Teaching of Astronomy in Asian-Pacific Region

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Preface

We start to publish our Bulletin of "Teaching of Astronomy in Asian-Pacific Region" of the International Astronomical Union (IAU) by this issue of February 1990. A Working Committee (WC) of astronomical education in the Asian-Pacific (AP) region of the IAU was settled during the A-P regional meeting of the IAU held in Beijing in October 1987, to discuss our efforts for activation of astronomical education in the AP region. After exchanging some numbers of letters within members of the WC, the chairman of the WC made proporsals on our activities: 1) to promote exchange of materials and techniques for astronomical education, 2) to promote activation in teaching of astronomy at some AP countries having no professional astronomers, 3) to promote exchange of school teachers and their ideas, and 4) to start a regular (semi-annual at the begining) publication of this Bulletin. These proporsals were approved at the WC meeting in Baltimore, USA during the IAU General Assembly in August 1988. The Chairman of the WC hopes this Bulletin will support activities of astronomical education in the AP countries and will develop much.

February 26, 1990

Syuzo Isobe
Chairman of the WC

Members of the WC
S. Isobe (Chairman; Japan), A. A. Aiad (Egypt),
B. Hidayat (Indonesia), Z. Lee (China),
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SYDNEY OBSERVATORY AS A MUSEUM

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INTRODUCTION

For one hundred and twenty four years, Sydney Observatory's main role was to carry out astronomical research. In 1982 the Observatory became a branch of the Museum of Applied Arts & Sciences and thereby undertook a new role as a museum of astronomy. A four-year, million dollar project was begun to restore the building and its grounds to their 19th century appearance.

PAST AND PRESENT EXHIBITIONS

Since 1982 there have been three exhibitions in the building. The first was put in prior to the start of the restoration programme. It was a very basic exhibition with many panels containing text and illustrations. The highlights were a large Sun-Earth-Moon model, a random access slide projector and a computer which showed the northern sky visible from Sydney on any chosen date.

The restoration was planned in three stages specifically so that at least part of the building could be kept open to the public throughout most of the work. Although subsequently the Department of Public Works used this as an excuse for delays in completing the restoration, it was an invaluable exercise. Much was learnt about running the building as a museum and a number of improvements were accordingly made in the restoration plans.

The close of the first exhibition coincided with the opening of the "Return of the Comet" exhibition in 1986. This exhibition on Halley's Comet was somewhat more elaborate. In the first and main display area visitors found themselves in a spaceship. In the spaceship there was spot lighting, synthesized music and a fluorescent background of stars and galaxies. Exhibits included:

.the written record from 1835 of the first (European) sighting of Halley's Comet in Australia and the telescope with which the observation was made;

.the telescope with which the Great Comet of 1861 was discoverd;

.plates of the comet made at the Observatory in 1910, together with modern contrast enhanced prints from the plates;

.computers, interactives and a 10-minute audiovisual.

During the five months the exhibition was open it was attended by 47,000 visitors.

The present exhibition is called "Hands-On Astronomy" and it has been open since January 1988. It consists of over twenty interactive exhibits. They are prototypes which are being trialled for possible use in the planned permanent exhibition.

PLANNING AN EXHIBITION

A visit to a museum should not be a passive experience. We live in the television age in which people are trained from an early age to have short attention spans. Yet many astronomical exhibitions still consist mainly of panels with photographs and detailed text scattered around walls. These "textbook-on-the-wall" kind of exhibitions make astronomy seem rather dull. The information in them could be much better conveyed in a publication. A museum exhibition should take advantage of the three dimensional possibilities that are not available in other media.

There are a variety of tehniques that can be used to create a worthwhile exhibition. Among them are:

.The display of real objects. These should be INTERPRETED to bring out their significance.

.One way of interpreting them is to RECREATE a scene and put the objects into context. For example the Transit Circle room at Sydney Observatory could be restored to what it would have looked like a hundred years ago with chronographs and clocks.

.LABELS AND GRAPHICS are important in interpreting objects and are a crucial part of any exhibition. The labels should convey the essential information required but should do it succinctly and at a level that can be easily understood by children and adults with no background in the subject.

.INTERACTIVES are an important part of a modern exhibition. They are a useful way of illustrating scientific principles and they are extremely popular with visitors, especially children. Although there are many interactives that can be found in museums throughout the world, interactives on astronomy are rare. Sydney Observatory is one of the few places in the world that has been developing them.

.COMPUTER INTERACTIVES on astronomy have great potential. Important concepts can be conveyed to visitors in a form that is lively and stimulating. Computer graphics, animation and quizzes can be used. These exhibits tend to be the most popular, especially with children. The programmes have to be specially written so that they are indestructible and the instructions for use are so simple as to be clear to the visitor within a few seconds. Commercially available programmes are not suitable.

.VIDEODISKS are a modern technique. A number of disks on astronomy are available, each with up to 54,000 images. With a computer controlling the videodisk player many imaginative interactive displays are possible.

.AUDIOVISUALS can be used in a variety of ways from a 30 minute multi-slide projector presentation in a darkened theatrette (as at the Parkes Visitor Centre) to a 20 second looped video running on a monitor among other exhibits.

.Many concepts can by vividly illustrated by three dimensional scale MODELS. A model of Sydney Observatory in 1858 could show the original usus of the various rooms. Other possible models could be of the AAT and of the interior of the Sun.

.An INTERESTING ENVIRONMENT could be created as was done for the Halley's Comet exhibition at Sydney Observatory in 1986.

.An important facet of any exhibition is that there are helpful human beings -GUIDES- for the visitors to talk to and ask questions.

Future exhibitions at Sydney Observatory will utilise the concepts outlined above to make it an exciting place to visit.

FUTURE EXHIBITIONS

The next exhibition at the Observatory is likely to be a temporary exhibition tentatively titled "the Eye and the Telescope". This will examine some aspects of vision such as colour and the perception of stereoscopic depth and relate them to astronomy. A number of spectacular David Malin photographs will be included in the exhibition.

Some planning has been undertaken for a permanent exhibition but it is likely to take a few years for that exhibition to eventuate. It will discuss the history of astronomy in N.S.W with an emphasis on the achievements of Sydney Observatory. Timekeeping at its relevance to astronomy will also be covered. Modern astronomy will be represented by a section on the Solar System and another section on techniques of modern astronomy.

In the long term there are plans to extend the building to create more exnibition space and to build an underground planetarium seating about 120 people. If and when these plans are likely to come to fruition depend on the vagaries of politics.

During 1988 three aquariums opened in Sydney. Will we have to wait till 2088 for a much needed planetarium?

SDNEY OBSERVATORY : PUBLIC PROGRAMMES

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What I hope to do in this paper is to look at the two major sub-themes of this conference. Namely, what is currently being done to try to communicate the excitement of astronomy to the general public? And perhaps more importantly, how could we do this better? I'll be paying particular attention to the public programmes currently being offered here at Sydney Observatory to examine these questions.

When I first started in this job, back in '84, I was fortunate enough to go on a two month tour around the world to look at a whole range of public observatories, planetaria and similar institutions, which in some way or other are educating the public in astronomy; and I sometimes found regrettably, examples of visitor centres or displays at research observatories, which were mediocre, fairly unsuccessful, and which basically didn't work.

An example of what I believe to be an unsuccessful astronomy display for the public is regrettably fairly close to home and I think that anyone who has been to the visitor centre at the AAT at Siding Spring would most probably agree with me, that it could be qreatly improved.

This display, which has been up now for some years, was I understand, put together by a professional astronomer and a graphic artist only. Much of it consists of enormous amounts of printed information all over the walls, written at such a high level that one could easily think it was lifted straight from a university textbook. It doesn't succeed as a teaching tool for educating the general public in astronomy because it's written way above the interest level and ability of the average person.

Now I appreciate that professional research institutions have as their primary function, that of research and not public education. But it still seems to me a pity that often this enormous interest that the person in the street has in astronomy is not tapped and utilized by everyone in the profession. Token efforts in the long run achieve little, in that they neither broaden the public's appreciation of astronomy as a profession, nor do they exploit the financial and other possibilities which could arise from a more educated average population.

OK, I've criticised some other places, but perhaps it's time for us to look a little bit closer to home and see whether we've done any better here at Sydney Observatory.

In the middle of 1984 I was appointed as the first permanent education officer assigned to the observatory which only a year or so before had become a branch of the Museum of Applied Arts and Sciences. My brief was basically to devise public programmes in astronomy and to assist in the development of the site as both Australia's only museum of astronomy and as a public observatory.

In late 1983 the Government commenced a restoration programme for the building and the grounds to restore them to their 19th century splendour-a project which in the end cost a little over one million dollars and which completely changed for the better, particularly the interior, this lovely old building. One of the first priorities that we gave to public programmes at the Observatory was to tackle what we discovered to be a chronic lack of audio visual material.

The Observatory had been neglected for a number of years in many ways and there was very little in the way of slides, films or videos that could be shown to the public. Some had been shown for years and years; I remember well, first looking at the old rusted cans in which they were kept and which had obviously been around for some time.

I recall one film which was so old that the colour had completely faded, it was sort of sepia tinted throughout.

