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Bridging the gap between secondary school and 'The History of Science': An educational experience

Abstract

Young students in Spain are taught the theory of natural selection, the law of conservation of mass, the three laws of motion, relativity, etc. However, they are often not aware of the person behind these discoveries or when and how they came about. Although the "The History of Science" is an essential part of learning about science, this subject is not covered in secondary school science curricula. To bring "The History of Science" closer to these students and give them the chance to develop a scientific mind and debate scientific issues, we designed an educational programme involving several small changes in the way science is taught. Namely, part of the science classes was devoted to researching and teaching "The History of Science" (the first metals, Galileo's period, Marja Sklodowska's life, etc.).

(1) Introduction

Spain boasts a national policy on education.¹ However, the degree of adherence to this policy differs in each region. Thus, the 17 Autonomous Communities in this country each devise their own independent education systems. Our results derive from Catalonia.² During primary school education (children up to the age of 12 (six levels)) mechanisms to promote science are absent. In contrast, the science curriculum established for secondary education includes several subjects such as Biology, Chemistry, Physics, Maths, and Technology. Secondary education is divided in two periods. The first, which covers children up to the age of 16 (four levels), is compulsory, while the second, involving 16- to 18-year olds (two levels), is comparable with high schools in several countries. After completing this stage, students sit a common university entrance exam.

In this context, students in secondary schools in Spain can gain scientific knowledge only by learning theories, concepts, definitions and through practical demonstrations, all these activities requiring high memory capacity. Most students do not appreciate the impact of developments in science and technology on aspects of our lives: health, farming, energy, the environment, etc. The repercussions of these advances extend from scientific and economical issues to those related to sociological questions. We therefore uphold that the subject "The History of Science" is indispensable to our students.

Scientists and teachers are responsible for disseminating scientific knowledge. In Spain, science teachers in secondary education are confronted with the need to encourage debates on science in their classes, but in many cases they are not supported by a background knowledge of "The History of Science" on the part of the student.

(2) Science textbooks

Furthermore, our evaluation of the presence of "The History of Science" in Spanish textbooks highlighted several points. A number of textbooks neglected this subject. Furthermore, in several books a few illustrations or/and words were devoted to only a few scientists. Finally, only three textbooks of more than 40 analysed provided small biographies of 2–3 scientists. Below we give some

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¹ www.mec.es/educa/sistema-educativo.

² www.xtec.es/estudis/eso/curriculum_eso.htm, www.xtec.es/estudis/batxillerat/curriculum_bat.htm.

examples from physics and chemistry textbooks used in the final year of secondary school (students 15–16 years old):

Science textbooks with only pictures

Archimedes, Galileo, Newton, Lavoisier, Mendeleiev,...

Science textbooks with a few words

| Archimedes | Avogadro | Marie Curie |
|--|--|--|
| (Syracuse 287 BC–212 BC) Mathematician and physician, he used these principles to determine the proportion of gold and silver in Heron’s crown. | Italian scientist. His contemporaries showed contempt for him. Only after he died was his hypothesis accepted. | She made some important discoveries related to radioactivity and several isotopes. |

Science textbooks with small biographies

An important scientist: Linus Carl Pauling.

Life and science in the 19th century: Michel Faraday.

These examples show us the situation of “The History of Science” in secondary school science curricula in Spain. The publishers of science textbooks can choose to add or omit part of “The History of Science”. In fact, the addition of this subject to Chemistry textbooks was discussed by Lavoisier and Fourcroy in the 18th century.³ These scientists addressed the convenience of this subject in their preliminary speeches of the “*Traité élémentaire de chimie*” and the “*Système de connaissances chimiques*”. Lavoisier did not support the addition of history to textbooks, considering that textbooks including history would distract the scientist from the matter at hand. In contrast, Fourcroy agreed with increasing references to history. At the end of the 18th century, science and textbooks were considered exclusive to scientists. Times have changed and we now wish to disseminate science at all levels of society. At student level, textbooks provide the means to achieve this aim.

We uphold that “The History of Science” be considered an essential element of secondary education as it provides students with basic knowledge which will help them to understand science and its principles. In this regard, to attract students’ attention, we propose a strategy to make science and its history more interesting.

