist in literature in support of the above points and to show why astrology is not a science. It will be worthwhile spending some part of astronomy education in demonstrating these facts to children.

12.5 Concluding remarks

Science teaches rational thinking, and the application of the scientific outlook goes well beyond the laboratory walls. Astronomy boldly applies the laws of science to the grand laboratory that is our universe. Some natural phenomena can be awe-inspiring and, if not explained scientifically, can lead to superstitions and irrational thinking. Children could learn how to think rationally and not get carried away by superstitions, pseudoscience, and loose-thinking, if they are given some introduction to astronomy as a science and are encouraged to apply scientific criteria to see why astrology is not a science. Indeed, at the school level, it may be possible to encourage children to argue with their parents and try to debunk their beliefs! The school may set up a parent-teacher forum wherein such ideas

can be freely discussed. It may be worthwhile involving parents also in the viewing of astronomical phenomena like eclipses, transits, or even routine night-sky watching. In short, there is considerable scope for the introduction of astronomy in the school curriculum, but in the science stream and not as an appendage to geography!

Comments

Martin George: Given the far stronger following of astrology in India, does this make it harder to teach the difference between astronomy and astrology in schools?

Jayant Narlikar: This makes it all the more important to teach it! But in India, because of the stronger following, it is necessary to get the message through to the parents of schoolchildren too. So, yes, this makes it twice as difficult.

Case Rijdsijk: Astrology is on the rise not only in India but around the world – do you have an explanation for this?

Jayant Narlikar: Life-style as a whole is getting more competitive and stressful. There are often situations when a person is at a loss to respond properly. At such a stage there is temptation to leave the decision-making to someone else. Astrology or astrologers claim to provide answers. Even though they are not based on rationality or facts, the so-called answers attract the person especially under a stressful condition. This may provide a possible answer to the question.

John Hearnshaw: You noted that superstition in India has increased since the end of British rule in 1947. Does this mean you advocate a return to British rule?

Jayant Narlikar: No! Of course not! It has been found in other instances that in a repressive regime, free thinking is suppressed, and when the repression is lifted, all different thoughts and beliefs, including superstitions, spread more freely. In the Indian context, one major factor contributing to growth of superstitions is the information technology revolution that has spread pseudoscience rapidly.

Allan Kreuiter: There is a major flaw in Western astrology that precession has changed 12 zodiac signs into 13. Are there similar Indian equivalents, and what is the response to pointing out astronomical flaws in astrology?

Jayant Narlikar: Indian astrology has a Greek, not vedic, tradition that is not known by the public and not appreciated when explained.

John Baruch: One serious pseudoscience we have to deal with in the UK to an increasing degree is creationism. Do you have this problem in India? If so, how are you dealing with it?

Jayant Narlikar: This is only one of many problems we face. There is a website at the AAS put together by a group of four that deals with this (see Chapter 13 of this volume).

T. K. Menon: It is not only in India that beliefs of government officials can influence actions affecting service. For example, in a recent proposal for an accelerator in a Canadian province, the reporters were asked to remove all references to "Age of the Universe" because the Head of Government felt that he knew the answer to be 4,000 years.



Fig. 12.2. Statue of Aryabhata (476–550), an Indian astronomer/mathematician, at Inter-University Centre for Astronomy and Astrophysics in Pune, India. Photo by Jay M. Pasachoff.

Editor's Note: Indian astronomer Aryabhata is thought to have computed pi to five decimal places, to have computed a table of sines, and to have proposed, as Jayaram Chengular of the Giant Metrewave Radio Telescope described, “(1) a heliocentric theory, (2) that the earth spins on its own axis, (3) that moonlight is reflected sunlight, and (4) that eclipses are caused by the shadow of the moon, and to predict eclipses.”

Aryabhata is also the author of the first of the later siddhantas called *Aryabhattiyam*, which sketches his mathematical, planetary, and cosmic theories. This book is divided into four chapters: (i) the astronomical constants and the sine table, (ii) mathematics required for computations, (iii) division of time and rules for computing the longitudes of planets using eccentrics and epicycles, (iv) the armillary sphere, rules relating to problems of trigonometry and the computation of eclipses.

The parameters of *Aryabhattiyam* have, as their origin, the commencement of Kaliyuga on Friday, February 18, 3102 BCE. He wrote another book where the epoch is a bit different.

Aryabhata took the Earth to spin on its axis; this idea appears to have been his innovation. He also considered the heavenly motions to go through a cycle of 4.32 billion years; here

he went with an older tradition, but he introduced a new scheme of subdivisions within this great cycle.

That Aryabhata was aware of the relativity of motion is clear from this passage in his book, “Just as a man in a boat sees the trees on the bank move in the opposite direction, so an observer on the equator sees the stationary stars as moving precisely toward the west.”

The first Indian experimental space satellite, launched in 1975, was named after him.

Reference

www.hindunet.org/science_after_aryabhata/