Perhaps the best example of all was one which had been made, I think originally by the CSIRO and which talked in glowing terms about the future of radio astronomy when the Parkes Telescope opened!!! So, in the first 12 to 18 months a considerable sum of money was spent on simply buying audio visual programmes to show to the public because astronomy is a difficult subject in some respects to explain. In other areas of this museum there are a number of objects which form part of the collection, and indeed astronomy also has objects, primarily in the area of clocks and telescopes.

The difficult and unique aspect of astronomy, in presenting it to the public, is that you can't really bring into a room and show to people the primary objects that are under study. You can't show people planets at close range, or pass around a star to examine or walk outside and look at a galaxy in the yard. So you're very much dependent upon visual representation of most of the objects of research and study in astronomy. And that's why we decided very early in the piece that this was a subject area where visuals played a very critical part and that the best and highest quality visuals, whether as slides, printed material, films or videos, were absolutely essential to run successful and stimulating programmes for the public, and for schools.

So all told we probably have spent colse to $16,000 on quality audio visuals which are used widely. We have a huge number of slides and a very good collection of video discs,video tapes and 16mm films which are shown regularly in the public programs. Also, we decided that most people come to an observatory, particularly a public observatory, to see telescopes and look through them. This is especially the case with our night visitors. They don't come here basically to look at the history of the building or of the people who have worked in it, or of research projects that have occurred within its confines. They come here to learn about the sky and whenever possible to look at things in the sky through telescopes.

From the start we decided to stress the pulic viewing sessions which are held every night, and over the years we have expanded them quite considerably. When I began, we used to open four nights a week, one session a night. We now open 6 nights a week, one session a night for six months of the year, two sessions a night for darker months of the year. And these are very successful of all these evening programmes were the recently completed Mars Opposition viewing nights where for three weeks we removed our usual restrictions on bookings and adopted an "open door" policy. Over 20 nights we had more than 6,000 visitors through the Observatory. Up to 580 in any one particular night and we stayed open for three hours with three telescopes operating non-stop.

Early last year, the Government provided a small amount of money (I think the final figure was about $150,000) for the museum to fit out the building, after the completion of the restoration programme. There was some debate within the museum whether we should commit this money to installing some sort of a permanent exhibition, however small and low-key.

It was my view and that of the staff who work on the site, that the amount of money was quite insufficient to mount a worthwhile permanent exhibition in the building, and eventually that point of view won. The money was spent on developing the lecture theatre that you're sitting in today; also to buy a new telescope for the north dome, and develop prototype interactive exhibits which you can see throughout the building.

The observatory of course has had for over 100 years, a telescope in the south dome. This 29cm refractor has been used for public viewing sessions for many years and exclusively for public use since the research functions were curtailed in 1982. We felt that there was a need to have, in the northern dome, a modern telescope-something that would contrast with the historical one in the south dome. We're very pleased that recently we've inaugurated public viewing sessions with a new 35cm computer controlled reflector and that seems to be working fairly well.

In the longer term we would hope to use it with a television camera, which would actually show pictures down here through the video projector.

Finally, I'd just like to refer to some of the difficulties we had in tracking down good quality teaching programs on astronomy. As you would all be aware, the vast majority of the Earth's population lives in the Northern Hemisphere and the problem with that is that the Northern Hemisphere has a totally different sky to the Southern Hemisphere.

So, whenever we looked for good quality teaching films or videos about the night sky, we've always been hampered by the fact that they were always made in the UK or the USA, or maybe Canada, and hence had little relevance to Australian skies. Apart from the lack of people, another problem with the Southern Hemisphere is that not only is the vast majority of it water, but of the land masses that are there and the peoples who inhabit those land masses, the numbers that speak English as their native tongue are very much in the minority. Apart from Australia and New Zealand and a small number of people in South Africa, there are very few groups who have English as their first language.

This has presented a problem for potential makers of films and videos on Southern Hemisphere skies, because the market is particularly small and unless you do a, say, Spanish version of your film, you don't have very much chance of getting your money back. So, when some funding became available form the museum about the beginning of this year, I investigated very quickly the idea of doing a video, on the Southern skies and in collaboration with Terence Murtagh, the director of the Armagh Planetarium, we put together in June this year, a 20-mimute video called "Southern Stars" which looks briefly at the Southern Hemisphere skies over the four seasons of the year and tries to help people find their way around.

THE PAST AND PRESENT STATE OF ASTRONOMY EDUCATION IN THAILAND

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ANCIENT THAI ASTRONOMY

About 300 years ago in Lopburi and Ayudhaya, many astronomical observatories were designed, constructed, and supported by the Roman Catholic priests from Europe and by King Narai the Great of Siam (Thailand). The interesting recorded history of Thai astronomy was found in the national museum of France a few years ago. Afterwards, the ruined observatories were searched for and found. A tercentennial commemorative ceremony of Thai astronomy was held on April 30, 1988.

The French emissary and the Roman Catholic missionaries in the reign of King Louis XIV first visited Thailand in 1685. Besides intending to spread the Catholic religion, they carried out research on surveying local and celestial positions. A Thai royal astrologer calculated and predicted a total lunar eclipse on December 11, 1685. King Narai, together with the missionaries, observed the eclipse at Lopburi through a telescope having magnification of 30 to 72. A partial solar eclipse was also observed near the same place on April 30, 1688. Sanpaolo, a Catholic church on the outskirts of Lopburi, was the site of the first astronomical observatory in thailand, built in 1685. Another observatory in Lopburi, built in the house of a Persian emissary, later became a Thai temple. Other astronomical observatories were supposedly built in Ayudhaya, the capital of Thailand in King Narai's period, and should be worthy of search and restoration. However, the historical events on record have not yet been clearly found out.

About 120 years ago, King Rama IV in the Charkri dynasty, greatly interested in astronomy, precisely calculated and predicted a total solar eclipse on August 18, 1864. The king, together with Thai, French, and English people, were eyewitnesses to the eclipse at Wakor in Prachuabkhirikhan. Until now, no one clearly understands what method he successfully used for this masterpiece. An astronomical observatory was built at Khaowang in Petchaburi in 1860. The king measured the height of the sun and pursued his calculation in astronomy. He set 100 East as the Thai Prime Longitude. A clock tower built at this longitude started Bangkok Mean Time, earlier than Greenwich Mean Time. His palace was furnished with telescopes, microscopes, barometers, and other scientific instruments. He was declared "The Father of Thai Science" not long ago. August 18, the date of his predicted eclipse, was selected to be "the Thai Science Day," in which scientific exhibitions, demonstrations and/or other activities yearly take place in schools and universities throughout the country.

PLANETARIUM AND POPULARIZATION

The Bangkok Planetarium, situated beside the national science museum, was established in 1964. The planetarium, with a dome 20-meters in diameter, has a seating capacity of 500. Within the planetarium precincts, an astronomy exhibition is well planned. It contains various photos, posters, and models, but lacks computers.

The thai Astronomical Society was formed in 1980, the year in which the Astronomical Amateur Society closed. The society office shares the rooms in the planetarium building. This society has about 1,000 members, mostly amateur astronomers. Their activities are various. Astronomical training, seminars, and colloquia are occasionally held with astronomy lecturers. Competitions in astronomy tests, photos, and drawing pictures and periodically held and/or alternatively held on special occasions such as the Thai Science Day. The society issues books, slides, pictures, constellation maps, and a quarterly journal in astronomy. New aims are to possess bigger telescopes and to restore the ancient observatories in Lopburi and Ayudhaya.

PUBLICATIONS

Television, newspapers, and popular journals are rarely helpful in regularly distributing articles on astronomy except for news about launching of spacecraft and well-known celestial objects such as Halley's Comet and Supernova 1987A. At present, there are two important monthly scientific journals, which are great favorites among students. The journals regularly publish articles on astronomy. Popular pocket books on astronomy are usually not beyond amateur comprehension. Textbooks written by university lecturers are published merely to benefit their teaching, and are seldom sold in bookstores. Advanced textbooks from abroad are insufficient.

PRIMARY AND SECONDARY SCHOOLS

At the primary-school level of education, there are many self-taught books to practice reading and comprehension of the physical environment. Five of these books are on elements of astronomy: the sun, the moon, stars, rockets, and a journey to the moon. At the secondary-school level (grades 7 to 9), no astronomy book is available. Lessons concerning astronomy appear in a few chapters of science textbooks. Only liberal arts students, not science students, in all high schools (grades 10 to 12) can take optional subjects in physical sciencs. One of the books, entitled "The Earth and Stars," largely contains concepts about motion of the earth, the moon, and planets.

UNIVERSITY LEVEL

In each education college, students majoring in general science are required to take an astronomy course. For example, the course in astronomy and space is compulsory in Surin Education College. The contents of this course are mainly electromagnetic waves, astronomical instruments, celestial objects, and space exploration. This course in general astronomy is neither profound nor complex, it is appropriate for students who are going to be teachers in secondary schools.

In some universities, an elementary course on astronomy or partially on astronomy is open to most undergraduates. The contents of the EARTH AND SPACE SCIENCE course in Srinakharinwirot University mainly includes elementary climatology, geology, and astronomy.