(3) Initial test

Most of our work focussed on students in the final year of secondary school (ages 15–16) and the first year of high school (ages 16–17). Students were asked to complete an anonymous questionnaire about science, scientists and “The History of Science”. This questionnaire had several steps, which covered the following details in order:

1. Details about the classroom, gender, age and day when the questionnaire answered.
2. Interest in science and biography (Table 1).
3. Knowledge of scientists and discoveries (Figure 1–3).
4. “The History of Science” (Table 2).

Three hundred and fifty-three questionnaires have been completed since 2003, of which 51 % correspond to female students and 49 % to male. Analysis of the answers given by students shows a low level of interest in science.

³ See Grapí, P. (2005): “The convenience of history of science in chemistry textbooks at the beginning of the XIXth century. A reflection from Lavoisier and Fourcroy’s positions. *Actes de la I Jornada sobre la història de la ciència i l’ensenyament Antoni Quintana Mari*”. *Societat Catalana d’Història de la Ciència i de la Tècnica*, p. 69–73.

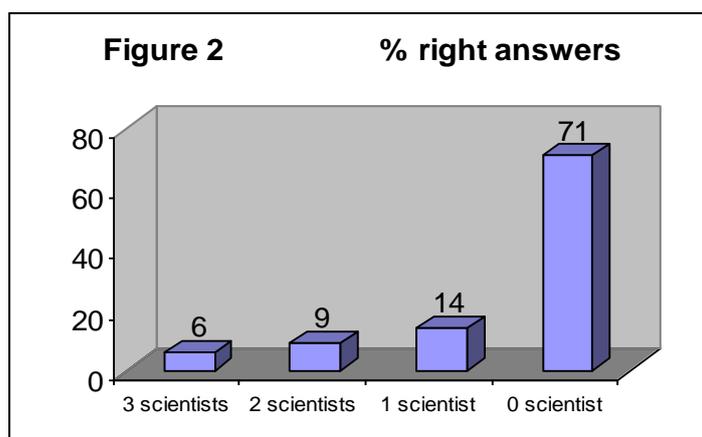
| Table 1. | | |
|---|------|-------|
| Student interest in science and biography. | Yes | No |
| I am interested in science. | 30 % | 70 % |
| I have read some biographies. | 12 % | 88 % |
| I have read a biography of a scientist. | 0 % | 100 % |
| I have read something about a scientist’s life. | 8 % | 92 % |

We observed that interest in science (we did not ask about interest in enrolling on a science degree) has decreased. Few students had read biographies, but nobody had read a biography of a scientist. Given this observation, we changed the question, making it more general by asking students if they had read anything about a scientist’s life or about science history. 8 % students had read something about a scientist’s life. Table 1 also reflects the loss of interest in science by young people in Spain: a phenomenon that is also detected around Europe.

The third section of the questionnaire was as follows:

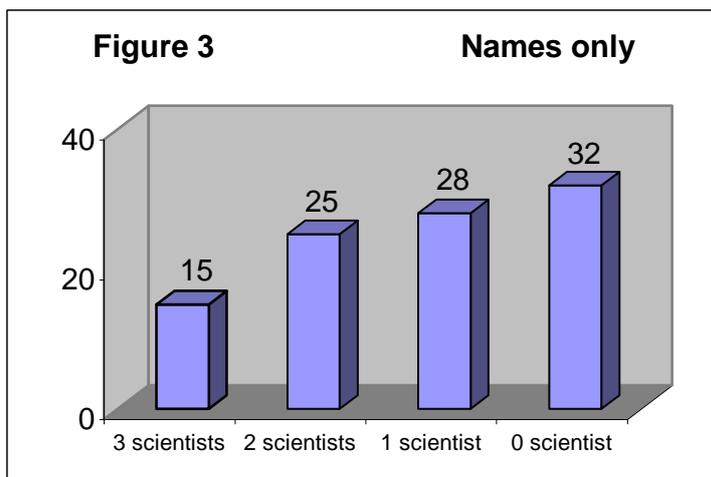
| Figure 1 | | |
|------------------------------|--|--------------------------------|
| Fill in this form: | | |
| Names of 3 scientists | Period: 1) Before Christ 2) Before 1000. 3) Before Columbus. 4) Before 1900. 5) Before 2006. | What did they discover? |
| | | |
| | | |
| | | |

Answers were considered correct only when the scientists’ names and corresponding period and discovery were given properly. Using these criteria, 70 % of the students gave incorrect answers (Fig. 2).



