The Training of Teachers

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1. Introduction

Informal and formal astronomy education is present through many channels: newspapers and TV; amateur associations; clubs and science associations; at school at any level. The teachers are not only the main agents of the educational process at school, but they are also very active in extra-curricular activities: they run clubs, educational projects etc.

These activities are present everywhere in the world, as can be seen from the reading of the National Reports published every 3 years by Commission 46 "Astronomy Teaching" of the International Astronomical Union and published in its Newsletter.

A quick look at these reports shows that there is a huge variety of educational systems from one country to another: some countries have a specific curriculum in astronomy, others are just beginning to develop it; in other places, astronomy has been considerably reduced in the newly created curricula. One more difference: in some countries, education has a national curriculum; in others the responsibility for teaching is left entirely to each Province, a term used here to refer to the local situation. Such a situation and its consequences was were depicted by Wentzel (Williamstown IAU Colloquium 105, 1986).

1.1. *Why Astronomy in the curricula?*

In spite of these differences, a general trend can be drawn: it is very rare that astronomy is considered as a separate subject; it is nearly everywhere part of the programme either of Mathematics, Physics and Chemistry or Natural Sciences. The objective to be reached with the introduction of Astronomy in these fields was to widen the students knowledge of science, giving him (her) an idea of how to work scientifically from observations and known physical laws in order to get new knowledge within another field of science.

Astronomy can inspire students to study sciences, can help to fight against "math phobia" (see Appendix 1), but it is efficient only if the science teachers have a sufficient specific knowledge in the field of astronomy, in order that they feel competent enough to teach this subject.

1.2. *The Training of Teachers*

There is everywhere a huge demand for training school teachers in astronomy, whatever their level: elementary school teachers seldom receive much training in science in general and astronomy in particular; junior and senior high school teachers receive an initial training in mathematics, or physics-chemistry or biology, but with astronomy courses included in very few cases.

There is a general lack of teacher training in astronomy; the way it is organised varies from one country to another; and according to the many different local situations different strategies were defined, but very few of the teachers had initial training in astronomy at the university.

All teachers, primary as well as secondary, whether of physics, mathematics, earth science or geography, should thus be educated in astronomy both in initial and subsequent

in-service training. They should be instructed in scientific matters as well as in teaching methods; they need access to scientific research, to educational materials and methods and the possibility for exchanges of experiences.

It is obvious that a strong impetus was given during the Williamstown IAU Colloquium: a number of collaborations and activities in this field started there.

We have also to mention the International Conferences on Teaching Astronomy held at the Polytechnical University of Catalonia under the responsibility of Dr Rosa Maria Ros. The history of this conference started in 1984 and 1985 with the first and second Meetings on Teaching Astronomy at Secondary School for teachers from Catalonia; the number of participants increased every year and the following year, in 1986, the third National Conference on Teaching Astronomy in primary and secondary schools took place, open to teachers from all over Spain. After that, the conference became international, in 1990, with the 4th International Conference on Teaching Astronomy to teachers and professors representing all educational levels, ranging from primary schools to universities. The 5th one took place in March 1995: it brought together around a hundred participants, mainly teachers, from 15 different countries; they had the opportunity to attend five general lectures and to present their own ideas, experiences and contributions. All of them are published in the Proceedings. All those who attended one of these Conferences can attest how personal links were developed among participants and further collaborations started.

2. Present European situation

In what follows, we develop the present situation in Europe as we know it through the Workshop on the Teaching of Astronomy in Europe's Secondary Schools held at the ESO headquarters in November 1994 under the auspices of the Second European Week for Scientific Culture.

During this meeting, 100 school teachers coming from 17 western European countries gathered, as well as officials from the Ministries of Education of these nations.

The present status of astronomy teaching everywhere in western Europe was presented and an important exchange of information took place also during this meeting, for the first time in Europe, on that subject. The "European Association for Astronomy Education" (EAAE) was initiated.