AN INTRODUCTION TO ASTRONOMY is a compulsory course for general science students in Srinakharinwirot University. This follows a textbook written by Baker, ASTRONOMY. A similar course is elective for all science students is Khonkaen University but elective for physics students in Chiangmai University. The other elective course for physics students in Chiangmai University is ASTROPHYSICS, largely concerning the foundation of astrodynamics. Physics students in Chulalongkorn and Khonkaen Universities and offered ASTROPHYSICS and SPHERICAL ASTRONOMY as elective courses. A seminar and/or a project in astronomy can also be supplementally selected by physics students. A few laboratory exercises in astronomy are usually included in physics laboratories for physics students.

RESEARCH PROGRAMS AND M.Sc.LEVEL

Only chulalongkorn and Chiangmai Universities offer the M.Sc. in astrophysics. Astrophysics students mostly take the same compulsory physics courses as other physics students, they also take 3 to 4 selective astrophysics courses, seminars, and a thesis on astrophysical research. In Chulalongkorn University, theoretical stellar research, or observational solar or comet research can be chosen as a thesis topic for a master's degree in science. Variable and binary stars can be selected as a research project in Chiangmai University, which has equipment for photoelectric photometry and 40-cm (16-inch) telescope. Analyses of the positions of celestial objects and eclipses are carried out by astronomers in Khonkaen, Chulalongkorn and Srinakharinwirot University. Silpakorn University is likely to begin solar observation with a filter passing the K-line of ionized calcium. Without qualified technicians and advanced technology, some of these practical research projects are managed with difficulties.

PROBLEMS AND HOW TO SOLVE THEM

Astronomy in Thailand is improving at a slow pace, and sometimes, oscillates up and down. Difficult conditions exist more in advanced levels than in primary and secondary-school levels. For example, the best observatory admits the public but hardly allows cooperation in research with other universities. The government ordinarily pays little attention to astronomical support since such support is not in the country's development plans. Many astronomers, lacking sufficient equipment and encouragement, often find it so difficult to carry out their research that they turn their attention to other fields. Moreover, advanced journals and textbooks are insufficient. All these cause gaps in astronomy education.

These problems may be eradicated by cooperation with astronomers from well-developed countries in astronomy. It would be good to establish well-planned observatories in Thailand, managed by an efficient staff of foreign astronomers who could make justified allowances to enable enthusiastic Thai astronomers to participate in research. Starting from such a step, Thai astronomy would be likely to be on the threshold of prosperity.

DEVELOPING UNIVERSITY LEVEL CURRICULA AND RESEARCH PROJECTS : SPACE RESEARCH

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ABSTRACT

Challenge of space, demands an integration of diverse and varied fields in order to develop a new discipline of teaching at the university level. Interaction of education and space research for their mutual benefits and for the society in general is reviewed. An effort is made to answer some of the basic questions concerning the impacts, features, characters and suitability of space studies as an academic pursuit. The manpower requirments are estimated to the order of 1,00,000 persons besides a high potential of employment in allied fields. A comprehensive list of various aspects of the space research programme are appended. Different curricula have been suggested. Various categories of research projects are identified. The universities of the developing world do not have a culture of large scale infrastructure for innovative experimentation. Their problems and options have been addressed to. An international centre for space studies is proposed to redress the balance and to enhance the involvement of the developing world, particularly in application of the space technology.

INTRODUCTION

Over the last fifty years, the effort initially directed

Revised version of the invited talk at the United Nations International Meeting of Experts on the Development of Remote Sensing Skills and Knowledge, in co-operation with the Government of the United Kingdom, hosted by the University of Dundee, June 26-30, 1989.

towards the defence R&D and the study of the near earth environment has grown into a full-fledged field of space research. Revolutionary and dramatic developments have taken place during the thirty years, the post Sputnik period in particular.

Participation of universities and the research institutes in the space R&D programme had been extensive. Rather, most of the science programme were initiated and run by the universities. As such the training of the manpower in this direction is an automatic spin-off of the R&D effort. This was true only for the leading countries. Even formal courses for training were limited to a very few centres and were limited in their extent to a few specific aspects or fields. There was no time to initiate a comprehensive programme. Again, such prgrammes could be conveniently introduced only in an open system where pattern of formal education is not rigid or sequential. As a result, the American system being open could involve itself on a larger scale than most other national systems.

When it comes to applications, the world over the end users of space programme like those in the field of remote sensing and application to natural resources, environmental monitoring, mass communication,etc. have had different training; most often they had a strong base in their own fields where space based results could be applied.

In order to make space research a part of teaching and research activity at the university level, we try to define its basic characteristics. Space research here represents various activities of space programme of the last three decades. It includes the study of space sciences, space technologies, their applications and the impact on human conditions. Some segments of individual components of the space research have already been assimmilated in the educational programmes of advanced countries. Otherwise, whatever effort was made, it was largely to popularise the achievement of space research programme among the masses and in some ways even at the primary level of education. The Satellite Instructional Television Experiment (SITE) is one highly cited and commended experiment by the Government of India. It was carried out with the help of the geostationary satellite ATS-6 on loan from the NASA in mid seventies (Rahman, 1970). Villagers from 2,400 villages participated and were exposed to educational material on agricultural practices, family planning, natural resources, etc.

In the present context, the effort is to present the space research as a new integrated discipline and as a part of the educational system. In the following pages we have tried to look at the interaction of higher education with science and technological progress so as to evaluate how space research is becoming a source of change, of employment and enhancement of educational levels. Section 3 represents various charecteristics and impact of the new developments in space. It is followed by an assesment of the manpower requirements. Potential of space research to be followed as an academic pursuit is treated in section 5. Section 6 defines contents and various combinations for the curricula for different aspects of space sciences, technology and its application. Section 7 deals with the research projects. The problems of the developing countries with particular reference to India are covered in sections 8 and 9. A suggestion for an International Center of Space Studies is proposed in the last section 10. A list of various aspects of space research and suggested courses are appended at the end. The cases listed are illustrative and in no way exhaustive.

HIGHER EDUCATION AND SCIENTIFIC & TECHNOLOGICAL PROGRESS

Higher education provides the basic structure for human development. This is recognised in the set up of the university systems and other centres of higher learning which thereby become cradles of thought and innovation. This in due course has an application to various faculties of human existence. In a way, the evolution and development of higher education is the history of human endeavour. To suit their respective socio-economic situations, the developing countries need to pursue and adopt modified systems.

The general features of the contemporary scientific and technological progress are generally referred to as the scientific and technological revolution (STR). The STR today is an ongoing transformation of science, technology and society. It does not stop here. It has a strong impact on the educational systems which in the process, have generated the STR. The educational systems and stretched, modified and in certain situations go through a revolution. An additional factor in this interaction is that the STR is not linear nor are the new trends. Consequently, forecasting of new trends may not highlight some of the lesser foreseeable side effects of new technology. This could be more significant for education than for technology itself (Unesco, 1985).

Certain aspects of the close relationship between science, technology and education though apparently less evident, are significant in respect of their mutual development. New technology leads to new production processes, management systems, new socio-economic conditions including a shift in the demand for job skills and in certain situations even for new values and life styles. The new situations do affect the content of education, its objectives, teaching methods and the structure of education system for new technologies. Informatics and space technology are two such recent examples.

Space research has become valuable for global economic and social development, particularly in the area of communication, earth resources, meteorology besides the whole technology of warfare. Space research, when considered as a part of scientific and cultural programmes, contributes to human knowledge and provides the foundation to make useful application of the new technology (Pardoe, 1984).

CHARACTERISTICS OF SPACE RESEARCH

Space research is startingly new with a very fast rate of development.

It has its impact on science, technology, human existence and conditions of living.

It involves very large scale integration of basic sciences and technologies. Such a situation has not been experienced earlier in any scientific endeavour. However, it also involves even very small scale experiments by amateurs (Gee, 1984).

It has demanded miniaturisation in a big way. And hence it has introduced sophistication in all industry. The concept of microscale has arrived as a result.

It demands a new order of standardization so as to achieve extremely high reliability, lifetimes of ten or more years for a space probe with alternating periods of high activity and hibernation. Voyager 2 is one of the finest examples of this process at work.

Earth observations from space has its strategic implications in both the military and civil fields. It has generated the new fields of remote sensing and natural resources.

Advanced warfare demands the most advanced applications of space technology. Most of the earlier space programmes were primarily for the military.

Today, space research is an industry of its own where there is a powerful competition (Hertzfeld, 1985). The future plans involve manned space stations, solar power stations, etc. in order to develop space based industry such as material processing under microgravity and clean environment, the production of very high value medicines, etc. Today the slogan is whatever can be done in the laboratory can also be tried in space. And that is space research!

It has revolutionised communication beyond anticipation. Some of the spin-offs are large scale data handling, controlling traffic, navigation, direct broadcasting satellites and hence mass communication.

It brings in a large scale integrated participation of the governments, the public, the institutes, the universities, the industry. For example in putting man on the moon, more than fifty thousands industries, agencies and universities participated.

It has led to the development of new systems, systems management, new concepts in management of industry and other fields.

It has political implications whereby different nations have joined hands to develop technology for putting space labs in the orbit, even on a commercial scale and hence to compete with one another (Naraine, 1984). The European combine (the European Space Agency, ESA) was the first such effort and has led to many joint ventures in a big way. Multinational commercial venture INTELSAT is another example of participation by more than one hundred countries around the world. Consequently, coordination has taken place in other sectors also.

In other words, space research has affected the basic processes of human mind and conditions of human existence. It has led to new attitudes and perceptions of the world we live in.

