ASTRONOMY IN THE SPANISH PRE-UNIVERSITY EDUCATIVE SYSTEM: THE PARTICULAR CASE OF THE CANARY ISLANDS

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1.- INTRODUCTION

Astronomy contents do not only appear in the non compulsory subjects of Astronomy, but also in several other compulsory and non compulsory subjects of the Spanish pre-university educative system. We analyse the astronomy contents in the curriculum established by the law: when they do appear, in which subjects, which teachers are expected to teach them. To do so we classify the astronomy contents in several groups.

A spread of astronomy contents throughout the educative stages is observed. They appear in different subjects and not always as a physical science. We observe that the teachers expected to teach these contents are not always prepared to perform this task.

2.- RESEARCH METHODOLOGY

To analyse astronomy contents in the Spanish curriculum established by law we have classified the different conceptual contents into the following groups:

- **Sun- Earth- Moon System,** with concepts related with how this system works: day, night, year, seasons, sea tides, eclipses.
- **Solar System,** gathering concepts related to the description of planets, satellites, asteroids, comets, meteorites, extrasolar planets.
- **Stars,** with those referred to the physics of stars, stellar evolution, solar physics, brown dwarfs, gathering in clusters, compact stellar objects (white dwarfs, neutron stars, black holes).
- **Galaxies,** with those referred to the physics of galaxies, their description and classification, clustering.
- **Cosmology,** with concepts regarding the whole universe, its dimension, creation (Big Bang), universe evolution, Hubble constant, place of man in the universe.
- **Techniques,** telescopes, photography, measuring devices (hours, angles,...), artificial satellites, space rockets and its technology, space stations.
- **Positional Astronomy,** with concepts related to the observation of the sky, constellations, sky characteristics, sky laws, orientation through celestial bodies.
- **History of Astronomy:** change in the place of man in the universe, history of technology and discoveries, concept evolution.
- **Physics applied to Astronomy,** with concepts from physics where astronomy is used to illustrate, explain or motivate.
- **Historical Astrology,** critics to Astrology.
- **Extraterrestrial life,** with concepts about looking for extraterrestrial life.
- **Others,** with concepts not classified in the previous groups (nebula, interestellar medium,...).

3.- ASTRONOMY IN THE CURRICULUM ESTABLISHED BY THE LAW IN THE COMPULSORY STAGES

The Spanish pre-university educative system (BOE de 4 de septiembre de 1990) has four different stages, shown in Table 1 together with the pupils' ages at the beginning of each stage. We also note the options offered at the end of the two highest stages. It is observed that only two educative stages are compulsory.

STAGE	BEGINNING AGE	COMPULSORY?	FURTHER EDUCATION
Pre-primary Education	0 years old		
Primary Education	6 years old	✓	
Secondary Education	12 years old	✓	Formative Cycles or Professional Education
High School	16 years old		Professional Education or University

Table 1.- Data from BOE[1] of 4 september 1990.

Due to different factors, like the incorporation of women to professional activities, which favours the access of children to the educative system at very early ages, and the fact that in Spain the approach to reading and writing begins in the second cycle of Pre-primary Education, we will consider the latter as a part of the compulsory education in our analysis. Besides, we have to take in account that at the stage of Secondary Education there are non compulsory subjects. In this first part of the analysis we will only consider the compulsory subjects at Secondary School. Table 2 shows the distribution of the Astronomy contents throughout the education stages.

Educational stages	Sun-Earth-Moon System	Solar System	Stars	Galaxies	Cosmology	Techniques	Positional Astronomy	History of Astronomy	Physics applied to Astronomy	Historical Astrology	Extraterrestrial life	Others
Pre-primary Education												
Primary Education												
Secondary Education												

Table 2.- Data from BOC[2] of 26-6-92, 9-4-93, 28-1-94 and 19-8-96.

