COMMISSION 46
ASTRONOMY EDUCATION AND DEVELOPMENT
Education et Développement de l'Astronomie

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Commission 46 seeks to further the development and improvement of astronomical education at all levels throughout the world.

Contributions to this newsletter are gratefully received at any time.

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EDITORIAL

In this issue there are two linked articles with self-explanatory tiles – "Initiating large astronomical projects in developing countries" by Athem Alsabthi, and "Astronomy development strategies and the IAU" by Johannes Andersen. Dr Alsabthi's article is based on an email that he sent to the Commission 46 Organising Committee, and which generated a considerable amount of email correspondence. The Program Group for Advance Development (should that be "Advanced"?) is discussing the issue, and I look forward to future contributions on the matter to the next Newsletter, and also to contributions on current astronomy/space projects in developing countries. In this issue, astronomy in developing countries is the subject of three of the other articles.

I'm sure it dismays all of us to witness the widespread belief in astrology, alien abduction, and other pseudo-scientific irrational beliefs that surround our subject. It certainly dismays me. Many people holding such beliefs are not open to rational argument and solid evidence. However, for some people, particularly before such beliefs have become entrenched, perhaps there is something that astronomy educators can do. Of course, pseudo-science does not only surround astronomy, but it does seem that our subject is particularly well endowed! Views on what (if anything) astronomy educators should do to convince people that astrology does not work, and so on, will be welcome. Please be sure that I am not claiming that scientific beliefs are the only valid ones – far from it. It is the widespread belief in pseudo-science that is *demonstrably wrong* that concerns me.

I look forward to receiving interesting, even provocative material for the October 2001 issue.

Barrie W Jones
(for contact details see Officers & Organising Committee of Commission 46)

MESSAGE FROM THE PRESIDENT

A half year has passed since the 24th General Assembly of the IAU. We changed the name of our commission from Teaching of Astronomy to Astronomy Education and Development after merging with Commission 38, Exchange of Astronomers, and the Working Group on the Worldwide Development of Astronomy. We also set up a new system of program groups (PGs), each of which deals with a specific activity.

The PG Exchange of Astronomers, has provided travel grants to two young astronomers. The PG International Schools for Young Astronomers held a three-week meeting in Chiang-Mai Thailand last January. The PG Teaching for Astronomy Development supported Vietnam, Morocco, and Central America. The PG Solar Eclipses is preparing an activity for the African eclipse this June in collaboration with the United Nations. The PG Collaborative Programs has started discussions with other organisations such as ICSU, UN, COSPAR, and IAF. All these activities are progressing steadily. The PG Advance Development has contacted the Philippines, and discussions are under way on what activities this PG should take on.

As Commission 46 President I try to open all discussions with the Organising Committee members through the Internet in order that all members know how our commission is managed. I hope we can expand these open discussions to all the commission members in the near future.

Our commission intends to hold a special session during the 25th General Assembly in Sydney in 2003. John Percy is its chair and has started to arrange it with Australian colleague. I believe we will be able to provide further details of the session in the next Newsletter.

To identify the National Liaison of each country, Jay Pasachoff has tried to contact each relevant national organisation and has succeeded in getting large numbers of active National Liaisons.

I hope that all of us will continue the important work of Commission 46 during this new millennium year.

Syuzo Isobe
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INITIATING LARGE ASTRONOMICAL PROJECTS IN DEVELOPING COUNTRIES

The proposition is that the development of large scale astronomical projects in developing countries would have a better chance of success if better supported by the IAU Commission 46 program group Advance Development (AD).

This group should include a nucleus of expertise (task force) with experience in specifying, developing and carrying out a quality audit of astronomical facilities. Also included should be a broad based database of worldwide activity in this area together with a policy of active encouragement to individual government agencies on behalf of the astronomical/academic community in that country (see C46 Newsletter 53 October 2000).

From many years of experience in this field (In the Middle East in the past and the UK at present), I have come to the conclusion that initiating an astronomical project (or related projects such as planetaria) sometimes depends heavily on the external instigator (or initiator) rather than on people within the country. My experience shows that countries are very responsive to proposals, sincerely submitted by academic or international scientific organisations such as the IAU; it is sincere advice taken from a source with no vested interest. This makes our Program Group an ideal starting point for many developing countries.

The problems of scientific development in developing countries are numerous. John Hearnshaw, in an excellent paper to the IAU General Assembly in Manchester, put his finger on all the major problems facing developing countries. These problems are related to funding, access to telescopes, libraries, computers, and contact with the astronomical community worldwide. Hearnshaw's paper showed that there are many countries that have the scientific infrastructure, but nevertheless have only very modest facilities in astronomy. Saudi Arabia is an example. To be quite honest, his paper gave me the idea of setting up a “task force”. This task force could be part of AD, with the aim to contact suitable countries (such as Saudi Arabia).

The question that always arises is, do we wait for an appropriate organisation to request help, or do we take the initiative? Well, decades of experience show me that the latter seems to work almost all the time, meaning that almost all astronomical establishments in developing countries have been initiated from outside. This may seem illogical, but it is true. Waiting for a critical mass of astronomers to fuse to create sufficient pressure within a particular country does not seem to work. My own explanation is that building a large observatory (in developing countries this means a 1m telescope or more) is difficult because astronomical projects have no direct financial rewards, so governments in developing countries are reluctant to support such initiatives from within.

The next question is, which should come first: an observatory, or a critical mass of researchers in a developing country? Here again I feel I am a bit controversial in that I believe it is the observatory with a few astronomers (as a starting point) that will lead to astronomical awareness, rather than waiting for those astronomers to create a pressure to build an observatory. (A similar analogy can be put for the computer: do we provide or at least suggest such a system, or wait to be asked!)

If we accept the argument that the international astronomical community has a duty to lead the way in developing countries, what steps should be taken to implement this? Again I lean on my past experience, and suggest that a proposal to build an observatory should go simultaneously to the government and to the scientific community (astronomical or otherwise). In our case I would suggest that the task force, in coordination with University staff or research establishments, suggest the proposal. What would this proposal contain? In my opinion the proposal should be a well thought out feasibility study which takes into account the particulars of that country (economy, demography, etc.). For an oil-rich country with a heritage in astronomy and good infrastructure I would suggest a telescope 5m or more, and/or a large radio telescope, etc. I wouldn’t suggest a 1m telescope and tell them they can progress to a bigger one once they learn how to use this; many developing countries are stuck with old small telescopes with very little activity. I am sure every one knows many examples of this situation.