MANPOWER REQUIREMENTS

For such a diverse and comprehensive endeavour, a very high calibre manpower of administrators, scientists, technologists, middle level technicians and of course the decision makers is required. Over thirty years, the space programme has attracted and effectively employed a large manpower. But there had always been a lack of systematic training and formal teaching programmes to prepare such manpower, as it has been expressed in a dramatic manner by Swan and Swan (1984): "Remember the excitement of the 1960's during the rush to the Moon? Because of that race, there was no time to develop a cadre of skilled people trained over a period of 20 years in various disciplines of space. The Soviet Union and the United States rushed headlong into space depending on the education and skills developed for other endeavours. The excitement of space travel drew the best of the professionals mature enough to contribute significantly to the landing on the Moon. That period in history will surely not only be recorded as the greatest single achievement of scientific adventurism but, also, as unique in its remarkable management of the complex mix of the best talents of a generation".

It is rather difficult to have an estimate of the manpower requirements. Some of the projections are of the order of 50,000 men. The NASA employs about 22,000 men. The ESA has a strength of nearly 2,000 scientists and engineers. The Indian Space Reasearch Oraganisation ISRO employs 15,000 persons. A country like India at the present juncture would require about 600-1,000 persons every year trained in various aspects of space programme. This does not include technologists employed for the development of various segments of space technology.

At one stage it was estimated that the British have run short of trained manpower for space industry to the tune of 5,000 men (Farmer, 1981).

SPACE RESEARCH AS AN ACADEMIC PURSUIT

Basic requirements of any sustainable teaching and research programme in any field of study are the existence of intellectual challenges, employability, professional satisfaction, etc. The intellectual challenge implies new research potentials or initiatives arising every three to five years. This attracts committed intellectuals and idealists. Interestingly, the space research has projected a set of new research problems and challenges more often than any other field in the domain of science and technology over the recent years. It has led to the generation of a new set of satellites, every time attacking a new situation in the physical world of space. There had been serious failures but the future prospects such as those of the Hubble Space Telescope compensate.

Space research does satisfy basic requirements of teaching and research programmes. It is supported strongly with a vast routine data collected over the years with the help of various spacecraft missions.

The chances of adopting space research as a profession is debated by students, teachers and research workers at the higher level of the educational systems. Adopting space research as a career implies that one is getting on to basically a research career.

Should one plan going on to a research career? Will it be useful and remunerative in a wider perspective? For example in industry, and employer does not necessarily welcome the extra qualifications that a Ph.D., brings. It some cases, the employer is happy when the topic of the research is relevant to the firm at a certain juncture of its research activity. This is likely to happen in the case of engineering subjects but in case of esoteric of highly specialised/theoretical topics this may not be so. Some employers may recognise achievements of a higher degree by giving more money vis-a-vis the first degree entrants. Is the difference worth the extra effort put in? It takes a minimum of three years for a Ph.D degree. While a competent first degree entrant could have compensated or probably done better by advancement through the job over the corresponding period of the research worker. This does not imply that one should not do research if given an opportunity, but one should do it for the right reasons. A research career is therefore to be taken up more for its intellectual challenge than for money which the higher qualifications may bring.

At this juncture, a totally academic career is likely to be harder to get on with. The academic career has its own distinctive and exclusive identity. In spite of all the hardships and financial constraints, it is followed by a set of committed individuals. Space research in this sense represents one of the biggest challenges of the human endeavour.

The space research has generated new branches of knowledge like remote sensing. Its application to meteorology and the atmospheric sciences is a challenging job. The employability in such fields is high.

Initiating and carrying on a basic and mass education of space research in itself has a high employment potential.

CURRICULUM : WHAT TO INCLUDE?

To introduce and develop university level courses in space research is to integrate segmented components in the existing curriculum. This is one way of doing it, the other is to develop it as an independent discipline. The former is possible in an open end educational system. In the latter case it is to be formulated in an integrated form. However, a large number of problems arise in any such formulation. To start with, we consider the following components for introduction in any educational system:

Basic space science
Application to other sciences as a tool
Space technology

The basic space sciences include the near earth environment, the newly acquired knowledge of the solar terrestrial physics and the traditional fields of astronomy and astrophysics. It has a wide range, from the most practical aspects to the deepest cosmological questions (Fig 1). A contemporary scene is also listed in Appendix I. It is adopted from a NASA study "Out Look for Space" and represents a comprehensive list of sixty one future space objectives classified into 12 themes. The Cospar listing of various activities is also a very comprehensive list. Fig 1 and Appendix I represents various segments and linkages in space research. Different compatible combinations will generate suitable curricula.

To begin with, one year diploma courses could be introduced in between the degree and the research programme on specific fields of study such as remote sensing (imaging and image processing), aeronomy and solar terrestrial physics, meteorology and atmospheric sciences, rockets and missiles, exo-biology, etc. Some examples are listed in Appendix II and the list is no way exhaustive.

Curriculum may be formulated for self contained two or three year degree courses. This will depend upon what stage of education these are introduced at. This will also have to be related to the background level of physical sciences. The courses could also have a component on remote sensing, but limited to the science and techniques of imaging and image processing.

In the second stream where emphasis is more on applications than on basic sciences, diploma courses between a degree and a research programme could be introduced on space sciences and space technology. This will reorient candidates towards an understanding of the present day space programmes and its various segments so as to build a comprehensive background: how various space research systems work, how the data is collected, what sort of problems and limitations are involved in such missions, etc. This will further extend and interpret the results in the field of specific interest where the space programme had been applied. This is in order to exploit the full potential of the space probes such as the planetary probes, remote sensing satellites, communication satellites and various other systems, largely oriented towards the study of the environment and the cosmos.

There are now possibilities of using an orbiting space platform to conduct experiments on basic sciences like the chemical reaction rates, biological sciences, growing technologies like bio-technology, crystal growing or to develop medicine and microchips. Courses need to be evolved around these anticipated developments.

The space technology is a very significant segment of the space programme. The effort involved in it is estimated to be of the order of ninety percent of the space research activity. It integrates various disciplines of engineering and technology. A curriculum is to be evolved for an integrated course on space technology. High calibre technologists are required to be reoriented for various aspects of space technology, for example thermal engineering for the protective shield of the re-entry vehicle. Short term courses for selected fresh engineers/technologists need to be introduced between the first degree and the research level.

RESEARCH PROJECTS

A research project in the universities is an extension of the teaching programme or vice versa. It is difficult to draw a line between teaching and research, particularly in any open system of education. The research projects also depend upon the manpower and other infrastructure available in any universty department or a research institute.

Research projects in space research are manifold and span over the whole gambit of its activities. Thousands of research projects are conducted around the globe. Some of these involve large scale commitments as in the case of Faint Object Camera at the back of the Hubble Space Telescope.

The research projects are also generated on the basis of on going studies. Most of the space research projects in the fifties were an extension of the ground based studies of the upper atmosphere and of the solar system. One of the important examples of development is how the high altitude research in a small way in fifties led to the discovery of magnetosphere. Now the massive subject of magnetospheric physics occupies over 1,000 scientific investigators throughout the world and is represented by the publication of some two or three original research papers per day in formal scientific literature (Van Allen, 1988).

The university staff would normally like to take up projects which are based on analysis of data collected otherwise or theory oriented problems or at best, projects with traditional low technology experimental set up which can yield quick results by way of research output. However some of the university departments/institutes well equipped and carry a complete system's responsibility. This is rather a fashion in the developed and leading countries. However to do so, the universities in collaboration with the space agencies and/or the private sector can create a proper infrastructure in the form of a laboratory. The Mullard Lavoratory of the University College of London is one such example.

Independent ground based observations are required and are initiated to support the space based studies. AE satellites for the atmospheric studies, ground based observations for the Hubble Space Telescope or the ground truth for the remote sensing satellite observations are some of the examples being followed in space research.

Each one of the objectives of the NASA study (Appendix I) is having a variety of research projects to achieve these. For convenience, the projects may be classified as follows:

Space Sciences	Theoretical studies
	Modelling and simulation
	Data analysis of space missions
	New experiments for future probes
Space technology :	Mission concepts
	Fabrication and integration of systems
	Particular Specific Technology problem
Applications :	Remote sensing
	Earth resources
	Energies
	Atmospheric sciences/Near earth environment

DEVELOPING COUNTRIES AND SPACE RESEARCH

Space research involves the whole world. It is a global phenomenon. There is a concept of so called global space community. The participation of the developing world is marginal. The activity as "end-user" is slowly picking up; for example the use of remote sensing imagery for natural resources. The emphasis in space exploration is shifting towards its applications and hence its commercialisation. In the process, the developing world can significantly use the spin-offs. Remote sensing, weather forecasting, hazard forecasting, communications, etc. are some of the examples. New programmes are being generated. However, adoption of any high and sophisticated technology is a slow process.

There are insurmountable difficulties. In the developing world there is a serious lack of general awareness regarding the uses and applications of the space programme even among the administrators and policy makers. The latest information conveniently available in the advanced countries does not reach the third world. Reference material (like the imagery from remote sensing and meteorological satellites) is either not available or is beyond the purchasing power of individuals or institutions who could study and utilize it. In certain situations, it takes so much time to obtain the required material that one's interest in the study is lost.

