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## TEACHING OF ASTRONOMY AND SPACE SCIENCE: ASTRONOMY AND SPACE SCIENCE CURRICULA AT UNIVERSITY LEVEL IN PAKISTAN

### *Abstract*

*It is the Continuation of our review of contents of astronomy and space Sciences curricula in Pakistan (I. Rahim, R.K. Ansari, A.K.Zai, 2011) which dealt with only pre-university level curricula in Pakistan whereas, the present study reviews the university level curricula in Pakistan.*

*There are two types of higher education institutions in Pakistan. The state governed (Public sector) universities and institutes and the private sector universities and degree issuing institutions. Also, there are institutions under military control and R & D organizations. We will review the curricula of some such institutions and compare with curricula of United Nations programs on space applications.*

*It is concluded that the standard and span of AS and SS courses at university level curricula in Pakistan have highly been raised. However, no institution is granting degree in the specific area of commercial and industrial uses of space.*

*This means that as a nation we have just stepped on but not yet have started the journey to participate in the activities of industrialization and Commercialization of space and more efforts have to be put in this regard.*

*Keywords: Education in Pakistan; Space Science Education; Space Research; Space technology curricula*

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## *Introduction*

In [I. Rahim, R.K. Ansari, A.K.Zai, 2011] Contents of Astronomy and Space Sciences Material in Pre University Level Courses in Pakistan (Karachi) were reviewed. It was concluded that A & SS at school and college level are not included as a subject.

Then, searching for any reference of A & SS whether in the form of a paragraph, a verse, some lines regarding a topic of religious interest, some pages with reference to social sciences or chapters in general/physical sciences, it was found that this totals only to contribute not more than 8% of the whole text material. It was suggested to add sufficient chapters concerning A & SS at school level and to include it as subject at the intermediate level with a stress on practical and observational aspects [I. Rahim, R.K. Ansari, A.K.Zai, 2011].

It should be remarked that all these efforts should orientate on the welfare of humanity and while entering an era with the prominence of Space Science and Technology the first priority should be to save mankind from wars and natural disasters. Science and technology obviously play an important role in national development. It is noteworthy that to make such efforts truly fruitful, a general awareness of the young generation and its sincere involvement through proper education and training and generating proper human resource to work in space science and technology is a must.

In the past fifty years development of science and technology has been one of the targets of all governments in Pakistan. Since 1962 space science programs gained importance in the country's planning. But such programs were restricted and were hidden behind the curtains of secrecy because of their military uses.

For a long time no institution or university under civilian control was authorized to initiate such programs. Latter when such restrictions were lifted then A & SS programs were started in the University of Karachi and The University of Punjab.

Then proper curricula were developed by these institutions and afterwards by Higher Education Commission of Pakistan.

As early as the first satellite launched, United Nations declared the space to be used for peace only and for the benefit of all. For the enhancement and better understanding of space science, UN initiated a program for the benefit of all the regions on the globe.

In this regard, United Nations established regional centers in western Asia, Africa, Asia and Pacific, Latin America. These programs were particularly suitable for the teaching and training of A&SS. Education curriculum for the major fields of space sciences have been developed, to ensure the standard education of space science and technology.

This communication deals with the content of graduate/master's degree programs (astronomy and space sciences) of some universities and degree awarding institutions of Pakistan. It also compares these space sciences curricula with UN standard space programs.

### *Space Sciences Education and Curricula of Pakistan*

Most of the universities in Pakistan induct students after 12 years of education (After securing Higher Secondary or Intermediate level). There are around 57 private and 67 public universities in Pakistan. These include institutions for Business Studies, Management Sciences, Natural and Social Sciences and Engineering. Astronomy and Space Sciences have a natural affinity with Natural Sciences in particular with mathematics and physics, though in the past astronomy was taught to arts students as well.

University of The Punjab has a Master's program while University of Karachi has a separate institute that is Institute of Space and Planetary Astrophysics (ISPA).

In addition, departments of Mathematics and Physics at the University of Karachi have independent programs in A & SS. Federal Urdu University of Arts Sciences and Technology Karachi Campus also offers A and SS courses via its Mathematical Sciences Research Centre and the Department of Mathematics. In the following we look at the curricula of ISPA, University of Karachi and Institute of Space Technology (IST) of SUPARCO and the curricula proposed by Higher Education Commission (HEC) of Pakistan. We will try to assess the curricula with the help of their compulsory courses part.