The major difficulty that faces this proposal is to execute the feasibility study. This requires time and funding as anyone who is involved in initiating large projects knows (astronomical or otherwise). This study should be a mini-tender document, with a proposal for specification, site, construction work, cost etc. If you want to suggest a project you have to give that country at least a good estimate of time and expense, as well as the numbers of technical, scientific and administration staff who would run the project. Can the ADP program group do this? We cannot, unless we receive help. Probably the help can come from contractors who are prepared to help us with this in the hope that they have a chance to tender for such projects. I think for the worldwide development of astronomy it is a worthy effort.

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ASTRONOMY DEVELOPMENT STRATEGIES AND THE IAU

The development of astronomy education and research is part of the evolution and improvement of scientific education and culture in general. It takes place at many different levels and in a vast variety of settings throughout the world. For the IAU to fulfil our mission to help this development as efficiently as possible, especially in countries with a weak scientific tradition, we must recognise the diversity of the task as well as the strengths and weaknesses of the resources at our disposal.

For a successful educational programme, one needs the following ingredients:

- A favourable environment
- Resources (money, equipment, staff), and
- Experience.

In starting a new programme, the first item on the agenda is to identify a promising location for a new initiative. While innovative thought should always be welcomed, there is general agreement that long-term success for an initiative to set up an astronomy education programme requires a local basis of people with enthusiasm, drive, and a vision to see the programme as part of an effort to improve science literacy in general. In a small community, even a single outstanding person can sometimes assure success. Local political support is obviously a most valuable asset.

In my view, it is the task of the program group Advance Development to search for places where a new IAU initiative might be fruitful, through visits, personal connections, or in any other effective manner. Any opportunity identified would be discussed in the Commission, and if its potential is confirmed, perhaps though a small investment in a travel grant or similar, a programme would be defined and implemented, using such subset of the above tools as is deemed suitable for the particular circumstances of the case.

The IAU currently tries to help a number of countries at various stages in the "educational food chain" from schools to university education to mature scientific teams. The main resources in our current inventory of tools are: the flexible Teaching for Astronomy Development programme (TAD, which I would prefer to mean "Teaching Astronomy for Development"!) at the initial level; the International Schools for Young Astronomers in their proven, very successful format for university students at the graduate level; and the Exchange of Astronomers programme which also supports scientists at the postdoctoral and later stages.

Experience is the main resource of the IAU. We must use it to maximum effect. To this end I would propose, not a mere database of past projects, but an "IAU Cook Book for Astronomy Development". It would be structured in chapters according to level, i.e. primary/secondary school, high school, undergraduate and graduate university level, and the postgraduate level. Each chapter would list not just the best ingredients (text books, lab kits, educational software …), including regional preferences (what exists in which language, etc.), but also the recipes for what has worked well and how to recover if standard problems appear. It would also contain suggested time scales for preparations, so that both those in the field and those funding them would realise that, e.g., to set up a complete undergraduate astronomy course and turn out the first graduates is not accomplished overnight, but takes 5-10 years. In this way, unrealistic initial expectations and premature programme terminations can be avoided.

At each level, major options for initiatives would be identified and elaborated. A good example is the campus telescope which is often seen as a way to generate hands-on experience and student enthusiasm. Yet, some of these (both large and small) sit idle, collecting rust and spreading disillusion among students and donors alike because essential advice was missing. The Cook Book would tell such groups: which type of drive is needed and how to adjust it; what type of CCD camera is most cost-effective in such a setting; how to combine it with a simple spectrograph; which science programmes have proven most effective at given levels; which image processing software is recommended and how to acquire and install it; and practical hints, such as achieving maximum efficiency of use and effective protection of the equipment by giving the students responsibility for its operation; etc. But other examples could be given.

I imagine that a group under Commission 46 would be responsible for organising the preparation and maintenance of the Cook Book. It would probably be located at the IAU web site, for easy low-cost access from all over the world, and regularly updated as new programmes appear and experience accumulates. After, say, a decade, I believe one would have a reference volume that would help not only astronomy, but could become a model to other sciences how to structure this kind of information.

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SEEDS OF ASTRONOMY SOWN IN TANZANIA

After 20 years of variable periods of activity and dormancy, astronomy is now beginning to show its head over the barren soils of Tanzania. This is a country that lies just south of the equator with a very conducive climate which allows stargazing activities to be enjoyed almost the whole year round. It is famous for its natural beauty in the form of natural reserves and game parks. It also has a hidden treasure in its night skies that can be viewed through an unpolluted dark atmosphere. The unique position of Tanzania allows us to enjoy the full glory of the southern as well as the northern skies simultaneously.

However, interest in astronomy has been stifled due to lack of public awareness of this subject arising mainly from a dearth of specialist information relevant to our locality. The lack of interest in this region has helped ensure that the information provided in most of the prominent astronomy publications remains unsuitable for use by stargazers in Tanzania. Star maps and stellar events are calculated for high northern and southern latitudes, which cater mainly for observers in the developed world. However, with the advent of the information age and the explosion in the Internet, many more sources of relevant material have become available from which information specific for our location can be derived.

Over the last two years, regular monthly articles have been published in local respected daily newspapers as well as a monthly tourist magazine. The articles are also distributed via an e-mail list of more than 300 people and is regularly posted on my website www.njiwaji.com. These articles provide school students as well as the general public with reliable information on interesting topics ranging from lunar eclipses to the recent asteroid landing. They also provide a guide to the prominent stars and constellations and other astronomy events, giving local observation times and positions. Accompanying the articles are monthly star maps that have been produced specifically for our East African region. Such maps are impossible to find elsewhere so they have been found to be very useful for observers in Tanzania as well as in the neighbouring country Uganda. Since January this year the articles have found a regular place as an astronomy and science column of the daily newspaper and appear on the first Saturday of every month. For the past five months, I have also translated the articles into Kiswahili, a local language spoken by all Tanzanians and also used all over East Africa. This will enable a very wide coverage across a broad range of readers.

Astronomy activities in the schools have been promoted by starting astronomy clubs and holding astronomy fairs and regular stargazing sessions. Sufficient people have shown interest in starting a nation-wide astronomy club and this is being worked on. On 28 April, the Dar es Salaam Physics Teachers Association has invited me to hold a workshop on identifying the shortcomings in the astronomy portion of the secondary school physics syllabus. The topic of astronomy is either rushed over or not covered by teachers, so eventually we also hope to organise training seminars for teachers.