There is a shortage of experts to work on application oriented projects based on the data obtained from various space missions. Whenever an expert is available, the onus of keeping track of different activities of space programme and allied fields falls on the expert, besides taking care of one's own specialisation. One starts looking after and working in too many things, becomes more of an administrator than a scientist. In certain cases it can even work out to undoubted advantage to initiate and build a group and in other cases it could prove otherwise.

The adoption of technology is a serious long range endeavour particularly in a hostile environment. There is no choice but to build around the available manpower, to build a nucleus to train youngsters on the job or through short term sandwich courses. The developed countries may provide experts who could understand the prevailing conditions and hence initiate work with lesser facilities at the grass roots. Moreover, channels of information and data in a digestable format are required.

The curriculum for the developing world has to be on the same lines as in the developed world. For the education of the end-users, the curriculum will have to be modified to suit the socio-economic and geomorphological conditions. Some of the books may have to be rewritten accordingly.

The university culture in the developing countries is at variance with that in the advanced countries like USA, UK, West Germany or Japan. There are a number of obvious reasons. University research in developing countries is not sponsored by industry. The funding is largely by the government and its agencies. University laboratories are not adequately equipped for any experimental venture. Limited funding, fear of wastage and long gestation period discourages initiative into big and/or sophisticated experimental initiatives. However, there are isolated efforts and possibilities. Some of the modest programmes are suggested below. The examples are limited to a few ground based and space based studies of the near earth environment. However, the projects can be and are in thousands. Any list of the existing studies of any space agencies (say, COSPAR) will be illustrative and not comprehensive (cf.,Appendix I).

The traditional ionospheric research with such conventional techniques as ionosondes, dopplometers, total electron content measurements, ionospheric drift measurements, ionospheric absorption measurements, VHF/UHF scintillations from satellite transmissions, etc. can be undertaken.

VHF radars such as ST & MST radars are available in many developed countries as well as in a few developing countries. University groups sith a good space physics background can submit well thought out programmes for studying the dynamics of the upper atmosphere.

With increasing frequencies being used for radio communications, universities can initiate a number of application-oriented projects to study rain rate, rain attenuation, water vapour attenuation, rain drop size destribution to specify fade out margins in communication systems both in terrestrial and satellite based links.

Rocket and balloon pay-loads can also be tried with very modest lab facilities. Simple experiments such as Langmuir probe, ozone pay loads, propagation experiments, electric field experiments, and IR-Xray astronomy payloads, etc. are possible.

Simple optical telescopes can be pressed into service in association with high precision clocks to monitor the deceleration of orbiting satellites. This will give input for neutral atmospheric densities, thermospheric temperatures and their variation with solar activity as well as perturbations caused by magnetic storms.

The contribution of developing countries in the recent past in optical and radio astronomy has been of considerable value. As this discipline is gradually shifting from those of manpower oriented programmes to those of high tech instrumentation oriented programmes, the contribution from universities in developing countries is likely to come down. This has to be prevented by carefully planned programmes in locations that are not easily available in developed countries.

The theoretical study of orbital dynamics, planning of future interplanetary and space probes, participation in in-orbit new sciences are again within the reach of the laboratories and institutions of the third world.

The remote sensing both as a science and as an application is a full-fledged fast growing field to provide basic resource parameters for the developing countries. This aspect needs a separate treatment and a write up.

INDIAN EFFORT

The pattern of education in India is traditional (Wentzel, 1989). Five years of primary schooling, five years (three and two) of secondary schooling, two years of intermediate level, two years of undergraduate, and two years of graduate work is the break up. One year is being added to the untergraduate course as part of a new education policy (Ministry of Education, 1985). Doctoral work can extend from two to any number of years. The education in India is supposed to cater to a population of 800 million. Presently there are about 150 full-fledged universities with over 6,000 colleges affiliated to these universities where the bulk of undergraduate teaching is done. There are 40,000 high schools and at least five times as many primary schools. Astronomy and Space Sciences in small capsules is being taught in about twenty universities as a part of the physics courses at the masters' level. At some places, a few topics have been introduced at the undergraduate level. Interestingly, there is a fairly good content of popular space science at the primary level.

Recently there has been lot of activity at the amateur level, with about twenty planetaria, space and meteorological activity centres. The coverage in newspapers, over the TV as an extension of the Indian space rsearch programme is comparable to even the advanced countries. The sponsored research programme by the Indian Space Research Organisation, ISRO supports a large number of space research oriented projects in the centres of advanced studies and the universities. There are about 600 professionals involved with various aspects of space and astronomy in the country. The courses involved deal with certain portions of space technology also.

The ISRO has generated an effective infrastructure in the field of Remote Sensing over the last two decades or so. A further push has been given by the successful launching of the

Indian Remote Sensing Satellite (IRS-1A). At present about a dozen regional centres in the field of remote sensing exist. Teaching and research is conducted in about twenty five institutions. There are two nodal institues, the Indian Institute of Remote Sensing at Dehra Dun and the National Remote Sensing Agency at Hyderabad (Krishnamurthy, 1988). The courses are both basic and application oriented, short and long term extending to one year and Ph.D. programmes. The emphasis is on end users from various fields of environmental studies and natural resources. The study of basic imaging and image processing sciences and techniques is also being established.

We at Patiala have the following basic courses along with a Ph.D. programme.

Two years: M.Sc. course in Astronomy and Space Physics.
One year : Diploma in Space Sciences.
One year : Diploma in Meteorology and Atmospheric Sciences.
One year : Diploma in Remote Sensing.

We have generated some infrastructure, largely for the ground-based observations of the atmosphere, boundary layer, ionospheric studies, night airglow, satellite tracking. A full fledged observatory for meteorological studies has been set up which has a radiosonde and two weather radars. It is further supported by solar observations and astronomical telescopes upto the size of 60 cm.

INTERNATIONAL SCHOOL OF SPACE RESEARCH

Smaller and less developed countries find it very difficult to generate any significant infrastructure, both in terms of instrumentation and expertise, in order to develop a meaningful and comprehensive programme of teaching and research in space and its applications (Serafimov, 1985). However, the developed world, being the leader, is strengthening its base everyday. To compete with the two giants in the field is not easy. For that matter, at one time, even the West European countries had to delibarate and combine so as to have a collaborative venture in the form of the European Space Agency (ESA). The less developed countries can follow this example and combine. One small step in this direction is to establish an International School for Space reseach as a major international facility to redress the balance. It will generate programmes for the developing world.

The circumstances make the school not only timely but imperative. The school will provide a centre of excellence for teachers and students interested in space research, from the participating nations. Besides conducting a vigorous research programme of its own, the Centre will enable workers to visit it for varying durations. Large research projects could also be formulated and pursued. The projects could be conceptual, theoretical and applied in nature. Some infrastructure could be generated around the globe for effective participation in space programmes and missions. The aim will be to enable workers from less equipped areas to have access to the state of the art in instrumentation as well as in theoretical know-how. The activity will be supported by creating an excellent reference library, data centres and high quality computing facilities.

The school will take up teaching in collaboration with the existing departments around the blobe. It will also conduct advanced level workshops and summer schools on a routine basis. The ultimate aim will be to provide facilities, on the lines of the International Centre for Theoretical Physics at Trieste for the third world. The experts will be from all over the world. Funds for this purpose could be sought from various space and international agencies.

The details of the management system, the structure of the Center, its placement, etc. need to be worked out separately.

