El CSIC en la Escuela
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K-7 science teaching: an introduction

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Introduction

The overall objective of these pages is to think over the evolution of the concepts of *scientific literacy* of the society since the mid-twentieth century to the present day. In this period, the meaning of the expression has undergone certain changes, that can be divided into three periods: a first stage characterized by the elaboration of benchmarks, a second period centered in the Nature of the Scientific Research (NSR) and, finally, a third stage devoted to the so-called vision of the nature of science (VNOS).

On the same footing as the science learning and according to the guidelines of the European H2020, we should also consider the removal of existing barriers that generate discrimination against women in scientific careers.

Historical overview

Up to 1957 (date of the launch of the Sputnik) what we might call the romantic period takes place. Thanks to the influence of important researchers such as Thomas Huxley, Charles Lyell, Michael Faraday and John Tindall, middle classes began to be interested in a scientific view of the world, more for the benefits in the formation of the mind of the students through the beauty of this vision, the creativity of its practice and the inherent independence of thought and critical thinking than for any practical reason. Because of these considerations science makes its way into the official teaching programs.

Thus, we approach the date of 1957 with a world mired in the Cold War, still amazed by scientific discoveries and technological developments directly related to the Second World War, with a self-confident western block. Among other things, this confidence was reflected in the certainty that the education system of this side of the Iron Curtain was better than any other, therefore not in need of any modification.

In this atmosphere, to the astonishment of everyone, on October 4th, 1957 the Soviet Union launched the first man-made space satellite in history. This provoked (especially in the United States) a tremendous shock, fulminating the sense of security and scientific and technical superiority to which we have referred.

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The Sputnik was a serious threat that had to be neutralized. To do so, a series of research and development programs of a very high cost had to be launched. But, being the USA a democratic country, as was the case, the founding of such a state budget should necessarily be supported by the citizens, especially if the effort was to last for a long period of at least fifteen years.

Sputnik´s illustration. *Lopez Sancho (2003)*.

Furthermore, in a democratic society increasingly based on new technologies (transgenic crops, animal cloning, choosing the types of energies to be used, etc.) it is essential to count on citizens knowing what they imply, so they can take informed choices among different political programs with different approaches. This resulted in a new concept of scientific literacy which should reach all citizens, in the same way as had happened with the literal literacy had done it some centuries before.

As is mandatory in any social change directed from the state, the focus was concentrated on teaching at the early stages and, consequently, in the training of their professors and in the research on teaching methods.

As nobody in that historic moment had a clear idea of what knowledge was required in order to be considered scientifically literate, lists of scientific contents were elaborated, different for each discipline and, in some cases, for each country. It is the period of benchmarks, whose failure is evident now.

In our opinion, the concept was never well defined, and as pointed out by Bybee in his 1997 work, the term scientific literacy should be regarded as a slogan, only useful to express the importance of science education.

Given the difficulty of defining scientific literacy through a list of contents, a new proposal emerged the belief that science is known when you know how it is made, how scientists construct it. This idea is due to the Nobel Prize winner George Charpak who, in 1995, started the program *La main a la Pâte*, inspired by the *Hans On program* started by Leon Lederman, also a Nobel prize winner, in 1991.


George Charpak (Wikipedia) / Leon Lederman (Fisicanet)

With the failure of the identification of knowledge of scientific matters with scientific literacy, the idea that you really know what science is when you know how scientists do science began to emerge. And that marked the end of the benchmarks period and the starting of the nature of scientific research based on *inquiry*.

But this new way, when developed, turned out to be as confusing as the previous one. This was due to the fact that each discipline had its own peculiarities. Astronomy did not include experimentation, theoretical physics was done, in some cases, through *thought experiments* and some of the great discoveries were due to serendipity.

A few years after the starting of the inquiry period, deeper analyses of the nature of scientific knowledge took place, among which we cite the one due to John Durant, who in 1993 in his *What is Scientific Literacy* defines three distinct levels:

1. The lower one, which refers to the set of knowledge accumulated through history (commonly known as contents).

2. A middle level, which describes the way scientists work doing science (until recently erroneously called scientific method) and

3. The higher one, which studies the structure and characteristics of the scientific knowledge, is directly related to knowledge representation. The three levels altogether constitute what is now defined as the Nature of Science.