I am in contact with Eclipse 2001, hosted by the University of California at Berkeley http://www.museumeclipse.org/index.html who will provide a live webcast of the 21 June solar eclipse from our neighbouring country Zambia. I am trying to interest TV stations in my country to provide a live coverage of this eclipse by picking up the webcast.

I am also in communication with a South African astronomer Brian Fraser (closer to home!), who will be giving me occultation timings for stars by asteroids as seen from Dar es Salaam. We intend to be in close touch regarding the forthcoming solar eclipse as well for other mutual astronomy interests in the future.

An interesting site which gives an eerie view of the lunar phases, is
http://jasmine.uchicago.edu/fun/synodic.html

Very readable courses on astronomy can be found at
http://www.cnde.iastate.edu/staff/jtroeger/astronomy.html
http://www.mhhe.com/physsci/astronomy/arny/student/webtutor/index.htm

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PROMOTION OF ASTRONOMY IN THE PHILIPPINES

Astronomy is a science that has a universal appeal because it encompasses all fields of human interest and endeavour. In a developing country such as the Philippines where space science is considered to be just in its incipient stage, there is a need to promote astronomy to the general public. The emphasis should be directed towards youth because it will afford a better understanding of our planet, and thereby encourage them to participate more actively in the conservation and preservation of the environment. Moreover, there is also a need to focus people's attention on the significant contributions of astronomy in the advancement of the other sciences such as mathematics, physics, chemistry, biology, etc., to enable them to appreciate the importance of the science.

While work in astronomy in the Philippines has been going on for more than a century, the study of celestial objects is confined to its observation and publication of data, and a brief coverage in the general science curriculum of elementary and secondary schools. As the country celebrated its centennial of astronomy in 1997, immense efforts were exerted by the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) to enhance public consciousness to help improve and develop its astronomical service.

This paper deals with the promotion of astronomy in the Philippines with the primary objective of enhancing the knowledge of the public in the science.

Prior to 1897, astronomy was covered by the Observatorio Meteorologica de Manila (OMM), a private institution initiated by the Jesuits in 1865, which was later renamed the Manila Observatory (MO). On 28 April 1884, the Observatory became a government agency although its astronomical services were concentrated on timekeeping and observation of solar and stellar phenomena. In 1897, an Astronomy Section was formally established in the MO. From then on, primarily the same functions have been performed by the only government agency engaged in astronomy, which is PAGASA.

PAGASA conducts regular information, education, and communications (IEC) activities to promote astronomy in the Philippines. It receives students, teachers and other visitors in the planetarium and astronomical observatory, where lectures, stargazing and telescope sessions are given by its staff. No visitors come to the planetarium or observatory during the summer or semestral school breaks, except for the student-members of an astronomical society.

The Philippine astronomical service also organises seminars on basic astronomy for science teachers as a part of its continuing activity in science promotion. The teachers are given lectures and hand-outs on celestial motion and mechanics, solar and star systems, deep sky objects, galaxies, Universe, and astronomical instruments and methods of observation. Stargazing and telescope sessions are the usual activities after the daytime lectures.

In 1993, a presidential proclamation, declaring the third week of February of every year as National Astronomy Week, was issued through the initiative of PAGASA and the Philippine Astronomical Society (PAS) Inc. It emphasises the importance of the study of astronomy especially by youth.

To celebrate the first National Astronomy Week (NAW), PAGASA declared all its field stations open to the public for special lectures in astronomy. Admission to its Planetarium was free of charge during the Week. Telescope and stargazing sessions were held in several key cities, participated in by hundreds of elementary and high school students and science teachers in various regional centres of the Philippines.

Astronomy further gained nationwide interest among Filipinos when the total solar eclipse of 1995 was publicised by PAGASA in November 1994. A national committee, led by the Department of Science and Technology (DOST) and PAGASA, was created by the President of the Philippines to promote its observation and documentation. An extensive information campaign and lectures on the eclipse were conducted in many parts of the country, especially in Mindanao where the central path of the eclipse crossed the island province of Tawi-Tawi.

The discovery of Comet Hyakutake on 30 January 1996, barely two months after the total solar eclipse of 1995, heightened the level of interest in astronomy in the Philippines even more. The public was made aware of the discovery through a press release issued by PAGASA in mid February 1996. Increased concern by the public on the possibility of Comet Hyakutake crashing into Earth was perceived through numerous inquiries received by PAGASA as a result of the collision of Comet Shoemaker-Levy with Jupiter from 16 to 22 July 1994.

To sustain the momentum gained during the first two years, PAGASA initiated the issue of Presidential Proclamation 956, declaring 1997 as the Philippine astronomy centennial year, and constituting a national committee for its celebration. Among the activities implemented during the year was the program of information, education and communication (IEC) in astronomy through press releases, radio/TV interviews, seminar/workshops for science teachers and students, a symposium during the NAW, the distribution of astronomical posters, the preparation of a commemorative centennial publication, and a project proposal for the promotion of astronomy through the DOST Grant-in-Aid (GIA) program.

The fortuitous discovery and appearance of Comet Hale-Bopp from 20 March to 11 April 1997 lent beneficial support to the celebration of the centennial of astronomy in the Philippines because the interest of the public was maintained at a high level from its discovery up to its disappearance.

Astro Olympiad ’98 was one of the activities in the DOST-GIA project, entitled Promotion of Astronomy. It was a contest in astronomy for high school and college students in the Metro Manila. The contest consisted of elimination and final rounds, with 100 and 10 contestants selected in each stage. The elimination round was a written examination held at the Philippine Science High School on 27 June 1998. The final round was an oral contest, held at PAGASA on 3 July 1998. A panel of five judges supervised the contest. Cash prizes were distributed to the winners. Dr William Padolina, the former secretary of the Department of Science and Technology who wanted a science-oriented youth, supported the contest, hence it has become an annual activity.

Plaques of honour and recognition for Filipinos who have contributed a lot in the field of astronomy were also distributed during the awarding ceremony for the winners of the Astro Olympiad. The plaque was named Dr Casimiro del Rosario Award, in honour of the first Filipino director of the Weather Bureau after the Second World War, who pioneered astronomy during his tenure.