These contents are found in only one subject of the Primary Education (*Knowledge of the Natural, Social and Cultural Environment*) and the Secondary Education (*Natural Sciences*); and in two out of three subjects in the second cycle of the Pre-primary Education (*Physical and Social Environment* and *Communication and Representation*).

In the Compulsory Secondary Education (CSE) there are also non compulsory subjects which can be chosen by the student. Some of them, like *Classical Culture,* must be offered by all educative centres. Table 3 shows the distribution of Astronomy contents in the non compulsory subjects. Likewise, we can see that in the curriculum established by the law the Astronomy contents are treated from different points of view in the non compulsory subjects. We have to take into account that at the 4th course of CSE, specialization comes into the studies, and students must choose between 5 options of main subjects. The choosing limits the non compulsory subjects which they can study. Table 4 shows which non compulsory subjects can be studied in the different options at the 4th grade of CSE.

[1] BOE (Boletín Oficial del Estado) is the National Official Bulletin.
[2] BOC (Boletín Oficial de Canarias) is the Canarian Official Bulletin.

Non compulsory subjects	Sun-Earth-Moon System	Solar System	Stars	Galaxies	Cosmology	Techniques	Positional Astronomy	History of Astronomy	Physics applied to Astronomy	Historical Astrology	Extraterrestrial life	Others
Classical Culture												
Physics and Chemistry												
Introduction to astronomy												
History of Science												
Classical Languages and the terminology of Science and Technology												

Table 3. Distribution of Astronomy contents in the non compulsory subjects of Secondary Education. Data from BOC of 25-5-95 and 30-7-99.

Non compulsory subjects	Option A: Physics and Chemistry + Biology and Geology	Option B: Physics and Chemistry + Technology	Option C: Natural Sciences + Visual and Modelling Education	Option D: Visual and Modelling Education + Technology	Option E: Music + Visual and Modelling Education
Classical Culture					
Physics and Chemistry					
Introduction to astronomy					
History of Science					
Classical Languages and the terminology of Science and Technology					

Table 4. Possibility of studying the non compulsory subjects in one of the 5 options at 4th grade of CSE, where the main subjects of each option are specified. Data from BOC of 25-5-95, 30-7-99 and 17-4-00.

4.- ASTRONOMY IN THE CURRICULUM ESTABLISHED BY THE LAW IN THE HIGH SCHOOL

In the Spanish educative system there are 4 High School modes, all of them with Astronomy contents in some of their subjects. As it is the case with CSE, High School has compulsory and non compulsory subjects. Table 5 shows the distribution of the different subjects which have Astronomy contents.

Table 6 shows the distribution of the Astronomy contents throughout the subjects. *Fundamental Astronomy* and *History of Cosmology* are together in only one non-compulsory subject, but due to the different approaches and to the fact that it is suggested that the teacher can choose the approach he wants to apply, including the choice of using some topics from one part and some from the other, we have considered them as two different subjects.

5.- REALITY IN SCHOOL

Although Astronomy contents are compulsory, research done on Secondary School, High School, Teachers' Training and on Primary School teachers (De Manuel Barrabín 1995, Afonso López et al. 1995, Vega Navarro 2001) shows alternative conceptions to the ones accepted by science. Many students are unable to explain correctly the seasons' cycle (De

Manuel Barrabín 1995). Conceptions about our universe as being uniform, having black holes near our Solar System whose size is comparable to the latter ... are detected (Afonso López et al. 1995). It is alarming that half of the Primary School teachers can not explain in a satisfactory way the day and night cycle, or that for a third of them the Moon does not move (Vega Navarro 2001). Besides there is the fact that at teachers' training schools the contents of the subjects are not taught at all, but only methodology.

