

«Like the shroud that Penelope wove, Science is always in the process of doing and undoing. Its plot of theories and techniques allows us at the same time to interpret the world in order to manage it and to act on the world in order to understand it.»

## FOREWORD

This book is the result of the work of a group of teachers from the University College of Chester, United Kingdom, from the IREM of Pays de la Loire, France, and from the CEP of La Orotava, together with the Fundación Canaria Orotava de Historia de la Ciencia, from Spain, all of them participate in the European Project Socrates (Comenius 3.1) «European Interdisciplinary Teaching of History of Science in Secondary Education». Our main objective, like this book, was to contribute to the introduction of the history of science in secondary education, and consequently, to the necessary formation of teachers in this field, that due to its interdisciplinary nature, transcends the typical specialised teaching imparted in university studies. This circumstance and the shortage of the appropriate materials motivated the project to be centred on a selection of modules for the formation of teachers in history of science. But before commenting the activities and modules of the project, let us justify the need to introduce this discipline in secondary education.

## Why History of Science in secondary education?

It is paradoxical that the history of science is almost absent in secondary education, when history and science are well-ingrained disciplines in the curricula that all European citizens must study during their basic formation. On the one hand, science teachers centre their activity in achieving the students to acquire the knowledge that will allow them to continue superior studies or, at least, to have a basic idea of scientific facts and how technology works. On the other hand, history teachers do not include history of science in their programmes, except when the social implications have been very relevant. So the science teachers are devoted to their job: to teach science, leaving history for the history teachers whom in turn leave science aside, because they are teachers of humanities. This situation in secondary education is just the reflection of a very ingrained tradition: the separation of the two cultures, the humanistic and the scientific, socially so deeply rooted that we end up saying, “I am of sciences”, or “I am of arts”, as if it were a genetic characteristic.

Unfortunately, this schizoid vision contributes to the fact that science continues without being part of what socially is understood as culture. It is absurd that in the general history that students learn there is hardly any space for the history of science. And that for example, the XIX century is important in textbooks for this or that political or military event, and not because it is the period when sciences such as electrodynamics or electromagnetism were created, or the theory of evolution was developed. These are facts whose impact on the development of our civilisation is impossible to ignore and without them it is impossible to understand.

History of science helps students to understand the scientific concepts and models better. It allows them to attend their genesis and development, and therefore, to appreciate the building up of science, not as something completed, nor as a group of definitive truths, but like a beautiful and endless human construction where it is possible to participate. A teaching that doesn't only present scientific achievements as the luminous discoveries of privileged minds, but it also tells the story of the mistakes, of the long dark nights and the erroneous calculations, of the social environment that motivated their crystallisation. It allows reducing the distance

between the students and the sciences as an object of study. When their history is known, the sciences are humanised, they have faces that help students understand their own difficulties better.

This humanising character of the history of science is a consequence of its own interdisciplinary nature, which is a stimulus and a difficulty at the same time for secondary teachers, because they have to cross the borders of their specialities, through times where the disciplines were neither so divorced nor defined, where the philosophical or theological ideas weighed on the way of understanding and explaining nature. And it is not always easy, as university formation is quite specific, implying the use of languages, ideas and very partial conceptions. But history is enriching for teachers and students, since it establishes natural bridges among the different disciplines that are imparted in secondary education.

They are many reasons for defending the inclusion of the history of science in secondary education, and in the texts of this book you will find even more, blended into the concrete context of each treated topic. Let us see some of the general type, collected in the declaration of the Project that we reproduce below.

### **ANTIDOTE TO DOGMATISM**

#### *A Rationale for the History of Science*

*The history of science has been for too long a neglected part of the curriculum in secondary and tertiary education. This is unfortunate since the discipline has the potential to deliver a number of important educational objectives. Some of these are detailed below:*

#### ***A European Dimension to Culture***

*The study of the history of science shows how ideas and discoveries cross geographical and cultural boundaries and integrate national traditions. To take just a few examples, Descartes, Darwin, Galileo... are essential figures in the history of science in whichever EU country the subject is studied. It follows that the history of science is a useful vehicle to supply a European dimension to the curriculum.*

## ***Forging a Common Culture***

*Increasing specialisation in mainstream disciplines had led in many places to a damaging fragmentation of knowledge. In particular, within the natural sciences, whole areas of study have isolated themselves from a common cultural context. Against this tendency, the history of science can be used as an effective counter-measure and can assist in the process of relocating science within a common cultural framework. Students within the humanities also have much to gain from an appreciation of science as both a cultural product and a force instrumental in historical change.*

## ***Attracting Students to Science***

*In some subjects recruitment to science courses has been declining. Any suggestion that the most reliable system of knowledge that we have is perceived to be unattractive must be a subject of serious concern to educators. Providing a historical and human dimension to science enhances the likelihood that science will be regarded as more attractive and hence become more accessible to a wider variety of students.*

