Education and Training in Basic Space Science and Technology

Rajesh Kochhar

Indian Institute of Astrophisics, Bangalore, India

Ever since human beings learnt to walk upright they have looked at the sky and wondered. The sky has remained the same but human perception of it has changed. First a divinity to be feared and appeased: then a phenomenon to be observed and utilized: and finally a physics laboratory: the outer space over the millennia has acquired a depth, in keeping with tI1e changing patterns of humankind's relationship with its cosmic environment.

Basic space science today is at the cutting edge of intellectual enquiry, and, at its most glamorous, a child of high technology. But it is more than a branch of modern science. It is a symbol of the collectivity and continuity of humankind's cultural heritage. This mixture of science and culture is astronomy's strength as well as dilemma. Strength, because support for astronomy transcends all boundaries: dilemma, because this support transcends science also.

For promoting astronomy worldwide, especially in developing countries with memories of past contributions to science, scientific astronomy and cultural astronomy would need to be placed in a composite context. Even more importantly, modem (post-Copernican) astronomy, or modern science in general, itself would need to be repositioned in a more extended evolutionary sequence.

Cultural Copernicanism

The past few decades have ushered in an age, which we may call the Age of Cultural Copernicanism. In analogy with the cosmological principle (named in honour of Nicolaus Copernicus) that the universe has no preferred location or direction, cultural Copernicanism would imply that no cultural or geographical area, or ethnic or social group, can be deemed to constitute a superior entity or a benchmark for judging or evaluating others.

In this framework, science (including astronomy) is perceived as a multi-stage civilization cumulus where each stage builds on the knowledge gained in the previous stages and in turn leads to the next. Modern science is then the latest stage in continuum which for historical reasons developed in Europe.

This framework however is a recent development. The 19th century historiography advisedly projected modern science as a characteristic product of the western civilization decoupled from and superior to its antecedents, with the implication that all material and ideological benefits arising from modern science were reserved for the West. As a reaction to this, the orientalized east has often tended

to view modern science as "their" science, distance itself from its intellectual aspects, and seek to defend, protect and reinvent "our" science and the alleged (anti-science) eastern mode of thought. This defensive mindset works against the propagation of modern astronomy in most of the non-western countries.

In keeping with the principle of cultural Copernicanism, it would be desirable to construct a history of world astronomy that is truly global and unselfconscious. A step towards this direction would be to use scientifically descriptive tern1S like the Siddhantic and the Zij astronomy in place of the denominational terms like the Hindu or the Muslim (or Arab) astronomy. Also the trajectory from Greek astronomy to modern developments need to be charted out with greater respect for the intervening period. One could emphasize the Babylonian roots of the Greek astronomy itself, and highlight the contribution of the Zij astronomy towards modern astronomy (for example, Copernicus' use of the al Tusi couple). Similarly contributions of the Mayans and the Incas should be integrated into the mainstream. Equipped with this paradigmatic background, we can now address the question of teaching and popularization of astronomy, targeting audience at three levels.

i. Lay-persons, including decision-makers and fund-givers, who hopefully will form a scientifically sound impression about modem astronomical developments and astronomy-based cultural elements.

ii. School students, who would feel enthused about astronomy and retain appreciation for it in later life.

iii. College and university students who would study basic space science with some seriousness and provide from among themselves researchers and teachers.

Much of the following is based on the Indian experience, although an attempt has been made to place it in the wider context so that the analysis may have an extended validity.

Planetariums

A planetarium can be a powerful education aid. It liberates sky viewing from the constraints of weather and seasons as well as earth's rotation and sphericity. It can present cosmic objects and phenomena realistically and dynamically. A sky show can create a visual impact beyond the reach of a class-room lecture or the printed word. In addition, a planetarium can play the role of an astronomical community and education centre and a news room.

The first planetarium to be opened in India (in 1954) was attached to a school. Now itself semi-defunct, it failed to set a trend. There are today about 15 planetariums in India catering to the general public, mostly in bigger cities. The number of planetariums in India is very small when compared to the number of potential visitors. The reasons are financial. The amount of money required to set up and maintain a planetarium is outside the reach of most civic bodies or educational institutions.

Although planetariums attract audience with a diverse background, their programmes tend to be single, omnibus in nature. A typical programme is a mix of modern astronomical information and citations from scriptures and literature, mythology, rituals, social and religious celebrations and folklore. This modern-ethno mix goes well with a section of the viewers but has certain inherent limitations.

Astronomical content of the socio-religious life is based on a physical model of the universe that has since been discarded. The problem then is to devise a trajectory that would start from astronomy-based cultural elements, decouple them from their defunct physical content and arrive at tile modern worldview.

This is not an easy task. People who are familiar with modern science would perhaps find ancient references amusing (more like modern cosmologists' equation with Alice in Wonderland). However a typical visitor to the planetarium, already overwhelmed by modern science which he may even be inclined to view as foreign, may be tempted to view the modern-ethno mix as a modern endorsement of the ethno part. Also relating modern scientific developments to local or sectarian cultural elements rather than to cross- national developments may tend to encourage notions of cultural exclusivity. It is noteworthy that there is hardly any exchange of programmes among the planetariums. Also foreign-produced programmes do not seem to go well with the audience.