Subjects	Mode Arts	Mode Humanities and Social Sciences	Mode Technology	Mode Natural and Health Sciences
Physics and Chemistry				
Biology and Geology				
Physics				
Industrial Technology I				
Mythology and Arts				
History of Philosophy				
Fundamental Astronomy and History of Cosmology				
History of Science				
Physics and Chemistry				
Science, Technology and Society				

Table 5. Distribution of compulsory subjects (in black) and non compulsory subjects (in light grey) with Astronomy contents in the 4 modes of High School. Data from BOC of 25-5-95, 18-8-98, 30-7-99 and BOE of 29-1-93.

Subjects	Sun-Earth-Moon System	Solar System	Stars	Galaxies	Cosmology	Techniques	Positional Astronomy	History of Astronomy	Physics applied to Astronomy	Historical Astrology	Extraterrestrial life	Others
Physics and Chemistry												
Biology and Geology												
Industrial Technology I												
Physics												
Mythology and Arts												
History of Philosophy												
Fundamental Astronomy												
History of Cosmology												
History of Science												
Science, Technology and Society												

Table 6. Distribution of Astronomy contents in the different compulsory and non compulsory subjects given at High School. Data from BOC of 25-5-95, 18-8-98, 30-7-99 and BOE of 29-1-93.

Astronomy contents in Secondary School and High School are found in subjects ascribed preferentially to one of the following departments: *Natural Sciences*, *Greek*, *Latin* or

Philosophy. Whenever one of these departments is not able to teach the subject, it is ascribed to another one, which can be any of the following, as established by the law: *Natural Sciences*, *Mathematics* or *Spanish Language and Literature*. The teachers which belong to these departments are graduated in very different subjects, and thus most of them lack a scientific background in Astronomy contents. This is in contrast to what is established by the law, which prescribes the teaching of procedures from the point of view of physics. This is the particular case of History of Science, a subject taught by the department of Philosophy, where astronomy problems are supposed to be dealt with.

The non compulsory subject of Astronomy has been traditionally taught by those teachers which showed interest in this branch of science, i.e. by amateur astronomers, and its contents have been influenced by their approach to the subject as a hobby.

Taking in account that teachers do not know the contents they have to teach, it is hardly surprising that they frequently use textbooks. The consequence is that publishing editors have a very strong market in Spain. According to the report "National System of Education Indicators 2000" from INCE[3], 78% of Science teachers do frequently use textbooks in Secondary School. However, the use of textbooks does not assure the correct transmission of knowledge, given that the teachers are not able to correct possible mistakes in the publisher's proposal. This could lead teachers to teach non-scientific misconceptions.

6.- CONCLUSIONS

Astronomy contents appear throughout all pre-university educative stages, in compulsory and non compulsory subjects. Compulsory education has usual contents like *Sun-Earth-Moon System* or *Solar System*, and others related to hot research topics such as *Cosmology*. Besides there are different subjects which have Astronomy contents, from *Classical Culture* to *Natural Sciences*. That is, Astronomy contents are not seen only as science contents, but they are given a multidisciplinary character in the curriculum established by the law. This character is not taken into account in the teachers' training for any of the educational stages.
On the other hand, results about non-scientific misconceptions in students and teachers also point out the lack of knowledge of teachers.

Given the great amount of Astronomy contents distributed through very different subjects in the curriculum established by the law, it is necessary to train teachers of all educative stages in the corresponding conceptual contents. This training should contain the point of view of physics in the multidisciplinary view, without forgetting the professional perspective of the teachers to whom it is directed. For example, it is necessary to understand the scientific models from a historic point of view, to understand their consequences on the science of the time and on the present science. In this training, once conceptual contents are understood, it is possible to tackle the needs of teachers in school, with procedure contents and didactic proposals. A didactic proposal of something the teacher does not know is of no use to him.

We consider that the training of teachers is extremely important, given the fact that citizens meet their teachers as the first science popularisers.

NOTE

In the time since the oral communication and of this paper, new reforms have come into the curriculum established by the law for Secondary School and High School. The reforms concern how and in which subjects do astronomy contents appear. The changes can be seen in BOC of 30-4-02, 8-5-02, 10-5-02 and 10-6-02.

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