## ***An Instrument within the Teaching Science***

*The history of science can be used to give a realistic indication of the scientific method in action. Traditional science teaching has often been criticised for presenting a sanitised version of both the history of science and the scientific method. By showing how real problems were solved in real social contexts, the history of science can contribute to effective learning both within science and about science.*

## ***Epistemological Values***

*The history of science, properly constructed, can be used to overcome dogmatic and triumphalist accounts of scientific change. It shows science to be a dynamic set of ideas evolving through time. It reveals how science is both a social and intellectual process where knowledge claims are contested and negotiated. Perhaps more than any other discipline the history of science provides an antidote to dogmatism and a lesson in humility.*

There seems to be enough agreement, among the political and academic authorities, and among the scientists themselves, as for the necessity and excellence that the history of science forms part of the basic culture of any citizen and, therefore, about the necessity of its inclusion in basic and secondary teaching. However the same agreement doesn't exist on how to articulate that teaching.

### **Which should be the curricular space of the history of science in secondary education?**

There are, basically and in a summarised way, three types of answers. On the one hand there are those in favour of that it is the teachers who must include it in their particular programming of sciences, history or philosophy, in each case; others who think that it is necessary to create a new subject of history of science in the curriculum, and lastly, those who believe that it would be enough to carry out some extracurricular interdisciplinary experiences.

Let us see some of the arguments that appear in the discussion on the different options, having present that students, depending on their age, should get a valuation of the intellectual, technical, social and personal factors of the big episodes of the development of science, for example, the demythologisation of the vision of the world, the cosmological Copernican turn, the birth of the modern sciences and their experimental development in the XVII and XVIII centuries, Darwin's theory of evolution and its social implications, the basic ideas of astrophysics and of the sciences of the Earth that support our vision of the cosmos, Pasteur's discovery of the microbiological bases of infection, the theories of relativity and quantum mechanics, or the discovery of DNA and the genetic bases of life.

The first answer is, maybe, the most extended. It has the advantage that we don't have to enlarge the system of subjects, just alter it to make space for a new methodology that includes certain attention to the genesis and development of the history of each scientific topic to teach. Also, it has the advantage that it would be the teacher of natural sciences who would tell the history of Darwin's ideas or the birth of DNA, the physics teacher would explain the scientific revolution and, in general, each specialist would tell the history of their discipline. This same advantage has

some inconveniences, as the history of science is so interdisciplinary, it is difficult that a single teacher, from a unique point of view, could embrace the desirable polyhedral perspective. On the other hand, probably it is difficult to reduce the extensive programs of each subject to make room for this new focus. Anyway, this possibility would mean a notable improvement of the current situation, and for its realisation the additional formation of the teachers in the history of science in their own discipline, would be necessary.

The second answer is the one that has been promoted in the Canaries (Spain) and Greece, although with different approaches. The articles of the teachers Miguel Hernández and Ioannis Christianidis explain the implantation of the new subject of history of science in the curriculum of secondary education. We will just mention it here because of the novelty that this represents, they are the only cases in Europe where history of science is part of the official curriculum as a subject. In fact, the Penelope Project was born due to the need to form the canarian teachers in this new subject.

The third possibility offers the advantage that when several teachers of different departments participate, the students perceive with more clarity the relationships between the formation of scientific or technological ideas and their social and historical context. There is no doubt that the history of science offers a natural field where the strong relationship between the humanities and the sciences are observed with clarity. However their extracurricular character requires a supplementary effort, for that reason they are rarely repeated, and this reduces their influence to a few teachers and students. Anyway, these types of experiences are very stimulating for teachers and students, and very valuable as complementary activities for anyone of the two previous options. The work of Mercedes Coderch about the possibilities that a historical-scientific trip can offer to stimulate the interest of the students of history of science is a clear example of the possibilities of this type of experiences.

We don't have a definitive answer to the question on the curricular role that history of science should play, although we believe that anyone of them would improve the current situation and it would assure that the students understood the foundations upon which the modern world has been built. In the last years we

can appreciate a bigger social demand for this kind of knowledge. An example of this is the good welcome that television documentaries on topics of history of science receive or, also, the great acceptance of good books on scientific popularisation. Today editors are aware of this demand and in the bookstores more and more serious divulgation titles appear. In July 2000, the British Society for the History of Science organised an international congress in London titled “Science Communication, Education and History of Science” with the active participation of the teachers of the project John Cartwright, Cynthia Burek and Miguel Hernández. At the congress, besides verifying this social demand of the end of the century, the participants discussed what answer should be given in the field of education.