Ideally, a planetarium should produce different programmes for different types of audience. One set of programmes should aim to acquaint informed laypersons about their cosmic environment, while another can seek to place the world history of astronomy in a global civilizational context. Also, there should be programmes meant for the students and related to their text books (see next section).

Public lectures

Planetariums and to a lesser degree other organizations, including research institutes and universities, organize public lectures on astronomical topics. Some interesting insights can be obtained from the feedback provided by the lecturers.

The audience seems to be keen to know about the latest on our immediate cosmic neighborhood, the solar system. Description of results from space missions and discussion on the chances of life elsewhere are popular topics, even though extraterrestrial life tends to mean different

things to the speaker and the audience. There is often an interest in the positional aspects, as expressed in questions like: How far is comet Halley these days? or Sun is in Gemini now, isn't it?

Lectures on the physics of the sun itself, stars and galaxies fail to animate the audience which however comes alive when the origin of the universe is discussed. Here the listeners enjoy the feeling of being on as firm a ground as the speaker is. They can freely express their personal opinion on the closure or otherwise of the universe without feeling overwhelmed by the speaker. Of course, black hole remains an all-time favourite of the audience.

Interestingly, very often no matter what the specific topic of lecture, the questions tend to veer towards the scientific basis of astrology. It is not that the listeners want to be guided by the expertise of the speaker in formulating their views. Rather they already have an opinion (mostly pro-astrology) which they would like to see supported. Interestingly, in view of the strong support for astrology among laypersons and publicmen, scientists often refrain from taking a public stand on the issue. Even when they criticize astrology it is often done in such a subtle manner as to render it almost harmless. There have been instances when planetarium directors have lent tacit support to astrological practices or notions, partly out of their own convictions and partly with a view to playing to the gallery.

Popular books

A more permanent source of astronomical information, especially for young readers, is science magazines, science pages of newspapers and popular books. Very often the periodicals reprint articles taken from the international press. Since the background level of Indian readership is different, such reprints are of limited value. A niche exists for popular books in Indian languages. Unfortunately, very often these books are written by authors who do not have a deep understanding of the subject and are content with a superficial photocopy-and-staple job.

Such books (and articles) often contain conceptual and factual errors which innocent young readers are unlikely to be able to detect on their own. The remedy of course is that eminent research scientists and university teachers should write books for young readers. With few exceptions, this does not happen. The reason is that historically modern Indian governance, including the education system, has not operated on the well recognized principle of growth from the grass-root level but on the pretension that intellectual and material benefits given to the top layers will trickle down the hierarchy.

Of the 18 officially recognized Indian languages, two, Bengali and Marathi, seem to have the strongest tradition of science writing. Significantly, a publishing house in Calcutta is working on an ambitious plan to bring out 150 - 200 page books in Bengali on topics of current scientific interest, written and edited by working scientists.

Most of the educational programmes focus on handing down information. There are very few initiatives which seek to familiarize the target audience with the night sky through actual observations or with the nitty gritty of making and using telescopes.

Schools

The Indian school system caters co an enormously large number of students. A small number of schools offer education through the medium of English language, while the vast majority of poorly equipped schools teach through the local language, very often the mother tongue. The system is characterized by heavy centralization, obsession with examinations, severe paucity of funds, and populism. Such a system does not have much of scope for hands-on training. The emphasis is on teaching from textbooks written according to a centrally prescribed syllabus. The respect for and fear of the text-book could still be converted into an asset if the books were accurate, attractive and user friendly. This unfortunately is not the case.

Astronomy does figure in the school syllabus but suffers from over-kill. No attempt is made to ascertain the absorption level of young minds. Even 10-12 year olds are inflicted with terms like chromosphere and thermonuclear reactions. A 1989 text written for school drop-outs aspiring for a bachelor's degree through distance education covers the whole gamut of astronomical knowledge in a span of 60 pages: from epicycles to cosmic microwave radiation; from continental drift to types of clusters of galaxies; from the definition of optical astronomy to the design of Hale telescope.

To make matters worse, the bulky text books often dense, insensitive and not infrequently wrong. A school book informs the child of Saturn's rings adds that Saturn's atmosphere consists of poison gases, leading the child to the scary thought (expressed to friends, and sometimes parents, but to the teachers) that if one looked at Saturn's rings one would die. The distance education text referred to above expands IRAS as International Radio Astronomical Satellite.

In the interest of the mental and physical health of the school goers and for the sake of propagation of astronomical knowledge, it is important to answer the following two questions beforehand: (i) What level of information is consistent with the comprehension level of the target readership of the text? (ii) How is this information to be conveyed in a correct and lucid manner?