In July 1998 PAGASA announced the issue, on a monthly basis, of information on some significant astronomical events, in addition to the daily sunrise/set data. These events, called the Astronomical Diary, depict the phases and the positions of the Moon, the Sun, the stars, and some of the planets and their satellites. The primary aim of the diary is to enhance the interest and elevate the level of knowledge of Filipinos in science in general and in astronomy in particular.

In May 1999, four 25-cm and one 18-cm telescopes, one video camera, and one CCD camera were procured. The telescopes will be installed in four local regional centres and the CCD at the PAGASA astronomical observatory. The primary objective of this activity is to promote astronomy in the countryside by allowing the public, particularly students and science teachers, to observe important astronomical phenomena, thereby increasing their knowledge in this field, and arousing their interest.

Lastly, the agency procured a mobile planetarium in 1999, also to promote astronomy in the countryside by increasing the knowledge, and arousing the interest, of the public (particularly students) in the field of astronomy. The planetarium is brought to various places upon request on a first-come, first-served basis. In this regard, the public can be educated in this field with the least time, money and effort.

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JAPAN’S CONTRIBUTION TO UN PROGRAMMES IN DEVELOPING COUNTRIES

The cooperation between Japan and the United Nations in promoting space science programmes in developing countries is marking its tenth year in 2001.

Building on the successes of the past ten years, the Government of Japan, in cooperation with the Vienna-based United Nations Office of Outer Space Affairs, is continuing the establishment of Planetaria and astronomical telescope facilities at universities in developing nations. Japan’s initiative is facilitated through Japan’s Cultural Grant Aid and General Grant Aid Programmes. Cooperation between leading astronomers from the National Astronomical Observatory of Japan, Tokyo, with their peers in developing countries has been a main driving force for establishing planetaria and astronomical telescope facilities in developing nations around the world.

Planetaria have been donated to Uzbekistan (2000), India (1999), Sri Lanka (1998), Uruguay (1994), and Argentina (1993). Currently negotiations are on-going between the governments of Costa Rica and Japan to establish a planetarium at the Universidad de Costa Rica in San Jose.

Astronomical telescopes and supplementary equipment has also been provided by Japan to the Philippines (2000), Paraguay (1999), and Sri Lanka (1995). The Government of Chile is currently negotiating with the Government of Japan the establishment of an astronomical telescope facility at the Cerro Calan Astronomical Observatory at the University of Chile.

These developments follow recommendations made at the series of basic space science workshops organised annually since 1991 under the United Nations Programme on Space Applications, implemented by the Office of Outer Space Affairs in cooperation with the European Space Agency (ESA) and other international space related organisations.

The annual Workshops on Basic Space Science are intended to contribute to the world-wide development of astronomy and space science. Such Workshops have been organised in India (1991) and Sri Lanka (1995) for Asia and the Pacific, in Costa Rica (1992) Honduras (1997) and Colombia (1992) for Latin America and the Caribbean, in Nigeria (1993) and Mauritius (to be held in 2001 – see below) for Africa, in Egypt (1994) and Jordan (1999) for Western Asia, and in Germany (1996) and France (2000) for Europe.

Other projects considered during the UN/ESA Workshops on Basic Space Science, include:

- The feasibility of establishment of a World Space Observatory (WSO/UV)
- The Network of Oriental Robotic Telescopes (NORT)
- The annual publication of a newsletter (African Skies/Cieux Africain) for the astronomical community of Africa
- The development of educational material to be used in introducing astronomy into education curricula in developing nations at the university level.

Over the past ten years, astronomers and space scientists from 123 United Nations member states participated in or contributed to the success of the UN/ESA Workshops on Basic Space Science.

The United Nations Programme on Space Applications promotes awareness of advances in space science and technology and their applications, in developing nations. The Programme conducts annually, training courses, seminars, conferences, and workshops on space-related issues. It also administers a long-term fellowship programme for in-depth training of specialists in space science and technology, provides technical advisory services on request, and is contributing to the establishment and operation around the world of regional Centres for Space Science and Technology Education, affiliated to the United Nations, with the goal of developing indigenous capabilities.

Author's note: The organisers of the UN/ESA Workshops are particularly grateful to Prof M Kitamura, National Astronomical Observatory, Tokyo, Japan, for his untiring and unconditional cooperation in the past decade.

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MAJOR DYNAMICAL, PHYSICAL, AND TECHNOLOGICAL CONCEPTS OF SPACE SCIENCE

Abstract
The major dynamical and physical concepts and the associated technological concepts of space science are identified and discussed. A conceptual approach to space science education is developed and recommended.

The concepts, which are built within the framework of the suggested educational scheme, are shown as a way to teach different theories and applications.

The computational, experimental, and technical training techniques that are needed in space science are described, as are the steps at which they may be introduced through the suggested educational scheme. Different job descriptions correspond to different educational structures (modules).

Introduction
Any educational process is made up of several components. These include teachers, students, curriculum, and teaching methodology. The standard method in building an educational scheme (curriculum) for any specialisation is to divide the knowledge (scientific material) into major subjects and then divide each subject into major topics. However, education of any specialisation through its major concepts is, relatively, a new

trend in the developed world, which may be called the "conceptual approach". The approach is based on considering the major building blocks of any specialisation to be its major concepts. It possesses several advantages that can be summarised as follows:
1. it develops an integrated specialist who knows, applies, and uses several concepts in different subjects and specialisations
2. it improves the capabilities of lecturers in understanding and in teaching within several subjects and specialisations, using concepts well known to them in one subject and specialisation
3. it saves time in imparting educational materials to students.

These advantages can be tested and verified by using any suitable lecture feedback project (cf. Hodgson and Mc Connell (1980)). In this article, a conceptual approach is developed for space science education at the undergraduate level.

In general, there should be several educational structures (modules) at the undergraduate level that should aim to have graduates with degree specifications that will cover several job descriptions in space science institutions. To fulfil the objective, the paper will discuss the major dynamical and physical concepts, and the associated technological counterparts, with the required credits in the proposed educational scheme. Hence, one can choose the needed building blocks out of the major concepts for a certain job description in a certain position in the matrix of space science organisations.

Major concepts of space science

Space science is a good example of a science in which many concepts of different sciences are integrated and used to build up its educational scheme. The major building blocks (concepts) of space science are discussed in the following subsections.