However, of this 70 % only sixty one (17% of the total) did not respond, the rest wrote some names. However, on the basis of the criteria for correct answers established above, they were incorrect. For this reason, we next analysed the column of scientists’ names given. A result was considered to be good only when the name was correct. On the basis of this analytical criterion, the result was an improvement on the previous one: 1 out of 3 students could not name any scientist or were not interested in science. The lack of curiosity among pupils is difficult to tackle. Moreover, the

lack of attention to this discipline (chemistry and physics) is also accompanied by a loss of general motivation to learn science.



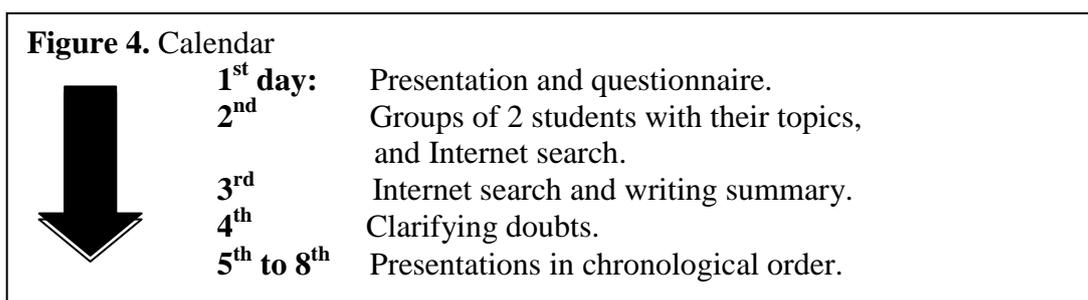
Finally, students were asked whether they considered that the subject “The History of Science” would be of help to them. Most did not understand the concept of “The History of Science”. Therefore a brief explanation was given and they were asked to reply to the question again. The answers were as follows:

| Table 2. Student knowledge of “The History of Science”. | | | |
|---|----------------------|------------|-----------|
| I think “The History of Science” could help me (first time). | What is this? | | |
| After explaining “The History of Science” | Don't know | Yes | No |
| I think “The History of Science” could help me. | 40 % | 30 % | 30 % |

It can be observed that most of the students did not know whether “The History of Science” could help them. This subject is not included in Spanish secondary school curriculum or covered in textbooks. The results of our analysis indicate that it is essential to promote this subject among young people if we are to improve their understanding of science. We therefore implemented a new educational programme with the aim to relate science knowledge among students (in their last compulsory year) and the world of science. Thus, several classes covering part of “The History of Science” were included in the Physics and Chemistry curricula.

(4) ‘The History of Science’ in the science classroom: a new educational experience

In the academic year of 2003, we designed an educational programme by making small changes to the teaching approach used but without decreasing science curriculum. Thus, part of science classes were devoted to researching and teaching “The History of Science” from the first metals to the 20th century.



This activity took 2–3 weeks (8 lessons) at the beginning of the Chemistry and Physics course. These lessons were not enough to cover all “The History of Science” related to these disciplines; however, more time was not available as the science curriculum had to be completed. A calendar of events is shown in Figure 4.

To increase the number of scientists and topics covered, students were divided into groups of 2.⁴ Table 3 shows several topics covered by students in the final year of secondary school (ages 15–16).

| Table 3. Some topics covered by pupils. | | |
|--|------------------|------------------|
| Metal Ages | Archimedes | Arabic science |
| China science | The Alchemists | Galileo’s period |
| Newton | Lavoisier | Faraday |
| Mendeleiev | Maria Sklodowska | Einstein |

Firstly, teachers gave students specific tasks, corrected their mistakes, and helped them to prepare their summary (only 1 printed page). In the following days, all groups were asked to present their work. In fact, and in chronological order of their topics, each group made a 15-minute presentation and answered questions posed by classmates. The implications of chronological order in the summaries presented are clear. These sessions provide the opportunity for students to discuss ancient scientific theories after acquiring knowledge in the “The History of Science” sessions. The teacher is on hand to assist in the explanations given. These presentations are characterized by intense interaction between students and teacher. Having finished the lessons devoted to “The History of Science”, feedback was collected from students via a new questionnaire. Most considered these classes valuable for increasing their knowledge of science and also greatly appreciated the opportunity to learn history related to science and/or science progress related to history.