It was recognised that there is a crisis for the teaching of scientific subjects everywhere; in that context, astronomy was felt as being a unique opportunity for promoting scientific teaching. It was generally emphasized that less formalism should be used in the teaching of physics, in order to concentrate more on experimentation and on the various representations of natural phenomena. In such a framework, astronomy fits well. Such a conclusion was reached independently and under various conditions in each country.

The EAAE goes further, pushing the idea that an overall holistic view of astronomy should be presented to all European children. One strong point of the "Declaration on Teaching Astronomy in Europe's Schools", which was unanimously adopted by the participants of the EU/ESO Workshop is the following:

"By the end of compulsory education, students should have been involved in observation, experimentation and discussion of the following ideas from astronomy:

- Our place in the solar system, progressing to our place in the Universe;
- The nature of objects we see in our sky, for instance, planets, comets, stars, galaxies.
- Examine thinking from the past ages and more recent times to explain the character, origin and evolution of the Earth, other planets, stars and the Universe.

In initial training of teachers and their subsequent in-service training, these ideas should be introduced and reinforced.

Recent studies of students' misconceptions and ideas in astronomy provide a useful basis for the further development of teaching methods."

3. Examples of Activities Developed in Europe

The training of teachers is organised in many different ways, but the needs are similar: (i) need education in order to be able to teach astronomy, (ii) need educational material, (iii) need educational methods and the possibility for exchanging experiences. It is interesting to note that nowhere was anything in that domain organised on a nationwide basis by the national authorities. Instead, several actions were undertaken spontaneously by various groups of professional astronomers and/or didacticians in sciences, in close collaboration with school teachers.

We mention in the following a few examples.

The **Italian Astronomical Society**, a free society of professional astronomers, amateurs and teachers, which established an Educational Committee many years ago: this committee is a sort of nucleus for activities concerning the teaching of astronomy: it regularly interacts with the public authorities, the other scientific societies, the teachers associations; it ensures the presence of astronomy in the science curricula; it works out curricula proposals; it offers modular courses for teachers; it arranges summer courses for teachers; it promote competitions in schools and text-books analysis and it bring out educational materials. It works in close collaboration with several didactic laboratories of sciences such as in Turin, Rome or, more recently Reggio Calabria.

The educational system in Germany is ruled by the authorities of the 16 regions (Länders) which constitute the German-Federal Republic; the situation has changed after the German reunification in 1989, because astronomy has been a regular teaching subject in the schools of the 5 new regions of East Germany. In this situation, a Working Group was established in the German Physical Society, which cares for teaching of "astronomy and astrophysics at school". In the last 5 years, this group has been continuously organising workshops. Interesting didactic material is being developed by Prof. Roland Szostak in the Didactic laboratory of Münster University. We mention also an interesting package of 31 programmes in Turbo-Pascal available from Dr. Rainer Gaitzsch in Bavaria: their intention is the physical point of view in many selected examples of astronomical problems.

The long-standing activity of the **Finnish Association of Amateur Astronomers, URSA**, which publishes its Newsletter Tahdet ja Avaruus (Stars and Space), a number of books, generally written by astronomers and organises locally public conferences given by professional astronomers.

The long-standing activity of the **Association for Astronomy Education** in the United Kingdom and its Newsletter "Gnomon" and that of the **French Liaison Committee between Teachers and Astronomers**, CLEA and its Newsletter "Les Cahiers Clairaut" are well known. '

It is worth noting that many exchanges have taken place among members of these different associations: Les Cahiers Clairaut have already published many contributions from Italian colleagues (Lidia Nuvoli, Nicoletta Lanciano, Mascellani...), Spanish (Rosa M. Ros, Estrallela, Anglada,...), German (Roland Szostak), Finnish (Pekka Teerikorpi), Polish (Cecylia Iwaniszewska)...

Joseph Nussbaum (Israel), Cecylia Iwaniszewska (Poland), Roland Szostak (Germany), Christoffel Waelkens (Belgium) have already given lectures to CLEA summer universities

for school teachers and several participants came from Spain and Belgium. Two workshops have also been organised in Paris in which Darrel Hoff (USA) and CLEA members exchanged their experiences. Foreign astronomers have been invited to participate in the annual meeting of the Educational Committee of the Italian Astronomical Society, in teacher training sessions in Barcelona or Münster.