Concept of an object orbiting around a source of gravity

This concept deals with the choice of an orbit for a space vehicle to move around any celestial body belonging to the Solar System, to fulfil definite objectives. In this context, students should learn different types of orbits and determine which type will conveniently perform the specified aim of the mission. Also, they should learn about different types of space mission, e.g. remote sensing, meteorological, geophysical, environmental, communications, scientific, astrophysical, etc.

They should realise that any space vehicle has six degrees of freedom, which are its position and velocity in three dimensional space.

To enable the students to choose the most suitable (optimal) orbit they should learn the relevant kinematical and dynamical concepts of astronomy and how to use them in this context (cf. Roy (1978), Kaufmann (1994), and Melek (2001)). While students are learning this concept, it is necessary to introduce to them the influence of:
1. the Earth's oblatness at the equator
2. the Earth's atmospheric drag force
3. the Earth's magnetic field
4. the direct and indirect solar radiation pressure on the chosen orbit.

Concept of optimisation

In this context, students should learn how to use the optimisation techniques in the determination of
1. the best latitude for launching the mission
2. the best time (month, day and hour) to launch the mission
3. the best initial launching angle
4. the best manoeuvring angles within the mission's trip to its chosen final orbit
5. the best geometrical shape for the spacecraft, e.g. sphere, cylinder, hexagonal, etc
6. the minimum payload for mission's objectives, designed initial trajectories and chosen final orbit.

While teaching the students how to determine all of the previous parameters; they should also learn how to calculate the minimum amount of energy (fuel) to put the mission in its final orbit.

Concept of the energy budget to put a spacecraft in its chosen orbit and for the payload instruments

In the framework of this concept, students should study how to calculate the needed energy (fuel) for the carrier of the mission; whether it is a single stage or multistage carrier. Also, they should learn how to calculate the needed electrical power for the payload instruments, using solar energy panels which can serve the mission during its life time.

Concepts of designing and choosing the mission's shape and materials
These concepts are dealing with the physical and chemical properties of different materials used in constructing the mission and its payload instruments, e.g. properties like rigidity, elasticity, conductivity, resistivity, against high temperature differences and all hazards in space. In this context, students should study space physics to know almost all different hazards that can meet the mission. Therefore, they should study material science and failure analysis for different materials under different conditions, for the purpose of getting the best performance either of the mission structure or of the used instruments. Also, they should learn vibrational mechanics and aerodynamics.

Concept of stability and life time
This concept is dealing with different factors affecting the mission lifetime and the order of magnitude of each factor in relation to the others. The theory of stability of differential equations and the catastrophe theory are useful in this context.

Concept of guidance and automatic and attitude control
Emphasis is on the role of communication science, electronics, software and hardware engineering, to transmit orders and information from the mission to the ground stations and vice versa (up and down links). Students should learn how to find the difference between the actual orbital elements, via tracking stations, and the calculated (theoretical) ones.

They should then learn how to design software for the mission and the ground tracking stations that can be used to modify the orientation (attitude) and the position of the mission to the desired values.

Concept of transmission of information and its analysis
In the framework of this concept, students should learn finite mathematics and its applications in digital technology that can be used to transmit information from the mission to the ground stations and vice versa (up and down links). They should study different factors causing possible distortions of the transmitted information and how to avoid them or to correct the received distorted information. They should also learn how to analyse the obtained information from the mission.

Designing different educational structures (modules)
It is clear from the previous section, that the major concepts of space science do represent a mixture of concepts in basic dynamical and physical sciences as well as basic and applied engineering sciences. Therefore, when one wants to fix the correspondence between different job descriptions and different educational modules one has to start with designing all possible job descriptions that will cover all the needed functions of space organisations. Then, one has to choose the relevant major educational building blocks, major concepts, to construct different modules corresponding to different jobs. Moreover, one may look upon space institutional structures (the matrix of relevant space science organisations) as composed of two main divisions, namely, the space segment organisations, and the ground segment organisations. Therefore, using this kind of division; one may divide the relevant jobs as follows:
1. mission analysis job: determining mission objectives and demands
2. mission dynamics job: designing the initial trajectories, choosing the final orbit and choosing the attitude control method
3. mission structure job: choosing the geometrical shape, type of antennae, materials, and sensors
4. mission payload job: choosing the optimal needed instruments
5. mission carrier job: choosing the most suitable carrier, and calculating the optimal needed energy and its type and source
6. mission hardware and software job: choosing and designing the needed software and hardware to be on board and on the ground segment
7. mission tracking and control job: correcting the spacecraft dynamics to its desired orientation and orbit
8. mission information analysis job: analysing the received data and information.

By the end of undergraduate studies, students choosing any educational module should be familiar with the relevant applications of the following theories:

1. Newtonian mechanics
2. aerodynamics
3. special and general relativity,
4. electromagnetic radiation
5. propulsion and energy transformations (thermodynamics)
6. optimisation
7. automatic control
8. stability.

Equivalent credits to each concept

In this prototype scheme, the required mathematics, physics and chemistry to be taught during the first two semesters in the full educational programme is not specified. In the next table are the suggested lectures, theoretical exercises, experimental and technical training, and the equivalent credits for each concept.

	Concept & lectures (hrs)	Exercises (hrs)	Training (hrs)	Credits
Orbits	12	8		16
Energy	4	4		6
Optimisation	6	4		8
Shape	10		12	16
Stability	6	6		9
Control	8	4	8	14
Information	10		10	15
Sum	56	26	30	84

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NEW ZEALAND INVESTIGATOR'S CERTIFICATE

The "Astronomy Education: New Zealand's Investigator's Certificate" programme is designed to encourage learners to become scientific investigators, using astronomy as the vehicle to get there. It is also aimed at encouraging participation in Science Fairs.

It involves: working with astronomers; undertaking an investigation lasting at least six months; keeping detailed records and making observational drawings. It also involves the investigator giving proof of these investigations by communicating the work scientifically. This could be by a science fair exhibit or some other method acceptable to a teacher or an astronomer.

It is a simple criterion-based programme. Administrators of the programme do not determine what the investigation will be. Any person who starts a challenge such as this is trusted to complete the challenges set, and the people verifying the criteria are trusted.

Effective communication will be judged by the success in transmitting the ideas within the investigation to others.

A final check is the ability of the investigator to withstand scientific questioning, an ability to verify conclusions based on the investigation. Are the conclusions reached valid in terms of the investigation? Is the investigator aware of the limitations of the investigation?