### *Higher Education Commission of Pakistan (HEC)*

Higher Education Commission of Pakistan (HEC) is the main authority to control the quality and quantity of the curricula adopted by the universities and degree issuing institutions of Pakistan. It not only monitors curriculum related issues but also provides guide lines in this regard and proposes the basic curricula.

From time to time the curricula undergo revision. Institutions are not bound to totally adopt the proposed curricula. They can moderate and modify according to the facilities and faculty available. HEC, Pakistan developed Space Science curricula earlier in 2004. It gone through multiple revisions and then in 2012 took [the shape as in \(http://www.hec.gov.pk/InsideHEC/Divisions/AECA/CurriculumRevision/Documents/SpaceScience-2011-12.pdf\)](http://www.hec.gov.pk/InsideHEC/Divisions/AECA/CurriculumRevision/Documents/SpaceScience-2011-12.pdf).

The main curriculum of BS/MS have 124-136 credit hours for BS and further 30 credit hours for MS. The compulsory part provides a strong base to a variety of optional. It focuses upon Mechanics and Thermodynamics, Statistical Analysis, Electromagnetic Theory, Statistical Analysis, Fundamentals of Remote Sensing, Atmospheric Sciences, Classical and Quantum Mechanics, Spherical and General Astronomy and Geodesy, Geographical Information System (GIS), Gravitational Physics, Space Plasmas,

Space Flight Dynamics, Solar and Ionosphere Physics, Digital Image Processing, Meteorology, Quantum Mechanics, Astrophysics, Analog and Digital Electronics, Navigation and Space Instrumentation, Space Mission Design, Semiconductor Device Fabrication. This foundational stuff leads to four specializations of Geo Informatics, Atmospheric and Environmental Sciences, Satellite and Space Communication and Space Physics (<http://www.hec.gov.pk/InsideHEC/Divisions/AECA/CurriculumRevision/Documents/SpaceScience-2011-12.pdf>)

***Space Sciences Curricula of Institute of Space and Planetary Astrophysics(ISPA), University of Karachi***

Institute of Space and Planetary Astrophysics (ISPA), University of Karachi was established in 1994. ISPA offers M.Sc., M. Phil./MS and Ph. D. programs in A & SS. The 60 credit hours course is required to be completed in two years for M.Sc. degree. Details can be found in Table:1.

***Table 1 Credit Hours earned by M.Sc. program***

| <b>S. No.</b>             | <b>Semester</b> | <b>No. of Courses</b> | <b>Type of Courses</b>  | <b>Credit Hours</b> |
|---------------------------|-----------------|-----------------------|-------------------------|---------------------|
| 01                        | First Semester  | 05                    | Compulsory              | 15                  |
| 02                        | Second Semester | 05                    | Compulsory              | 15                  |
| 03                        | Third Semester  | 05                    | 3 Compulsory 2 Elective | 15                  |
| 04                        | Fourth Semester | 05                    | 3 Compulsory 2 Elective | 15                  |
| <b>Total Credit Hours</b> |                 |                       |                         | <b>60</b>           |

The compulsory part of the curriculum focuses upon Spherical and General Astronomy, Geodesy, Foundation of Remote Sensing, Mechanics (Classical and quantum), Atmospheric Sciences and Dynamics, Space flight dynamics, Ionosphere physics, Astrophysics (Solar and Stellar), Gravitation Physics and Geo informatics.

It is obvious that these courses lay down a firm foundation for advanced topics to be covered in the optional part. Details can be found in at (<http://ispa-ku.com/Programs.html>, [http://www.uok.edu.pk/research\\_institutes/ispa/facilities.php](http://www.uok.edu.pk/research_institutes/ispa/facilities.php))

ISPA is the only institute in Pakistan that offers Ph. D. program in Space Science. Up to now it has awarded 6 Ph. D. and 12 M. Phil. degrees. Most of the theses are related to indigenous problems. ISPA is equipped with a small observatory with 6" inch reflector telescope, a high speed computational lab and a GIS lab.

### ***Space Science Curricula Institute of Space and Technology (IST), Pakistan***

IST is the institute associated with SUPARCO (Space and Upper atmospheric research commission, a national space agency of Pakistan) and was established in 2002.