ACKNOWLEDGEMENT

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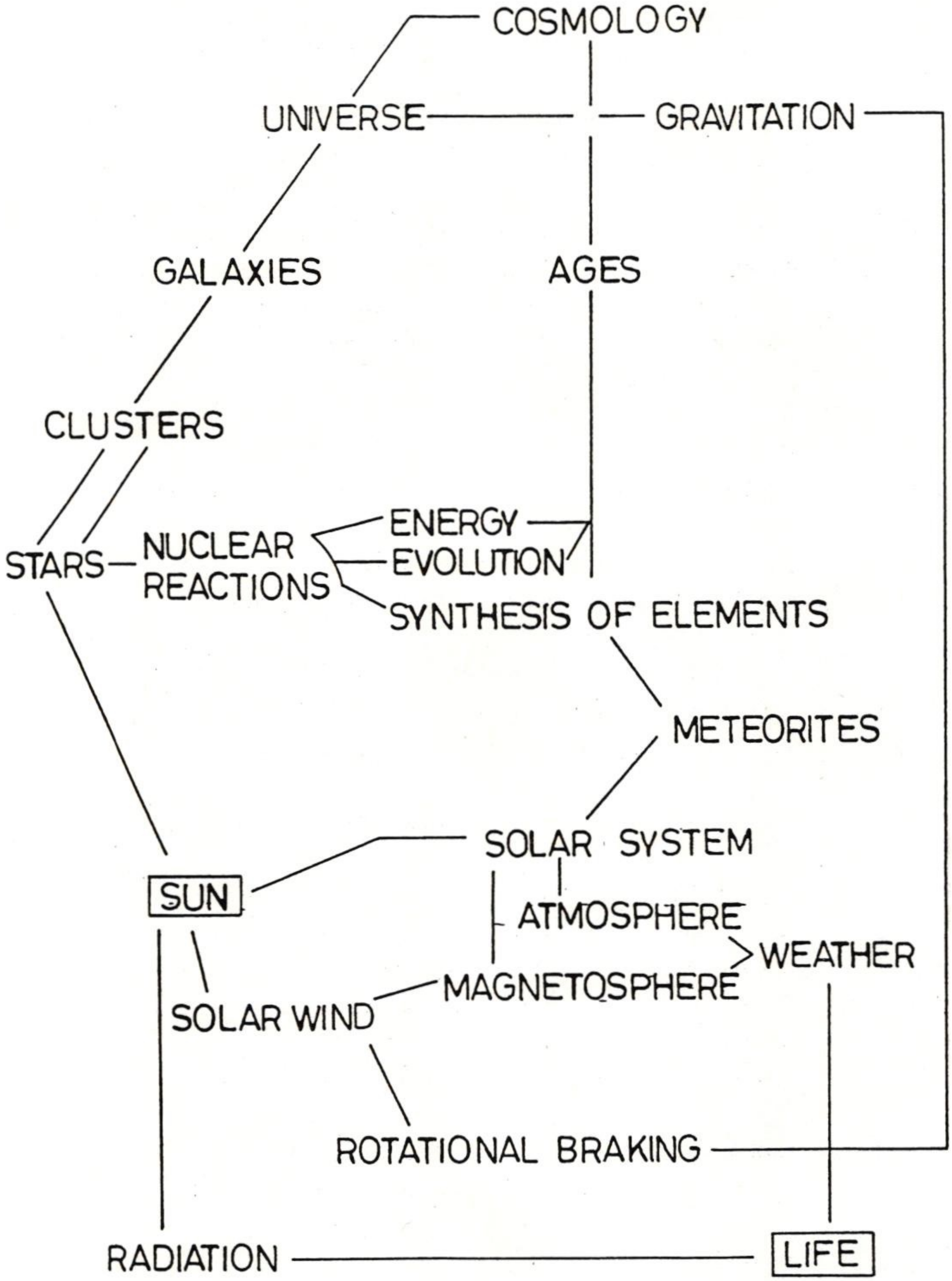
COSMOLOGY
UNIVERSE
GRAVITATION
GALAXIES
AGES
CLUSTERS
STARS
NUCLEAR
REACTIONS
ENERGY
EVOLUTION
SYNTHESIS OF ELEMENTS
METEORITES
SOLAR SYSTEM
SUN
ATMOSPHERE
WEATHER
MAGNETOSPHERE
SOLAR WIND
ROTATIONAL BRAKING
RADIATION
LIFE

FIG.1

APPENDIX I

EARTH ORIENTED ACTIVITIES RESPONSIVE TO BASIC HUMAN NEEDS

THEME 01: PRODUCTION AND MANAGEMENT OF FOOD AND FORESTRY RESOURCES

Global Crop Procuction Forecasting
Water availability Forecasting
Land use and Environmental Assessment
Living Marine Resource Assenssment
Timber Inventory
Rangeland Assessment

THEME 02: PREDICTION AND PROTECTION OF THE ENVIRONMENT

Large-Scale Weather Forecasting
Weather Modification Experiments Support
Climate Prediction
Stratospheric Changes and Effects
Water Quality Monitoring
Global Marine Weather Forecasting

THEME 03: PROTECTION OF LIFE AND PROPERTY

Local Weather and Severe Storm Forecasting
Tropospheric Pollutants Monitoring
Hazard Forecasting from In-Situ Measurements
Communication-Navigation Capability
Earthquake Prediction
Control of Harmful Insects

THEME 04: ENERGY AND MINERAL EXPLORATION

Solar-Power Stations in Space
Power Relay via Satellites
Hazardous Waste Disposal in Space
World geologic Atlas

THEME 05: TRANSFER OF INFORMATION

Domestic Communications
Intercontinental communications
Personal Communications

THEME 06: USE OF ENVIRONMENT OF SPACE FOR SCIENTIFIC AND COMMERCIAL PURPOSES

Basic Physics and Chemistry
Materials Sciences
Commercial Inorganic Processing
Biological Materials Research and Application
Effects of Gravity on Terrestrial Life
Living and Working in Space
Physiology and Disease Processes

THEME 07: EARTH SCIENCE

Earth's Magnetic Field
Crustal Dynamics
Ocean Interior and Dynamics
Dynamics and Energetics of Lower Atmosphere
Structure, Chemistry, and Dynamics of the Stratosphere Mesosphere
Ionosphere-Magnetosphere Coupling

EXTRATERRESTRIAL ACTIVITIES RESPONSIVE TO INTELLECTUAL HUMAN NEEDS

THEME 08: The Nature of The Universe

How did the Universe Begin?
How do Galaxies Form and Evolve?
What are Quasars?
Will the Universe Expand Forever?
What is the Nature of Gravity?

THEME 09: THE ORIGINS AND FATE OF MATTER

- What is the Nature of Stellar Explosions?
- What is the Nature of Black Holes?
- Where and How Were Elements Formed?
- What is the Nature of Cosmic Rays?

THEME 10: THE LIFE CYCLE OF THE SUN AND STARS

- What are the Composition and Dynamics of Interstellar Matter?
- Why and How Does Interstellar Dust Condense Into Stars and Planets?
- What are the Nature and Cause of Solar Activity?
- Corona and Interplanetary Plasma
- What is the Ultimate Fate of the Sun?

THEME 11: EVOLUTION OF THE SOLAR SYSTEM

- What Process Occurred During Formation of the Solar System?
- How do Planets, Large Satellites, and Their Atmospheres Evolve?
- How can Atmospheric Dynamics be Quantified?
- What are the Origin and History of Magnetic Fields?

THEME 12: ORIGINS AND FUTURE OF LIFE

- How Did Life on Earth Originate?
- Is There Extraterrestrial Life in the Solar System?
- What Organic Chemistry Occurs in the Universe?
- Do Other Stars Have Planets?
- Can We Detect Extraterrestrial Intelligent Life?

APPENDIX II

PROPOSED COURSES: EXAMPLES ONLY, not an exhaustive list:

Degree courses:	Space Technology	
Duration:	4 years	
Contents:	Basic engineering	40%
	Space technologies	40%
	Specific technology	20%

Note: Advanced treatment of one of the following

- Space Stations
- Satellite Communication
- Thermal engineering
- Space Antenna Technology

Degree courses: One of the following:

- Astronomy and Space Physics
- Atmospheric Sciences
- Environmental Sciences
- Astronomy and Astronautics

Duration: 2-3 years

Contents:

40% Basic Tools (Mathematics, Physics Electronics)
40% Specific field of study
20% Space Research
Project/open and lab work in the last year

Diploma courses: One of the following:

- Remote Sensing
- Satellite Meteorology
- Satellite Communication
- Data Processing
- Flight Dynamics

Duration: 1-2 year

Short Term courses:	Any theme from the space objectives in Appendix I
Duration:	1-3 months
Contents:	Respective material
	Space environment 30%
	Topical Studies 40%
	Applications 30%

INSTRUCTIONAL RESOURCES FOR TEACHING THE HISTORY OF ASTRONOMY

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ABSTRACT

The presentation of a course in the history of astronomy offers a challenge to the instructor in locating and obtaining an adequate selection of instructional resources. Slides, photographic prints, and overhead transparencies have become available through a number of suppliers. Reference texts and photocopies of archival documents are more difficult to acquire unless time is spent in visiting antiquarian bookshops and astronomical repositories with extensive archival holdings. These resources are essential for teaching the history of astronomy in a manner which will both stimulate and encourage students to pursue the subject in depth on their own.

My area of research has been mainly in the history of 19th century astronomy. During this 100 years, what advances and discoveries were made and which of these were most significant to the science of astronomy? A transfer of observational activity took place, moving from positional to physical astronomy, large telescopes came into operation and permanent records, which an astronomer could study later, became available through the invention of the photographic process. Selected regions of the sky could be mapped and the light from individual stars could be analysed by the application of the spectrograph. With all these advances, the 19th century came to an end, however, before an explanation was found to account for the tremendous and continuous energy output of the star closest to the earth, the sun.

REFERENCE TEXTS

Reference texts should be selected, and made readily available to the students, which cover the biographies of major participants in the subject and others dealing with the history of the development of the science. A short list of recommended authors and titles follows:

Great Astronomers by Sir Robert Ball
(London; Isbister and Co. Ltd., 1901).

Martyrs of Science by Sir David Brewster
(London; John Murray, 1846).

A Short History of Astronomy by Arthur Berry
(London; John Murray, 1898).

A Popular History of Astronomy during the 19th Century
- Agnes Clerke
(London; Adam & Charles Black, 1908).

A History of Astronomy from Thales to Kepler by J.L.E.Dreyer
(New York; Dover Publications, 1953).

History of Physical Astronomy from the Earliest Ages to the Middle of the Nineteenth Century by Robert Grant
(London; Robert Baldwin, 1852).

A Treatise on Astronomy - The Cabinet Cyclopaedia
- Sir John Herschel
(London; Longman, Rees, Orme, Green & Longman, 1833).

Handbook of Astronomy by Dionysius Lardner
(London; Lockwood & Co., 1875).

Pioneers of Science by Sir Oliver Lodge
(London; MacMillan & Co. Ltd., 1904).

A Test-Book of General Astronomy for Colleges and Scientific Schools by Charles A. Young
(Boston; Ginn & Company, 1893).