When each of the criteria has been verified and the relevant verification paper returned, the administrators will give consideration to awarding the certificate. In most cases contact will be made by Carter Observatory with some of those who have verified the investigation to double check what has been achieved.

Care and protection of the investigator always remains the responsibility of the parent or caregiver. This would mean that they would need to be prepared to accompany the investigator on a number of night observations. At no time can responsibility for the investigator be vested in an astronomer, a member of the staff of the observatory or school, or any other person involved in supporting the investigator.

The administrators reserve the right not to award the certificate if they have doubts about the application.

This is a rigorous programme that may not suit all participants, but an investigation once started can continue indefinitely and there is no time limit on when an investigator may submit verification evidence, except that of the programme's continuation.

Prior to being awarded the certificate, the administrator contacts the participant and discusses the wording of the citation on the Certificate. We also place on the certificate an image of the participant's choice, so it is a very personal award.

The programme is portable and we hope that others around the world will show an interest and adapt it to local conditions. Why not the "Astronomy Education: Calcutta's Investigator's Certificate"? The NZ$30.00 registration fee we charge participants is non- refundable.

All inquiries to Tony Fisher.

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NEWS OF MEETINGS

FOURTH EAAE INTERNATIONAL SUMMER SCHOOL

The European Association for Astronomy Education organises a teacher-training course every year to improve and promote scientific astronomical education in schools across Europe. Last year, 2000, the 4th European Association for Astronomy Education Summer School was organised in Portugal. It is important that every Summer School has its own theme, and all the workshops and working groups should revolve around it. This year the very interesting theme was Astronomy and Navigation.

Some centuries ago, maritime navigators discovered new lands on the other side of the then uncharted oceans using the Sun and the stars. In the present day, astronomical objectives in the realm of navigation are aimed at discoveries in outer space. In all cases, astronomy plays a key role in scientific advances. The Summer School is a unique forum for spreading astronomy teaching and encountering new perspectives in the field. This kind of meeting also promotes contacts and debates among European teachers and professors regarding astronomy topics and resources to improve the level of astronomy teaching at European educational establishments.

In accordance with the theme, the workshops primarily covered a wide spectrum of different aspects of astronomical navigation problems. Background information was presented on the most important fundamental astronomical phenomena (the apparent motion of the Sun through the zodiac, the apparent motion of the celestial sphere, tides) as well as elementary theoretical explanations. The fundamental problem of determining an observer's position on Earth was discussed taking historical aspects into consideration, with special emphasis on the central role of astronomical knowledge, mainly during the era of the great discoveries (America, Africa, India, Asia). Different practical solutions to this problem were demonstrated, and intensive training was also provided with the help of models of historical instruments (sextant, astrolabe, quadrant, cross-staff) as well as with modern electronic devices (GPS). In addition to these practical activities, the participants gained experience on how to handle astronomical telescopes and improved their skills in practising basic astronomical observation techniques. These activities were supplemented by discussions on didactical and methodical problems with regard to the implementation of astronomical topics in the curricula and with respect to different levels.

The level of the workshops was suitable for all school levels (primary, secondary and university). The participants obtained many new ideas and models of tools for teaching astronomy and making observations of the sky. They took all the practical tasks very seriously. It was possible to see enjoyment, interest and curiosity in their faces. They worked very hard.

Participants at the 4th EAAE Summer School

Some of the subjects in the workshops that illustrate the range of the subjects covered were as follows.

Photographs of constellations

This is a valuable activity for high school students because it really “brings stars in the classroom”. Students have the chance to work with star pictures that they make themselves – this is an important point. And like under the real night sky, they can make different kinds of observations and measurements.

Where am I? Answer by GPS

This activity leads to deeper understanding of one of the modern technologies. It answers the questions “How does it work?” and “How do I use it?”. In everyday life, we use a lot of technical devices. Of course we cannot know everything about them. This is impractical. We need not know in detail how the GPS receiver, mobile phone, and the refrigerator work. But for most effective use it is always better to know a little more than “push the button and follow the instruction”. This activity gives us such a possibility.

Making a simplified sextant for didactical use

Apart from the evident goal of this activity – making a sextant for didactical navigation purposes – additional goals are achieved at the same time. Thus, students gain handwork skills and apply their knowledge of mathematics in practice. An important side-effect is that students see the development of measuring devices from a historical point of view. This builds the bridge between present and past.

Travelling through the Galaxy: three-dimensional models of the constellations

By adding the third dimension to “flat” constellations that we see in the sky, this activity helps students to imagine the true Universe, filled with stars, nebulae and galaxies and, perhaps, crossed by alien spaceships! But instead of science fiction stories, these models are based on accurate data received by scientific satellites. This activity also develops the spatial perception of students that is critical in many applications – geometry, design, architecture, etc.

The proceedings of the 4th EAAE International Summer School, published in three languages, contain the activities carried out, such as general lectures, general working groups, workshops and posters. The Summer School offers participating teachers the opportunity during and after the Summer School to discover new, different, and interesting activities for use in the classroom. To this end, the Proceedings are useful while the Summer School is in progress to avoid the need for taking notes and to help overcome any barriers caused by linguistic difficulties. It is also invaluable for the revision and rereading of its contents after the Summer School has finished. This kind of practical document also enables other teachers unable to participate in the conference to obtain a written record of the activities.

The proceedings of the 4th EAAE International Summer School will be available from ros@mat.upc.es

Given the success of last year's Summer School, the organising committee is well on the way to preparing the 5th Summer School to be held in Germany 2-7 July 2001.

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INTERNATIONAL CONFERENCE ON PRIMARY SCHOOL SCIENCE AND MATHEMATICS EDUCATION

This was held in Beijing, 1-4 November 2000, and was organised by the International Council for Scientific Unions (ICSU) and its Committee on Capacity Building in Science (CCBS).

This is the first meeting on education by ICSU and the resolution says that the second meeting will be held in Rio de Janeiro in conjunction with the ICSU General Assembly. Over 60 scientists, educators, teachers, and representatives of governments and the private sector from over 20 nations gathered in Beijing, China, to discuss problems and opportunities in science and mathematics education in primary schools. The meeting started with a speech by the Minister of Education, China. The ICSU representative, Dr Larry Kohler described how this conference was accepted during its last General Assembly.