It offers BS/MS degrees in many fields rich in A & SS. These are Aeronautics and astronautics, Electrical Engineering, Mechanical Engineering, Space Sciences, Remote Sensing & Geo-Informatics and Communication Engineering.

The compulsory part of the curricula focuses upon Mechanics (Quantum and Classical), Remote Sensing, Thermodynamics, Atmospheric and environmental Sciences, Meteorology, Electromagnetic waves and antennas, Space Plasma Physics, Astronomy and Astrophysics, Space flight Dynamics, Solar and Ionosphere Physics, Digital Image processing, Analog and digital electronics, Navigation and Space Instrumentation, Communication Networks, Satellite Communications, Space Mission Design, Optoelectronics, Embedded system in space, Research Methodology, Space Applications Laws and policy, Space system project Management (<http://www.ist.edu.pk/ss/undergraduate-programs/bs-space-science/course-outline>).

IST has the facility of many labs of its own and of SUPARCO. The comparative study of compulsory space sciences subjects of HEC, ISPA and IST is shown in Table 2;

*Table2 Compulsory space sciences subjects comparison of HEC/ISPA/IST.*

|     | <b>HEC</b>   | <b>ISPA</b>  | <b>IST</b>                             |
|-----|--|--|--|
| 1.  | Mechanics(Classical, Quantum) <sup>***</sup>       | Gravitational Physics <sup>**</sup>                    | Environmental Sciences                 |
| 2.  | Thermodynamics <sup>**</sup>                       | Fundamentals of Remote Sensing <sup>**</sup>           | Electromagnetic waves and antennas     |
| 3.  | Statistical Analysis                               | Geographical information System(GIS) <sup>**</sup>     | Communication network                  |
| 4.  | Semiconductor Device Fabrication                   | Atmospheric Sciences and Dynamics <sup>**</sup>        | Satellite communications               |
| 5.  | Space Plasma <sup>**</sup>                         | Electromagnetic <sup>**</sup>                          | Optoelectronics                        |
| 6.  | Analog and Digital Electronics <sup>**</sup>       | Astrophysics <sup>***</sup>                            | Embedded system in space               |
| 7.  | Navigation and space instrumentation <sup>**</sup> | Astronomy (General, Spherical, Geodesy) <sup>***</sup> | Research Methodology                   |
| 8.  | Space Mission Design <sup>**</sup>                 | Solar and ionosphere Physics <sup>***</sup>            | Space applications laws and policy     |
| 9.  | Meteorology <sup>**</sup>                          | Space Flight Dynamics <sup>***</sup>                   | Space system Project Management        |
| 10. |  |  | Digital Image Processing <sup>**</sup> |

**LEGEND:**      **\*\*** *Subjects common in any two, \*\*\** *Subjects common in all Subjects independent are without “\*\*”.*

### ***Astronomical Observatories in Pakistan***

As evident from the above discussion, curricula related A &SS are sufficiently up to date and are capable of leading the future professionals to advanced areas. Use of telescopes, observational experimentation and observatory work is an essential part of the training of A & SS students. Unfortunately there are a few observatories in the Universities of Pakistan. Only a small observatory equipped with a6”refractor at the University of Karachi, the and Use of telescopes and Space-based assets such as telecommunication, Earth Observation and navigation satellites

support a wide range of applications and are increasingly integrated into public infrastructures and policy of decision making. This desire guided to develop small capable satellite of affordable cost in universities and institutions.

This sustainable development and use of applicable space technology need advance computation labs, space laboratories and observatories. In Pakistan most of the Research and development universities and institutes are based on theoretical and mathematical modeling. The pathetic conditions of universities observatories decrease the moral of students. To keep their interest alive and produce more efficient work they need advance laboratories, observatories and facility to collect data.

Pakistan has three observatories

A. Astronomical observatories of university of Karachi

B. Astronomical observatories of university of Punjab

C. Naval Observatory of Jinnah Naval Base(JNB)

Karachi university observatory or KU observatory is operated by ISPA where students learn basic handling of telescope. The observatory of Department of Space Science ion the University of Punjab, Lahore is the oldest Observatory of Pakistan. It established in 1985 and one of the oldest center of research and development of Space Science in Pakistan [2]. It is equipped with two small telescopes, and one seven inches reflecting telescope.