4. Conclusion

It is interesting to note, that though the situations in different European countries, and even within a given country, are somewhat different, similar conclusions are reached concerning both the contents and methods. Emphasis is being put everywhere on the importance of making observations, or at least studying observational documents, on constructing models and instruments.

Many school teachers prefer to construct for themselves, preferably with their pupils, relatively simple models, rather than buying more sophisticated ones ready to use, provided that the simple device illustrates sufficiently well the concept it is aimed at. However, they manifest also a strong interest in using modern techniques, such as CCDs.

We have also to mention the problem of the language, and not only the language, but also of the culture. Because astronomy is not only a science, cultural aspects are particularly important. The exchange of pedagogical documents may thus have different trends. Sometimes, they are simply translated from one language to another; sometimes, the same practical activity is presented in a different way.

It is clear that such teacher training can be made neither rapidly or massively especially when astronomy is part of the curricula. It needs progressiveness and feedback. This is the way the CLEA is working in France since 1977.

APPENDIX 1: THE POINT OF VIEW OF A FRENCH MATHEMATICS SCHOOL TEACHER (Josée Sert)

As a Mathematics teacher, I have been teaching Astronomy to students in the last year of their curriculum and who have chosen the Literary option of the Baccalaureat. Until June 94, the official instructions stipulated that about one third of the curriculum could be chosen among several optional topics, Astronomy being one of them. The students were to go through an oral examination for the *Baccalaureat*, during which they could present a personal project related to this optional subject. The syllabus consisted mainly of the History of Astronomy up to Newton's gravitation law and the measurement of time (sundials and calendars).

As years passed and I gave lectures on these subjects, I could assess how important it was to teach Astronomy, and this in several ways:

First, Astronomy is a means of reconciling those students who had often been "negatively"oriented towards Literary studies because they were not good at mathematics, with scientific subjects. Their curiosity towards such topics emerges at once and bursts into numerous questions, especially if you are lucky enough to take them to an evening observing session. It increases when they are confronted with science, a field still fraught with uncertainties, but where knowledge progresses fast and it leads them to other fields that help them to get answers. You can then notice that students are more active and develop skills (such as searching for information, delivering a lecture ...) and that they even accept using the mathematical tools which they have so far considered as artificial. As an examiner, I could see rich and thorough studies presented by students on topics they were particularly interested in (for instance the origin of the Universe, the possibili-

ties of extraterrestrial life in the solar system ...) as allowed by the particularly flexible syllabus.

Then, this brought them elements of a scientific culture which they had never approached before: the evolution of our ideas on the Universe through History, how and why this evolution occurred, what an experimental process consists of (the relationship between observation and the model), the difference between a model and a theory, how ideology or religion can influence the advancement of knowledge and stimulate their reflection on Man and his place in his environment.

For that reason, throughout these years, because of the students' queries or hints, I have more particularly dwelt on some particular points, sometimes with the help of the Philosophy teacher. I developed Aristotle's ideas; I made the students concretely study the equivalence between the Ptolemaic and the Copernican models. I emphasized the importance of observation in the process that led Kepler to his laws, the fundamental reflection of Galileo on inertia. I opened the issue of the influence of the Copernican revolution in other fields than Astronomy. I tried to bring to light the qualitative leap that the theory of gravitation represented and at the same time I encouraged the students to apply their own research method, not only to books but also to their immediate environment: getting pictures from observatories, searching for calendars different from the Gregorian one, thus discovering that their grandmother, their neighbour or the grocer at the corner of the street may practice another religion (which is of great interest because it involves contact with other people and respecting them, and instructive in so far as beliefs may be an obstacle to exchanges, for example if you cannot obtain a calendar because any document that bears the name of God may not be thrown away, or because you don't pledge to burn the sheet of a block calendar after it has been used).

So I discovered that the great interest of Astronomy was that it could lead these non-scientific students towards processes that made them discover the surrounding world, in order to understand its physical reality and become aware of some of its human dimensions. Is that not a promising start with respect to the education of the European citizens of the year 2000?