The four-day programme was rather open. At plenary sessions, each country showed its present situation or new trials, with session names: 1 Reform of science and mathematics education – examples from the field; 2 Science and mathematics education in the Asia/Pacific region; 3 What science and mathematics should be learned; 4 Preparing teachers who can teach the new curricula; 5 Student learning of science and mathematics – what does cognitive science tell us? Between these plenary sessions, we had parallel sessions with five subgroups: 1 Content and assessment; 2 Implications for high school science and mathematics teaching; 3 A role for technology in supporting quality science and mathematics education; 4 Learning science and mathematics before and outside of school; 5 Teacher training and continuing education.

Applicability of computers and the internet was discussed deeply. The necessity of science education to connect with daily life was also discussed.

We visited a kindergarten and an elementary school belonging to the Beijing Normal University and found a high level of curriculum. I felt that those children belong to an elite class. We also visited the China Science and Technology Center , which is a modern museum.

At the final session, the Beijing Conference Statement was produced after several revisions. It says that a building of capacity to use science, mathematics, and technology is very important to advance the human condition world-wide, and is becoming crucial to personal, national, and international "survival".

There were representatives of only three unions, two of which were Chinese, and the only IAU representatives were from overseas. Julieta and I strongly requested to the meeting that organisers should make much more effort to have representatives from a large number of member unions, since the support of scientific communities is essential to create good educational curricula even at elementary schools. The conference organisers accepted this request and will prepare the next conference along this line.

Syuzo Isobe
(for contact details see Officers & Organising Committee of Commission 46)

SIXTH INTERNATIONAL CONFERENCE ON TEACHING ASTRONOMY (ICTA6)

This year again has taken place the International Conference on Teaching Astronomy. This 6th conference was organised by the UPC Technical University of Catalonia in Vilanova i la Geltrú, a Mediterranean town near Barcelona. It took place 23-25 November 2000. The number of countries participating had increased from the last time thus showing consolidation of the conference as a meeting to provide information on and to compare new developments in astronomy for teachers from universities, secondary schools, and in some cases primary schools. This kind of meeting is important to bring people together to discuss their successes and their problems. The continuity in a group of institutions sending members to participate in every conference, and the participation in every conference of some professors and teachers, has led to common tasks and has given the conference the feature of a working-group with continuity.

There were five general lectures, one by each of Syuzo Isobe (current president of IAU Commission 46), Robert Estalella from the University of Barcelona, Edward Kononovich from the Stremberg Institute, Richard West from ESO, and Joan Solà-Morales from the Technical University of Catalonia.

Dr Isobe presented his general lecture during the opening session of the conference. The topic was "Astronomy as one of the important fields in an integrated school curriculum". He presented examples of stories containing scientific concepts and other aspects of the curriculum. Dr Robert Estalella in "Teaching astronomy: how and why?" presented examples at different levels. At the primary school level astronomy can be taught by Sun shadows, and night-time observations of the sky, with the naked eye, binoculars, or with a small telescope. At the secondary school level he proposed as an important goal to convince the student that the same laws of physics are applicable everywhere in the Universe, from the classroom to the most distance galaxies. Dr Edward Kononovich presented his general lecture about "Solar activity, weather and climate" always through a didactical approximation and emphasising the teaching point of view. Dr Richard West talked about "Modern astronomy and educational opportunities: examples from ESO". This talk was concerned with the general interaction between astronomy and the public (in this case schoolchildren), mostly as exemplified by recent and coming work at ESO. A number of important research results and their educational opportunities were described and also some future projects were mentioned.

Finally, in the closing session Dr Joan Solà-Morales gave a talk "Mathematics in the year 2000 and teaching astronomy". This contribution arose because the International Mathematical Union declared 2000 as the World Mathematical Year. The organisers of the 6th International Conference on Teaching Astronomy considered that this celebration could be represented in the Conference because the borders where astronomy ends and mathematics begins are extremely diffuse. Also, the problems and the methods of teaching astronomy have much in common with those of teaching mathematics.

A collection of 40 talks and 35 posters took place during the three days of the conference, offering the opportunity to exchange a lot of ideas for experiments. As a consequence of the rich exchange of information and the contrast of different point of view, the teachers and professors that attended the conference prepared during the last session a declaration to governments. This declaration was sent to the President of IAU Commission 46 to be distributed to the international forum. This declaration explains the opinion of the participants at the conference, and its contents appear below. It is very important for all the participants at the conference to obtain the support of the IAU to divulge this declaration and to achieve their proposals.

The proceedings of the conference will be available in few months from ros@mat.upc.es

Vilanova Declaration

Teachers, educators and astronomers from 22 countries, from Europe, North and Latin America, and Japan, met in Vilanova i la Geltrú (23-25 November 2000), invited by the Universitat Politecnica de Catalunya (Spain) for the 6th International Conference on Teaching Astronomy (Pr Rosa M Ros Conference Secretary).

They reported and discussed the important role of astronomy in education, their teaching activities, experiences, and pedagogical strategies in astronomy education using a multidisciplinary approach.

As a conclusion of this conference they emphasise the importance of putting together several experiences carried out in different cultural contexts. They recommend that IAU Commission 46 should help official contacts with authorities aimed at developing the teaching of astronomy. They stress that teaching material must be developed by educators and teachers themselves, in close co-operation with astronomers, in their own cultural context and validated through interaction and co-operation between teachers and astronomers in meetings such as this one.

Moreover, the access to these teaching resources must take place on a non-commercial basis, preserving the different cultural approaches.

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A WORKSHOP ON EDUCATION AND PUBLIC OUTREACH IN ASTRONOMY

Giant eyes put their heads together! A workshop to brainstorm and share ideas on Education and Public Outreach (EPO) in astronomy was held at the South African Astronomical Observatory (SAAO) in Cape Town 16-20 February 2000. Representatives from most of the world's large state-of-the-art radio and optical telescopes attended.

Professor B D Reddy, Dean of the Faculty of Science at the University of Cape Town, opened the workshop and then participants delivered short presentations on their EPO activities. As was expected, it was found that, in spite of different environments, facilities, and funding, there was a great deal of common ground that could be exploited to promote astronomy.