The department laboratory of Remote Sensing/DIP laboratory used both for training and research field. On regular basis weather images are received from NOAA Satellites. That observation and reading are used for analysis of synoptic weather phenomena.

Jinnah Naval Base (JNB) is marine and naval Research and development base. JNB is under control of Pakistan Navy and not open for students and civil researchers.



The basic Aim of naval observatory is to produce positioning, Navigation, Weather forecast, Timing (PNT) for Pakistan Navy and Ministry of Defense ([http://en.wikipedia.org/wiki/Pakistan\\_Naval\\_Observatory](http://en.wikipedia.org/wiki/Pakistan_Naval_Observatory)).

### *United Nations Space Sciences Curricula*

The regional centers established by United Nations belong to India, Morocco, Nigeria, Jordan, Mexico and Brazil. The purpose of these centers is concerned with the development of capabilities of scientist, researchers, and university educators and contribute sustainable in the development of each country [9]. Such programs develop understanding about the following.

- A. Satellite Meteorology and Global Climate (SMGC)
- B. Satellite communications and geo-positioning system (SCDI)
- C. Remote Sensing and geographic information (RSGI)
- D. Space and atmospheric sciences (SAS)

The courses emphasize the development of skills and knowledge of scientist, engineers and university educators in natural, physical sciences and analytic disciplines (<http://www.oosa.unvienna.org/oosa/en/SAP/centres/education-curriculum.html>).

The basic curricula of Satellite Meteorology and Global Climate are Meteorology, Climatology, Oceanography, Atmospheric Physics, Mathematics, Statistics, Computer techniques, Overview of meteorological satellites/orbits. Application of Image Processing and GIS: Instrumentation and meteorological sensors, Image interpretation and application, Image processing techniques, Basic GIS. Satellite data retrieval and Application: Geophysical parameter retrieval, Atmospheric parameters, Land and ocean parameters, Land and ocean parameters.

Numerical models and global climate divided in three parts first Numerical models and satellite data assimilation: Regional and global models, Concept of data assimilation, Satellite data

assimilation and second Global climate: Climate change, Impact of climate change, Climatology based upon satellite data third part is based on Environmental issues: Atmospheric chemistry, Environmental protocols, Disaster management. Some optional courses also offer for advance students like Potential uses of future satellite instruments, advanced applications of Satellite Data, Advanced satellite data assimilation in NWP, Advanced GIS.

The curricula of satellite communication and geo-positioning system based on Communication systems and digital signal processing, Satellite communication systems, Earth station technology(Transmission, multiplexing and multiple access, Broadcasting using communication satellites), Applications and trends in satellite communications: Operational communication satellite systems, Network planning, management and operational issues of satellite communication systems, Satellite communications for development, education and training.

The field curricula has two basic courses first Fundamentals of remote sensing and GIS based on Remote sensing, Image interpretation and image analysis, Photogrammetry and Geo informatics, second Remote sensing and GIS applications in natural resources surveys and environment based on Advances in remote sensing and GIS, Satellite meteorology, Earth processes, Sustainable development and integrated resource management, Natural disaster monitoring and management, Environmental analysis, management and global issues. Remote sensing and GIS applications in thematic areas (elective in one of the following): Agriculture and soils, Forestry and ecology, Geosciences, Human settlements, Water resources, Marine.

The basic courses of space and atmospheric sciences are Mathematics for space scientists and engineers, Structure, composition, dynamics and evolution of planetary atmospheres, ionosphere physics, Solar wind, magnetosphere and space weather, Astronomy and astrophysics, Basics of spacecraft design, construction and launch, Space biology, Space geodesy.

The Compulsory subjects for training of university students in program of space application of United Nations can be seen in Table:3.

**Table 3 Compulsory subjects for training of university students in program of space application of United Nations.**

|   | <b>SMGC</b>                              | <b>SCDI</b>   | <b>RSGI</b>  | <b>SAS</b>  |
|---|--|---|--|---|
| 1 | Meteorology                              | Communication systems and digital signal processing | Fundamentals of remote sensing and GIS   | Structure, composition, dynamics and evolution of planetary atmospheres |
| 2 | Climatology                              | Satellite communication systems                     | Remote sensing and GIS applications in natural resources surveys and environment | ionosphere physics  |
| 3 | Oceanography                             | Earth station technology                            |  | Solar wind  |
| 5 | Atmospheric Physics                      | Applications and trends in satellite communications |  | Astronomy and astrophysics  |
| 6 | meteorological satellites/orbits         |   |  | Basics of spacecraft design construction and launch                     |
| 7 | Application of Image Processing and GIS  |   |  | Space biology   |
| 8 | Satellite data retrieval and Application |   |  | Space geodesy   |
| 9 | Numerical models and global climate      |   |  | magnetosphere and space weather   |