TRANSPARENCIES

While transparencies are available in sets for teaching a course in introductory astronomy, there are few covering topics in the history of astronomy. With overhead projector pens available in a range of colours, the "home-made" transparency offers a better approach. Here specific aspects of the subject can be isolated and presented as the instructor wishes, revealing a touch of personal ingenuity.

ILLUSTRATED BOOKLETS AND PHOTOGRAPHIC PRINTS

The Science Museum, South Kensington, London, stocks a wide selection of photographic prints covering sundials, water clocks, astrolabes, sextants, quadrants, telescopes and chronometers. When mounted, these are most useful in arranging a small display on a particular area of the history of astronomy to awaken student interest.

The Illustrated Booklets provide excellent condensations of the history of specific topics, for example, Astronomical Telescopes, Astronomy Globes and Orreries, Spring Driven Clocks and Watches and Timekeepers, Clocks, Watches and Sundials. The illustrations, in colour, are of the highest quality. The brief descriptions in the text are adequate in coverage for a student in an introductory course.

SLIDE SETS

For slide sets dealing with historical iteme in astronomy, the best source of these is the Bookshop of the National Maritime Museum, Greenwich, England. The sets cover topics such as Stonehenge, the Old Royal Observatory, Chronometers and Navigation Aids.

With major planetariums now established in many countries, bookstores attached to these carry a wide variety of slide sets and individual slides on historical topics in astronomy. Information can be obtained through the bookstores on other potential sources of slides. NASA and other government sponsored Space Agencies have sections which supply slides on Lunar Exploration, views of Planets, Satellites and Ring Systems, originating from the spacecraft photos taken during fly-by or closest approach to these objects in the solar system. In teaching a course on the history of astronomy, the instructor may use these slides in presenting "Old and New Astronomy". Slides can be made from figures of these same objects, appearing in text-books of the 19th and early 20th century, to illustrate the "Old" astronomy. Students will become aware of what the advances in technology have done in making feasible the recent exploration of other members in the solar family.

ARCHIVAL SOURCES

In many countries astronomical societies have long been established;in some instances the membership is comprised of professional astronomers while for others professional and non-professional (amateur) astronomers are involved in the organization. The Royal Astronomical Society of Canada falls within this latter category and includes many members from countries outside of Canada. Such societies frequently have a committee designated to look after the history of astronomy which may lead to the development of an Archive and a Library to serve the needs of members of the Society.

National Observatories, that is those supported by government, develop libraries to serve mainly the needs of professional astronomers. Storage of observations remains, for the most part, as the responsibility of the observatory. Notebooks and documents related to published papers may be stored in an observatory archive and later transferred to the National Archives. There may be no fixed policy on this procedure; if an index is available, or a published list of manuscript collections, these greatly assist in locating the papers of a specific astronomer. Observatories connected with a university frequently use the University Archives (normally part of the Library system) as a repository for historical information.

Archives provide services to the historian of astronomy through photocopies of documents and, if figures and tables are to be used in a publication, these will be supplied as photographic prints. Credit should be given to the supplier of these items. Photocopies of archival documents are unquestionably the best means of arousing student interest in the subject. The archival searching carried out by the instructor is basic in isolating and condensing the important contributions made by an astronomer during his career. If I refer to my own work, I have looked closely at the development of astronomy during the mid-19th century in Fredericton, New Brunswick, under William Brydone Jack. His papers and notes have been well looked after and are stored in the University of New Brunswick Library-Archives and in the Archives of the Provincial Museum.

In the abstract of one paper which I published in the RASC Journal, the following summation appears:

"Four main phases comprise his contributions to this science: the building and equipping of the first astronomical observatory in Canada, the preparation and presentation of the first public lectures on astronomy given in Canada, the improvement of land surveying in New Brunswick through the establishment of methods for standardizing surveyor's chains and checking magnetic compasses, and the application of "galvanism" or the electric telegraph to the determination of differences of longitude between centres in New Brunswick and the United States".
From the above abstract, a student taking a course on the history of astronomy visualizes the distinct steps taken by Brydone Jack as the science of astronomy and his own career developed. The student is confronted with a problem common to all natural sciences, standardization, and the steps taken on this in the previous century. What approaches would be followed to-day? There is the realization that the electric telegraph was being applied to one of the more difficult problems in astronomy, longitude determination. By understanding the methods used in the mid-19th century, the student may enquire in his own way what he would do at present to determine the longitude of his observing station. In the northern hemisphere he must be aware that, due to a convenient Pole-Star, the latitude of his station is easily determined.

SUNSPOTS-AN IDEAL TOPIC FOR A COURSE IN THE HISTORY OF ASTRONOMY

In teaching a course covering the history of astronomy, the instructor is provided with unique opportunities to select a specific topic and follow its development. In watching this science unfold, the student will have a valuable and memorable experience. Sunspots is one of many topics which is ideal.

The discovery of sunspots has been associated frequently with the invention of the telescope and its first practical application to astronomy by Galileo about the year 1609. Recent work on early astronomical records by Stephenson and Eddy has shown sunspots were known and observed by non-telescopic means many centuries prior to the first decade of the 17th.

With a small low-power telescope, Galileo observed these objects moving across the disk of the sun at different speeds, depending on their position or latitude. Just after the mid-19th century, Carrington studied sunspot movement at greater length and concluded the sun rotated on an axis and exhibited differential rotation. That is, its period of rotation was markedly different at the solar equator and at the poles.

By the latter part of the 18th century, Alexander Wilson had analysed the change in shape of a sunspot as it approached and eventually disappeared over the solar limb. He deduced sunspots were depressions in the surface of the solar disk, thus bringing to an end the earlier supposition the spots were planet-like opaque bodies floating in the solar atmosphere. Sir William Herschel speculated about the spots, assumed he was looking through luminous cloud layers above the sun's surface and seeing a dark solid surface beneath which was possibly habitable. Joseph Henry, a physicist in the United States, measured the temperature of several spots and found values much below that of the surrounding areas on the solar disk.

It remained for an apothecary, H.Schwabe, To compile a lengthy record of daily observations on sunspots. After two decades he reported finding a certain periodicity in the appearance and disappearance of these objects, giving rise to the ten-year, and later the eleven-year sunspot cycle. Shortly after this announcement it was discovered that the frequency and magnitude of magnetic disturbances on the earth followed a similar eleven-year cycle.

As the student is guided through the stages of the steady progress of the science of astronomy, illustrated here by the build-up of knowledge on sunspots, an awareness develops of the need for systematic observations followed by logical deductions. During a period of about two and a half centuries, the significant features apparent to the student are the periodic rotation of the sun on its axis, at a differential rate (a contrast with the rotation of a solid body like the planet earth), the true nature of sunspots, the temperature of the spots compared with the surrounding areas on the solar disk and the periodicity in the number of spots, which is connected to the periodicity of magnetic disturbances on the earth. This ideal topic should stimulate a student to study in more detail the visible features of the nearest star, the sun, and heighten his consciousness of the profound influence this body exerts each day on the planet earth.

The intent of this presentation has been to provide a few brief examples of areas for study and sources of available information in the history of astronomy. The number of topics which could - indeed should - be studied is limited only by imagination. The close examination of these topics should lead the researcher and instructor into virtually every aspect of published and unpublished materials, audio-based information, visual and other cartographic items and even commercially produced sources pertaining to individuals, events, theories and discoveries bearing on astronomy and its history.

RECENT DEVELOPMENTS OF ASTRONOMICAL EDUCATION FOR HIGH SCHOOLS IN KOREA

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Ministry of Education of the Korean government has launched two major programs for the advancement of high school education in Astronomy. These are

(1) the supply of telescopes to high schools and student science museums, and
(2) new editions of text books for high schools.

TELESCOPES

The Korean Government has intensively promoted the reinforcement of science education programs in high schools for last few years. As of this program a total of ninety telescopes, seventy-five 10 cm reflectors and fifteen 15 cm reflectors, were purchased by the Ministry of Education from local manufacturers and were given to high schools and the student science museums in major cities in the nation. Students that belong to schools where there are no telescopes and recommended to go to the nearest student science museum that is well staffed. There are ten such museums run by the government and two others by private organizations at present. Of those museums, student museums in Pusan City and in Kyongi Province are noted for their equipment, the former preserves one 20 cm Goto reflector and ten refractors and reflectors of smaller aperture, and the latter is furnished by one 30 cm reflector and six smaller refractors and reflectors.

SCIENCE TEXT BOOKS

Science text books for Junior High School (7th grade to 9th grade) had been published only by the Ministry of Education annually under government policy to maintain the high standard and the quality of the books. This policy, however, has been changed to be opened to other publishers for competition, and then the Ministry approves six different text books from those that meet the qualifications set by the Ministry each year. Astronomy section occupies 38 pages in the third volume, which is for 9th graders.

Science text books for Senior High School (10th-12th grade), have two different names, SCIENCE and EARTH SCIENCE. SCIENCE has four different volumes; Ia (biology), Ib (earth science), IIa (physics), and IIb (chemistry). Volumes Ia and Ib are required of all 10th graders, and the astronomy is contained in Volume Ib with 36 pages. In 11th grade, students are required to chose between a science emphasis or a liberal arts emphasis. For those science major students of 11th and 12th grade Volume IIa and IIb and PHYSICS and CHEMISTRY are required and either BIOLOGY or EARTH SCIENCE is required according to the student's choice.