Delegates at the STARTEC Workshop enjoying lunch in the Library at SAAO, Cape Town, February 2001. *Standing*: J. Alonso, Ian Morison (Jodrell Bank), Sandra Preston (HET/McDonald), Mary-Kay Hemenway (HET/McDonald), Dave Finley (VLA), Peter Michaud (Gemini), Terry Teays (STScI/Origins Education Forum), Richard West (ESO/VLT), and Frank Cianciolo (HET/McDonald). *Kneeling*: Case Rijsdijk (SAAO/SALT), Daniel Altschuler (NAIC/Arecibo), M Cote, Jose Alonso (NAIC/Arecibo). *Photographer*: Luis Cuesto Crespo (IAC/GTC) who also attended the workshop.

During the following two days there were intense discussions on what the aims and objectives of a collaboration should be. It was felt that these large state-of-the-art astronomical facilities play a significant role in expanding the frontiers of knowledge. As a result they bear a responsibility to enhance the awareness of people regarding our place in the Universe and the importance and relevance of scientific endeavours. By sharing their resources and expertise, members will enhance their own EPO activities and be better able to carry the excitement of astronomy to a wider audience throughout the world.

These deliberations ended with a Memorandum of Understanding which committed representatives from the collaboration, known as STARTEC (State of the ARt Telescope Educational Collaboration), to attend future meetings to achieve the objectives and goals of the collaboration.

The success of the workshop was due in some part to the small size of the group attending during the set-up process, but it is intended to confirm some, and invite others, fulfilling the criteria to join at a later stage. The collaboration will be announced at various expos/events and the following were initially identified: EAS, Munich, September 2001; EWST, Geneva, November 2001; American Astronomical Society (AAS), Washington, January 2002; and Instituto d'Astrophysica d'Canarias (IAC), February 2002.

The next meeting scheduled for STARTEC will be held at Arecibo 7-8 December 2001.

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TENTH UN/ESA WORKSHOP ON BASIC SPACE SCIENCE

This 10th workshop will be held in Mauritius 25-29 June 2001. It will be oriented to the opportunities for developing countries to participate in world space observations and in the utilisation of space technologies. Though research is the main focus there will be coverage of "Education and Networking of Telescopes, with special reference to the southern hemisphere". Updated information about the workshop can be obtained at http://www.seas.columbia.edu/~ah297/un-esa/

Barrie W Jones

(for contact details see Officers & Organising Committee of Commission 46)

IN BRIEF

N C RANA MEMORIAL OBSERVATORY

Issue number 45 (January 2001) of KHAGOL – a publication of the (Indian) Inter-University Centre for Astronomy and Astrophysics – reports on the creation of the N C Rana Memorial Observatory, located at the MGM Engineering College, Nanded. Professor Rana was the enthusiastic representative of India to IAU Commission 46 until his untimely death, shortly after IAU Colloquium 162 (New Trends in Astronomy Teaching) held in London UK in 1996.

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BOOK: AMATEUR-PROFESSIONAL PARTNERSHIPS IN ASTRONOMY

I am proud to announce the publication of Amateur-Professional Partnerships in Astronomy, edited by John R Percy and Joseph B Wilson (Astronomical Society of the Pacific, 414 pages, $52 US). This is a comprehensive and engaging account of amateur (volunteer) astronomers' outstanding contributions to science and education. It is the proceedings of a symposium held in Toronto in 1999, as part of a larger Partners in Astronomy conference, during which the City Council declared Toronto to be "the centre of the Universe". The book includes the texts of 63 papers, three panels, summaries of 28 poster papers, and extensive discussion; the 137 authors include amateur and professional astronomers, educators, and students.

John R Percy
(for contact details see above)

EDUCATION AND PUBLIC OUTREACH INITIATIVE IN CANADA

The Canadian astronomical community, represented by the Canadian Astronomical Society (the organisation of professional astronomers), and the Royal Astronomical Society of Canada (which includes professional and amateur astronomers), has recently embarked on a formal education and public outreach (EPO) program, funded by a new Science Promotion Program of the Natural Sciences and Engineering Research Council of Canada. Canadian professional and amateur astronomers, and their institutions and clubs, are already active in EPO; the new initiative will provide structure, coordination, and resources. For more information, see www.casca.ca/ecass/issues/winter2000/ for a fuller article by me.

John R Percy
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WHAT I LEARNED FROM A SCHOOL OF EDUCATION COLLABORATION

At the January 2001 joint meeting of the American Astronomical Society, and the American Association of Physics Teachers, there was an interesting panel discussion on the above topic. It is clear that Schools of Education can benefit from the expertise of astronomers – especially for pre-service teacher education. I can assure you that, as one who has engaged in such collaborations, the astronomer can benefit as well. After all, most professors in universities have little or no training in effective teaching and learning and related topics. I would be happy to hear from other astronomers who have had experience with such collaborations.

John R Percy
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ASTRONOMY CURRICULUM AND BOOK FOR GREEK SCHOOLS
Two years ago a new curriculum and book were introduced in Greek schools through the Greek Ministry of Education and Religion. I was a co-author. Astronomy is optional at the 2nd grade of high school and is taught for about 40 hours per year i.e. 2 hours per week.

Question: what should we include in any future book? Information on a topic, or procedure plus activities for the topic, or all of this? If the latter would this mean a book with too many pages? Could Commission 46 introduce some guidelines to be followed?

Could we have official information on what's going on in astronomy curricula all over the world, including at which level each topic is taught? Does Commission 46 already have such information?

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COMMISSION 50 WORKING GROUP ON CONTROLLING LIGHT POLLUTION
IAU Commission 50's working group Controlling Light Pollution is initially focussing attention on a pragmatic programme of control of light pollution where the largest investments have been made recently in ground-based optical and infrared telescopes, and where substantial large-scale activity is expected over the new few decades.

Commission 50 realises the central role that education has in informing the world community, at all levels, about the critical need to protect our dark skies, including the regions around major observatories. To reach the huge target audience, the working group will have to work with schools and universities, the mass media, specialised media, planetariums, science centres, astronomy clubs, and so forth. The working group will therefore be relying largely on being able to work effectively with the best of the existing public outreach media. On the web-site of the working group you may find very interesting activities on the subject, suitable for schools and universities.
http://www.ctio.noao.edu/light_pollution/iau50/

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Organising Committee

This presently consists of the President, Vice-president, Past-president, a representative from the IAU Executive Committee, the chairs of the program groups, and the vice-chair of the program group Exchange of Astronomers. For details of the OC, and for the other members of the program groups, see the website below, and also Newsletter 53, under Section B of the item, The Business Meeting of C46 2000.

National liaisons

These are listed on the website **http://physics.open.ac.uk/IAU46**