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As can readily be seen, the first level corresponds to the definition of the benchmarks, the second to the way in which science is done and the third one, which was new, is what is defined as the View of Nature of Science (VNOS).

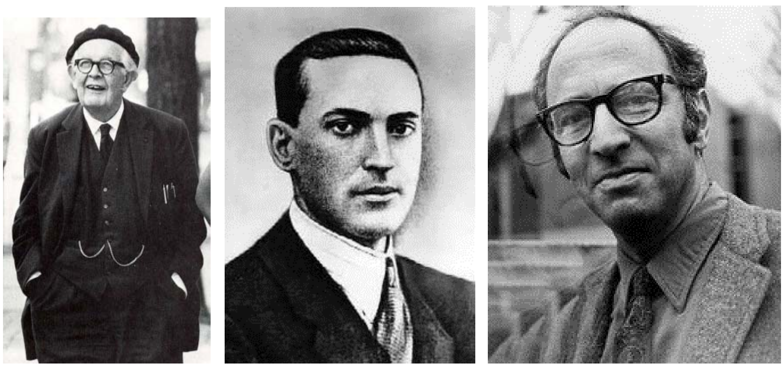
Although one could think that the definition of VNOS inherited from the previous stages of scientific literacy the defect of being inaccurately defined, in this case it is mainly due to its being an active research field and under constant review, taking part in it, on the same footing, scientists and teachers (mainly those with early stages students).

It is clear that to understand what VNOS is we must have some knowledge of scientific contents in order to know what we are talking about. Those contents should be determined by the teachers, according to the age of their students and their cultural status of them.

The View of Nature of Science is, as Durant states, a knowledge of higher level. It deals with the ways in which science is built, how scientific knowledge is generated, the internal structure of science in data, laws and theories, and how those theories substitute one another over the history.

We could say that the View of the Nature of Science relates to scientific contents as linguistics is related to language speaking. Linguistics handles the different languages, grammatical structures, relations between them and the transformations undergone as the object of its study.

At the present time the teaching of science has become a cross-disciplinary research field, on which converge, beside the classical areas, the ideas of knowledge representation and knowledge management. From the first one it takes mental representation methods, which perfectly fit the Piaget and Vygotsky models and social views of Kuhn's; from the second, explicit and tacit knowledge concepts are taken, in coincidence with the Dreyfus brothers study of expert levels of knowledge.



Jean Piaget; Lev Vigotsky y Thomas Kuhn (Wikipedia)

Within this new point of view, the scientific contents or explicit knowledge is to be found in textbooks, reports and memories. Implicit or tacit knowledge, on the other hand, lives only in the minds of professionals, being impossible to represent it in reports, notes or to be easily explained.

As research goes on in the field of science teaching, it becomes more and more clear that the View of the Nature of Science is a tacit or implicit knowledge, being mandatory to the teachers to master it in order to transmit it to their students. Helping the school masters to achieve this level of knowledge is the main goal of the present project.

Definition of targets

The overall objective of this project is to go one step ahead on the way science is taught in the early stages, advancing from the learning of just some contents to a new way in which the Nature of Science becomes apparent. Contributing, taking part in the ongoing research, to develop what should be the new standards of teaching and learning methods for school teachers and students is our first goal.

The specific objectives of this project, in accordance with the foregoing statements, are:

1. Acquiring new concepts, such as inquiry-based learning and the view of the Nature of Science, musing on them and discussing the most appropriate strategies to introduce these concepts in each cognitive stage of the students.

2. To avoid gender discrimination related to scientific activities at all stages of education.

3. Making available to teachers and teacher training advisors the necessary tools to facilitate the teaching of science to both school teachers and students, according to the new trends.

4. Discussion on the key points that currently use research teams to assess the knowledge that teachers and students have about Nature Of Science.

5. Creation of working groups to design how to bring scientific knowledge to the classrooms as well as to discuss the results.

6. Elaboration of a report explicitly pointing out the achievements and shortcomings of the work done within this program, outlining future lines which are considered necessary.

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