Colleges and universities

After spending 12 years in school. Indian students have a number of options open to them. They can join a 4-5 year course in engineering or medicine. (This is the current preference of the brightest of the students). They can go to a college for a 3-year course leading to a bachelor's degree in science, humanities, commerce or management. Courses leading to master's degree in science are offered in

the universities which also offer bachelor-level honours courses in science. The higher education system, like the school, is inflexible and examination oriented. It is also heavily weighted against basic space science

The following are some of the features of the Indian higher education system, which may be of all interest in a wider context.

i. At the B.Sc. level, basic space science is almost entirely absent from the prescribed syllabus.

ii. For the non-science students there is no provision for any astronomy teaching.

iii. Of the 150 odd universities in the country, perhaps no more than five or six have astronomy or space science departments. (Chances of receiving grant-in-aid are higher if the moniker contains the key words space science.). In the universities, there seems to be resistance from well-entrenched branches of modern physics to the introduction of a new discipline like space physics.

iv. There are only two observatories attached to universities; both are dysfunctional. One, with a 1.2 m reflector, due to lack of funds; the other, with a 0.5 m reflector, due to its location right in the middle of a well-lit lively campus.

v. The actual number of students studying for a master's degree in space science (including astronomy) or offering space science as a special paper for M.Sc. in physics is very small.

vi. Most of the teaching tends to be bookish rather than practical, which in turn emphasizes "learning" rather than problem solving. More generally, the social ambience that permeates the academic world also glamorizes brahmanical type of studies as against dirty-hand experiments.

vii. There is almost total decoupling between fund-starved universities and rather well-endowed research institutes. A student enrolling for Ph.D. in the latter has to spend two years acquiring the necessary background knowledge. (Here also emphasis is on theory rather than experiments and observations). This is not a very satisfactory practice. It is better to catch students young. If basic space science were taught at B.Sc./M.Sc. level, many students may discover that they have an aptitute for the subject which they may decide to pursue. A positive, though small, step is the conducting of summer schools where college and university students are given lectures as well as, at times, practical training with optical and radio telescopes.

The Inter-University Centre for Astronomy and Astrophysics established at Pune in 1988 seeks to create an awareness about astronomical sciences among the university and college teachers and students.

viii. Ironically, as the pace of scientific developments in astronomically advanced countries has quickened, the access of astronomically developing countries to current technical literature including modern text-books has decreased drastically. The reasons are: increase in the list-price of astronomical publications; devaluation of most currencies against hard currencies; and general increase in the number of publication channels. During the last 20 years, the price of a typical text may have shot up more than three times. During the same period Indian rupee has gone down from eight rupees a dollar to 40, so that a library would need a 102 times enhanced budget to remain stacked at the two-decade old level. Such money has not been forthcoming. Consequently, interested students often turn to outdated texts. As for research journals, most libraries subscribe to only well known journals, whose standardization itself works against cross-fertilization of ideas. Conference, proceedings, etc, which convey a flavour of the ongoing debate among researchers are often considered too expensive to be purchased.

ix. It would seem that in the absence of a vibrant, demanding and alert student community, it is difficult to produce an authoritative text. In this context, Indian and foreign reviews of a 1992 Indian astrophysics text are instructive. An Indian review obligingly includes a four page corrigenda on "typographical and other errors", The foreign review is gaurded: "While they (students) will find much valuable material therein, particularly in the more well-established parts of stellar interiors/atmospheres, interstellar matter, and motion of stars in galaxies, I fear that they will also find the book rather uninspiring, and short of excitement about the latest topics". Interestingly, while an Indian reviewer expresses his unhappiness at the "price which is unusually high for [Indian] students", the western reviewer concludes, "The fact that it is very cheap in ‘western’ countries must commend It to impecunious students”..... "It would seem almost too good to be true to find a text book on astrophysics for 6!”.

x. It is quite clear that a handful of purely-research institutes, decoupled from the B.Sc./M.Sc. level students can only be of limited utility. If the culture of teaching of, and research in, basic space science is to take roots and spread, the university system at large would need to be activated by creating a core of inspiring teachers and by providing rather rugged, easily repairable small observational facilities under university auspices at a number of spread-out places.

Semi-amateurs

As has already been noted, many better performing students these days prefer to join institutions offering engineering and other professional courses rather than enroll in pure sciences. Many such institutions have good or excellent workshop facilities. They are in addition mostly residential, so that the students are free of family loyalties and restraints.

This segment of the student community needs to be encouraged to take to astronomy. They can set up astronomy clubs with the help of interested faculty members and even establish small observatories to house 20-30 cm aperture telescopes. They can expect to receive free consultancy, encouragement and technical help from research scientists on individual as well as institutional level.

In view of the limited human and material resources in astronomically developing countries, there is need for cross national cooperation and exchange of notes so that mistakes are not duplicated and benefit can be obtained from others' experience. In training of manpower and preparation of source material, countries at more or less same level of industrial development can coordinate their efforts under the auspices of agencies like the United Nations, and take to studying and enriching basic space science as an intellectually stimulating and culturally enhancing exercise.

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