### *Space Sciences Curricula in the Development of Pakistan*

The objective of the National Curriculum Revision Committee (NCRE) for Space Science established by HEC is to provide a base line for the development of different specializations in space sciences. The national space agency of Pakistan, Space and upper atmosphere Research commission (SUPARCO) are R & D organizations to establish and develop projects for the uplift of Space Science in the country. These include projects to develop socioeconomic uplift of the country as well.

Researches in ionosphere, geomagnetism, astronomy and astrophysics are all part of it. But its pilot study based on Geographic Information System (GIS) and Satellite Remote Sensing (SRS), environmental monitoring, mapping and natural resources surveys are considered important for their utility. The satellite PAKSAT-1 is also providing services of national and international usage. The remote sensing satellite system [RSSS], comprises of two remote sensing satellites, one carrying an electro-optical payload and the other a synthetic aperture Radar (<http://www.suparco.gov.pk/pages/sas.asp?saslinksid=1>).

A pilot project for Tele-medicine is also in progress. Jinnah Post Graduate Medicine Center (JPMC) in collaboration with SUPARCO has a satellite communication based telemedicine network. The JPMC works as a hub connecting other hospitals such as the Civil Hospital, Shikarpur. This remote site in interior Sindh is linked through Paksat-I. The patients of rural areas connect with the Doctors and Specialist in JPGMC through video conferencing.

Despite all these activities of practical importance which are deeply concerned with A & SS, no institution is granting degree in the specific field of commercial and industrial specializations. For such specializations engineers and scientist need training abroad.

### *Conclusion.*

In our view a curriculum with traditional Astronomy and Space Science (A&SS) courses (though are of extreme importance) is not sufficient to enter in an era construed of a new span extending to the industrial use of Astronomy and Space Science, humanization of space and a use of these subjects for the betterment of society. It requires the inclusion of newer topics more specifically fulfilling such needs.

This study stressed to indicate that what challenge is urgent to meet from the point of view of the developing countries in general and for Pakistan in particular, where, because of its huge population and waste of resources a crisis has already been developed in every walk of life.

It is more than obvious that either to put efforts towards acquiring the benefits of the utilization of space science and technology which involves a network of satellites for commercializing the space, monitoring the environmental, weather forecasting, prediction of natural disasters, estimation of water available in future and glacier melting, exploration of agricultural and energy sources, etc. or to PERISH.

One must be sure that the utilization of space science and technology for development is open to every nation and region. It can be made more beneficial to the whole humanity via international protocols. It is the perspective in which this study reviewed the Astronomy and Space Science Curricula in Pakistan.

In this regard, curricula of the Institute of Space and Planetary Astrophysics (ISPA), University of Karachi, Sir Syed University of Engineering and Technology, College of Aeronautical Engineering Risalpur and Institute of Space Technology (IST) of Space and upper Atmosphere research Commission (SUPARCO) were under consideration. These curricula were compared with the curricula of United Nations programs on space applications.

Quality and quantity of AS and SS courses at university level in Pakistan were found to be at par with the international standards. Though the curricula related to specific area of commercial and industrial uses of space are lacking but the nation has started throwing pebbles in this ocean.

In the above discussion we have reviewed the current situation of the teaching of A & SS education at university level in Pakistan. It was found that our curricula are well up to date to fulfill the need of Space Scientists and Astronomers in the country.

But as regards the industrial and commercial usage of space technology, the curricula are deficient. Here we would like to add suggestions for further improvement.

- i. Funds must be provided to make a well-equipped advance astronomical observatory.
- ii. Well organized computer and satellite labs must be established.
- iii. Easy availability of satellite data should be made available to researchers and developers.
- iv. For general awareness regarding national and international problems open discussion forums should be established.
- v. Collaboration with international institutions and organizations should be made strong.
- vi. Scholarships for training in Space Science and Astronomy should be frequently available.
- vii. National international trainings and workshops should be organized.

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