For those liberal art students of 11th and 12th grades, only two subjects among four (PHYSICS, CHEMISTRY, BIOLOGY, and EARTH SCIENCE) are required of their choice.

Subject	Student
SCIENCE Ia, Ib	All 10th graders (Liberal arts, Science, and Technical majors)
SCIENCE IIa and IIb + PHYSICS and CHEMISTRY + One from BIOLOGY and EARTH SCIENCE	11th and 12th graders (Science major only)
Two from PHYSICS, CHEMISTRY, BIOLOGY and EARTH SCIENCE	11th and 12th graders (Liberal Arts major only)

Astronomy takes one whole chapter (70 pages) in EARTH SCIENCE, which will be used by the 1990 academic year. Each of text books will last for five years with minor revisions each year. Text books for Senior High School are also competitive, and seven publishers were selected by the Ministry for the 1990 edition.

The adoption of text books of all kinds depends solely on individual school teacher who will test the books over a period of examinaion for one month. Each of the books being examined are numbered. After a period of examination by the teachers, the Ministry of Education collects the numbers of books requested by teachers throughout the country that will need to be printed.

Request for the details of astronomical program in Korea from readers is welcomed.

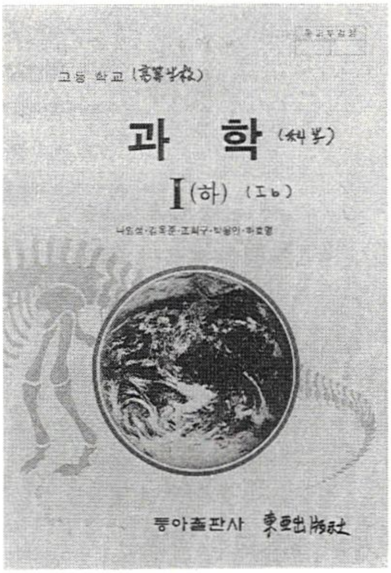

Fig.1. Cover page of one of seven SCIENCE Ib, the senior high text book to be used for 1990-1994.

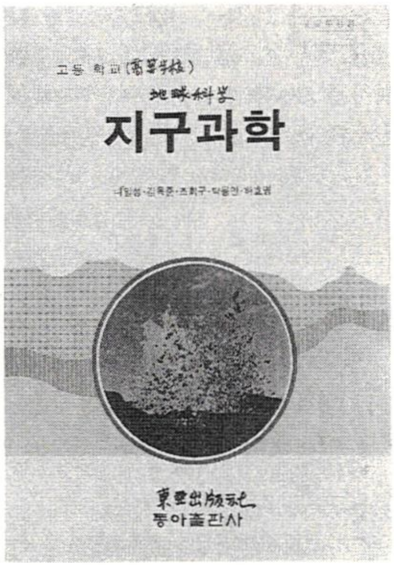

Fig.2. Cover page of EARTH SCIENCE book for 1990-1994.

The Present Situation of Astronomy Education in the University of the Air

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1. Introduction

The University of the Air is the university where students learn by means of radio and television as well as textbooks, like the Open University in England. Schooling also is set up for some subjects. The University consists of only one faculty, the Faculty of Liberal Arts. Students who graduate from the University receive the degree of Bachelor of Arts. The Faculty has the following six majors: Living and Welfare, Human Development and Education, Social and Economic Studies, Industry and Technology, Humanities, Understanding Nature. Physical science belongs to the major field of "Understanding Nature". All the faculty members belong to one of the major fields.

There is not an entrance examination for the University. Anyone who has a high school diploma and whose age is equal or over 18 can enter the University as a regular student. There are four kinds of students. Regular students can graduate from the University and obtain the degree of Bachelor of Arts. Nonregular students for one year are enrolled in the University for one year Nonregular students for one term are enrolled in the University for one term. Special students, who have not a high school diploma and want to become regular students, can become regular students after acquiring 16 credits.

The university was established in 1983 and it started to accept students in 1985. In 1989, 544 students obtained the degree of Bachelor as the first graduates. The university has adopted a two term system since 1989.

2. The Present Situation of Astronomy Education

At present, the teaching staff of the university for astronomy consists of two persons, i.e., the author who is an associate professor and Professor Shinya Obi who also is the Vice-President. The present situation of astronomy education in the university is described in the following.

(1) Subject

For each subject, students take lectures on the air (radio or television). Each lecture is broadcast for 45 minutes. Most subjects give 2 credits. The 2 credit subjects offer a series of 15 lectures on the air. For each subject, there is also a textbook. In general, there is one-to-one correspondence between lectures on the air and chapters of a textbook. Thus, the textbooks for the 2 credit subject contain 15 chapters in general.

There are three kinds of subjects for the major field of "Understanding Nature" : Basic and Introductory Courses, Specialized Courses, Interdisciplinary Courses.

There is one subject for astronomy which belongs to Basic and Introductory Courses: Basic Earth Science and Astronomy (Astronomy). This subject deals with basic knowledge of the whole field of astronomy. There are four specialized subjects: Solar System, Basic Astrophysics, Structure and Evolution of the Universe, History of Astronomy. "Basic Astrophysics" deals with stellar atmospheres and interiors as well as stellar motions. All these five subjects are broadcast by television. Except for "Structure and Evolution of the Universe" , these subject give 2 credits. "Structure and Evolution of the Universe" gives 4 credits. Except for "Basic Astrophysics" and "History of Astronomy" , Professor S. Obi is the instructor in charge of the above subjects. The author is the instructor in charge of "Basic Astrophysics" , and Professor Yoichiro Murakami, who is a visiting professor and specialize in history of science, is the instructor in charge of "History of Astronomy" . For "Solar System" and "Structure and Evolution of the Universe" , there are several instructors in partial charge who are specialists in the fields relevant to the subjects.

(2) Class Room Lecture

Each student belongs to one of the eight Study Centers which stand in the Kanto area and where students take a term examination on paper. A series of five 2-hour-15-minute class room lectures is held at the Study Centers too. Students must go to the Study Center once in every other week to take a class room lecture. A class room lecture course give one credit. There ara two kinds of class room lecture courses for the major field of "Understanding Nature" : Basic and Introductory Courses, Specialized Courses.

There is one class room lecture course for astronomy which belongs to Specialized Courses: Earth Science and Astronomy. This course deals with earth science as well as astronomy.

There are also class room intensive lecture courses, which are held for two or three days in summer or winter at the Study Centers. The total time for a intensive lecture course is the same as a normal class room lecture course. The intensive lecture courses are also classified into two courses: Basic and Introductory Courses, Specialized Courses.

A few intensive lecture courses are opened at each term. For example, two intensive lecture course were opend at the second term in the academic year 1989: Structure and Evolution of Stars, Position Astronomy.

(3) Consultation about Learning

Students who ask advice about learning or have a question on the matter taught in lectures can consult with the teaching staff of the university. In order to hold a consultation, students must hand in an application beforehand and hold a consultation at the Study Center at the appointed time.

(4) Graduation Thesis

Regular students who want to graduate from the university must be enrolled for at least 4 years and acquire at least 124 credits. Moreover, these students must submit a graduation thesis to the university and pass an examination as to the thesis. Most students make a researche for the graduation thesis under guidance of the teaching staff of the university. Some students make a research under guidance of the staff of other universities or of research institutions. In the academic year 1989, 8 students passed the examination as to the thesis in total under the guidance of the author and of Professor S. Obi. Subjects of the researches cover a wide field from spectroscopy to astronomy education.

3. Some Problems in the Astronomy Education in the University

Some problems with which the astronomy education in the university are now confronted are described in the following. Many of the problems concern not only the astronomy education but also the education of the university for other fields.

(1) Subject and Class Room Lecture Course

Students seem to be strongly interested in astronomy, because many stydents take lectures of the subjects for astronomy. However, unlike other universities, there are students of wide range of age and of various occupations and the range of scholarship of the students is very wide. Thus, it is difficult to give lectures which satisfy students with both good and poor scholarship.

Furthermore, many students lack in basic knowledge of mathematics and physics. For example, many students do not understand logarithms and the laws of motion. Therefore, not a few students learning subjects for astronomy complain of difficulty in understanding. This situation mainly comes from that there is not an entrance examination. It also comes from the curriculum of the university under which students take any subject without prereuisite. At present, the curriculum is being reviewed.

There is another problem, which relates to lectures on the air. In some lectures, i.e., the characteristics of television do not seem to be made enough use of. For example, there are some lectures where only blackboard demonstrations of instructors are televised. This situation is partly because there is not enough time to prepare for lectures on the air. It is also partly because instuctors have little experience on the air. It will be improved with the accumulation of experience.

(2) Consultation about Learning

The most numerous questions on astronmy that students ask at the consultaion about learning are those which are concerned with black holes and the big-bang cosmology. It is desirable, if possible, that a book whould be published which gives a general readership an essential understanding of these themes.

(3) Graduation Thesis

Unlike other universities, most students of the university cannot frequently go to the university. Furthermore, at present, the number of the teaching staf is less than 60, while the number of the students under the guidance for the graduation thesis is more than 1000. Therefore, it is difficult to give them a sufficient guidance for the graduation thesis.

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