### **Teacher formation**

The different educational policies that contemplate the possibility of improving the situation, either by introducing obligatory or optional subjects of the history of science, or by creating guidelines for a change in the methodology that includes room for history of science in the different subjects, depends on the cultural and educational traditions of each country. To mention an example, the studies of philosophy in Portugal, Spain and Italy are imparted in secondary, while in many countries, such as Belgium, United Kingdom or Sweden philosophy is only studied at university level. This and other traditions, like associating the history of science to sciences itself or to history or to philosophy, mark differences that must be kept in mind when designing policies that deal with the problem. But, in any case, all of them will necessarily have to endow the teachers with the necessary knowledge to confront the new situation successfully. This has been the main reason why our work has been centred in the creation of formation modules for teachers in history of science. The selection of topics has sought to reflect the type of formation activities that are usually carried out in the three centres that integrate the project. Subsequently we will say a few words about them.

France has a long experience in the formation of teachers of history of mathematics; the existence of the IREM (Institutes of Research upon the Teaching of Mathematics) explains the situation

(see Xavier Lefort's article in this book). It is prominent their conviction that it is possible to work with students using original sources directly, this could be a shock for us, because we usually leave the study of the originals to the investigators and we prefer to work with good textbooks that are within the grasp of the students. However, they have been some time showing us that it is not only possible, but also much more formative, working with the students using original texts. The work of teacher Anne Boyé tells us the history of the negative numbers, with special attention to the rule of the signs: that minus by minus is plus; this eventful history helps us understand the difficulties that children have with the signs. The work of Xavier Lefort exposes the history of the development of the concept of the logarithms, a not very straight forward history, sometimes related with the social necessities of numerical calculus and others with the internal mathematical development of mathematics itself. To know the history of mathematical ideas helps the teachers, not only to understand the difficulties of the students, but also to make decisions on what and how to teach.

The British teachers impart courses of the history of science every year at Chester College, and for the selection of modules for the project they chose two topics that could be very attractive for students. John Cartwright, a biologist, talks about how we can use Darwin's ideas in class to illustrate diverse dimensions of the study of the sciences. And Cynthia Burek, a geologist, tells us the history of the age of the Earth and the birth of stratigraphy, and how to use history to introduce students in Geological Time. In definitive they are two topics that should be part of the cultural baggage of any person, devoted or not to science, because these ideas help us understand how we are related to life and our planet. Also, they suggest that some of the scientific ideas that today are perceived as solid truths probably will suffer very drastic changes. The history of sciences teaches us to be critical with scientific dogmatism.

As for the Spanish teachers, the Fundación Canaria Orotava de Historia de la Ciencia has been imparting formation courses of history of science for secondary teachers for more than ten years, and for this project they chose two topics from ancient science and one about instruments, besides the one already mentioned about historical-scientific trips. The teacher José Luis Prieto deals in his work on the vision of the human body in antiquity,



contrasting the vision of the Greek doctors, worried about health and illness, and the vision that philosophers and poets had of the body who paid more attention to the relationship of body and soul, or thought and language. This is a topic that could be very interesting for our students, as they are so sensitive to aesthetics and the acceptance of their own body. On the other hand, the teacher Sergio Toledo approaches a more physical-mathematical topic. Proposing to the philosophy teachers who impart history of science, to explain the history of certain fundamental concepts of philosophical and scientific thought, for example unit and multiplicity, space and time, matter and form. Lastly, the teacher Carlos Mederos shows in his work how you can use instruments to teach history of science. The achievements of the artisans and the deepest scientific theories can sleep implicitly in an instrument, being for the students an exciting experience to be able to discover them by the teacher's hand.

The works of Cynthia Burek and Anne Boyé about women and history of science in Geology and Mathematics respectively, deserve a special mention. Our classrooms, fortunately, are full of female students that, for very well known reasons, rarely find in the history of science models to follow. This is why it is very important that they know, through proper names, the heroic examples of the first women that were able to out stand in each field in spite of a society that denied them the capacity, the intelligence and the formation. All the women that today participate in scientific and technological environments under conditions of equality are in debt with them. Their example invites us to continue working in the field of education until all women, from all countries, can enjoy the same conditions and equality of opportunities.

These works, as we have already indicated, seek to be a sample of the type of materials that can be used in formation courses for secondary teachers, and all along the project we have tried to give them the biggest possible diffusion. Great part of them were used initially in a course for teachers from the Canaries (November 1999). Later on, some modules were imparted at the Lycée de Grand Air (La Baule, France) to students and teachers of secondary, and others were presented in different forums: at the 13<sup>ème</sup> Colloque Inter-IREM (Rennes, May 2000), and at the congress "Science Communication, Education and History of Science" that was

organised by the British Society for the History of Science (London, July 2000). Finally a course was imparted for European teachers, that took place in La Orotava, (Tenerife, July 2001), under the Comenius action of the Socrates Program. All the modules, together with many connections and other materials, can be found translated into French, English and Spanish on the web page of the project: <http://nti.educa.rcanaria.es/penelope>

Finally, we want to thank the collaboration and the support that we have received from all the institutions that integrate the project, as well as the European Commission (Socrates - Comenius Programmes), and we hope that many teachers find ideas in this book that can serve as a stimulus to achieve that history of science will be part of the common culture of all European citizens.

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