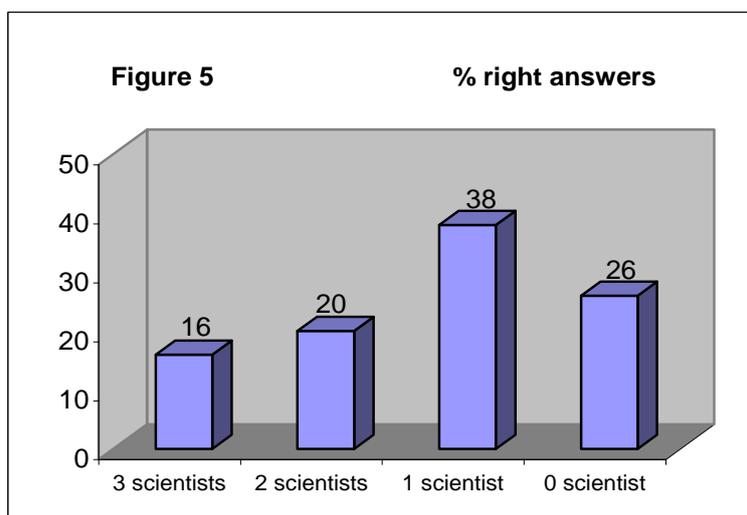
| Table 4. | | |
|--|------------|-----------|
| Student feedback about “The History of Science” class | YES | NO |
| The atmosphere in the class encouraged learning. | 92 % | 8 % |
| Learning in the class required greater concentration than in a normal class. | 24 % | 76 % |
| I feel that I learned the topics in the class in depth. | 72 % | 28 % |
| Learning in the class was difficult. | 32 % | 68 % |
| Learning in the class was exciting. | 88 % | 12 % |

As you can see, Table 4 speaks for itself, and shows us an increase in student interest in “The History of Science”. These results led us to recommend our students to do some science history reading over the summer holiday.⁵

⁴ For more details on this point, see Dennick, R.G. and Exley, K. (1998): “Teaching and learning in groups and teams”, *Biochemical Education*, vol. 26, p. 111-115.

⁵ See Fernández-Novell, J.M. and Zaragoza, C. (2000): “Discovering Galileo”, *L’espiral*, 19, pp 11-12; Isaac Asimov (1975): *Breve Historia de la Química (A short History of Chemistry. An Introduction to the ideas and*

To evaluate the contribution of “The History of Science” to our students’ knowledge of science, we then repeated the initial questionnaire. At the beginning of the following year, we gave the same questionnaire to the students that had passed their final year of secondary school and enrolled on the first year of high school. During the previous year all these students had covered “The History of Science” in their Chemistry and Physics classes. Our results show an increase in interest, and students showed improved knowledge about the lives of scientists. Only 1 out of 4 answers did not relate the scientist’s name with his/her corresponding period /and discovery, and more surprisingly, only 12 students were unable to name a scientist. The number of students who reported not being interested in science decreased drastically.



Our results indicate that coverage of “The History of science” in the secondary school science curriculum in Spain could make a positive contribution to learning science and may stimulate scientific vocation.

(5) Conclusion •

The science history class aims to provide students with a new approach to science. Furthermore, these chemistry and physics lessons seek to increase students’ knowledge of science, and teach them to appreciate the relationship between science, scientists’ lives and “The History of Science”. However, one of the main objections to the introduction of “The History of Science” into school curricula concerns the lack of time available in current curricula.

Finally, we recommend the following measures to stimulate “The History of Science” in classes:

- Initiatives in primary education.
- Changes in the national curriculum.
- Introduction of “The History of Science” as a new subject in secondary school science curriculum.
- Provision of specific training in “The History of Science” to cover teacher requirements.
- Use of “The History of Science” as a reference model for other science disciplines.

Concepts of Chemistry) (Madrid: Alianza Editorial; and Isaac Asimov (1990): *Cronología de los descubrimientos (Chronology of science and discovery)* (Barcelona: Ariel Ciencia).

• We thank our students for their input and Tanya Yates for helping in the preparation of the English manuscript.