

Recent directions in the interaction between research into didactics and the history of science

Cécile de Hosson

PRES Sorbonne-Paris-Cité, université Paris Diderot-Paris 7, Laboratoire de didactique André Revuz

Patricia Schneeberger

Université Victor-Segalen-Bordeaux 2, laboratoire Cultures éducation sociétés (LACES)

Introduction

In France, the emergence of studies devoted to the identification of ideas and forms of reasoning used recurrently by pupils and students when confronted with a given scientific issue constituted the first manifestations of interest in the history of science among researchers in the field of didactics. The results of these studies revealed some disquieting similarities between certain identified forms of reasoning and certain historical ideas. This was particularly the case in the fields of mechanics (Viennot, 1979), optics (Guesne, 1984), electrokinetics (Benseghir & Closset, 1993), biology (Giordan & De Vecchi, 1987) and geology (Gohau, 1995). This evident interest in the history of science among researchers in education followed the path traced by Bachelard almost forty years before and updated the notion of “*epistemological obstacle*” which had been created to account for the homology between certain aspects of the historical development of scientific thought and individual processes for the acquisition of scientific knowledge (Bachelard, 1938). In 1987, the journal *Aster* presented a first survey of the issue.

The main reasons which brought the researchers of that time to the history of science were epistemological in nature, namely, the search for a better understanding of the knowledge to be taught and the identification of the persistent difficulties and obstacles associated with the learning of this knowledge in the school context (Saltiel & Viennot, 1985; Astolfi & Develay, 1989). The attempts at inserting historical elements into the classroom were, to all intents and purposes, absent from the scope of research into the didactics of sciences; and even if the relevance of such insertions was regularly asserted, particularly within the institutional sphere (Hulin, 1984), the arguments invoked rarely left the realm of

intimate conviction.

Both in France and abroad, the following years saw the development of teaching sequences in which the history of science played an active role (Audigier & Fillon, 1991; Kipnis, 1992). This paved the way for a more systematic study of the conditions of creation of these sequences and the impact these sequences had on learning. Researchers in the field of didactics progressively broadened the horizons of their interest in the history of science with the 1990s seeing the emergence of new directions in research into the didactics of science. Basing his synthesis on the work undertaken in this context up till that time, Martinand presented several key points for the development of future research and distinguished four themes for possible exploration (Martinand, 1993): putting into perspective the history of scientific thought and research into the conceptions of pupils; transposing scientific practice and thought into school tasks and knowledge; studying the conditions in which the history of science is used in teaching; and studying the place of the history of science in the training of teachers.

Over the last twenty years, most research projects involving both didactics and the history of science have referred to at least one of these directions, bearing witness to the diversity of conceivable approaches. The results obtained might enable a more refined statement of the reasons which, for more than thirty years, have continually motivated researchers in didactics to explore the historical sphere. These results also enable researchers to describe the modalities of the exploitation of this exploration.

1. Associating research into didactics and the history of science: Why? How?

The articles in this issue of RDST aim to provide elements in response to the “*Why?*” and “*How?*” of the interface between research into the didactics of science and the history of science. We have chosen to introduce these articles by means of a brief presentation of several thematic axes which partially structure the current state of research into these matters.

Axis 1: Studying the contribution of the history of science to the learning of scientific laws and concepts

Axis 2: Studying the contribution of the history of science in order to approach the nature of science

Axis 3: Studying the historical approach in the institutional instructions

and the textbooks

As authors of this introductory article, we alone are responsible for this organizational choice. It goes without saying that current studies may be placed in one or more of these axes.

1.1. Studying the contribution of the history of science to the learning of scientific laws and concepts

In apprehending the fundamental concepts and laws of science, pupils should be able to take advantage of the fruits of history. Echoing this first direction, Dorier (2006, p. 29) suggests that a “*dialectic of epistemological nature*” should be initiated between two investigations, one focusing on the reasoning of pupils, the other directed at the evolution of ideas in the history of science. From this perspective, pupils do not necessarily have access to historical information: this may be a source of inspiration for the researcher but it does not automatically enter the classroom. It is expected that research along these lines should enlighten the researcher about the difficulties which pupils might encounter during their learning and that it should also enable the emergence of productive problems and/or the creation of appropriate learning itineraries.

1.1.1. Revealing the difficulties of pupils

Obtaining a better understanding of the difficulties encountered by pupils when faced with learning an element of scientific knowledge is still a productive direction for studies which associate didactics and the history of science (Galili, 1996; Romhdane & Maurines, 2005; de Hosson & Caillarec, 2009). In the hands of the researcher into didactics, the history of science is understood as the history of ideas and becomes a tool for didactical analysis. This approach is illustrated by the first article of this issue of RDST.

P. Crépin-Obert uses a historical and didactical comparative approach to characterize pupils’ conceptions and modes of reasoning and to identify obstacles to the construction of the concept of the fossil. The originality of this article is to be found in the idea of establishing relationships between the construction of problems in the classroom and the historical development of the concept of the fossil as problematized and rectified by scientific communities. P. Crépin-Obert analyzes two debates, one in the history of the subject, the other in a lower secondary school class. Both debates deal with the problems linked to the identification of a fossil and the historicizing of living beings on Earth. For each debate, the author uses a rigorous methodological basis to construct a space (symbolized in a diagram) from the constraints and possibilities, spaces which she then

compares. Without lapsing into the naïve “*recapitulationism*” which researchers in didactics endeavour to escape, she shows the points of convergence of the two debates. One of the main results of this particular research is the specification of a major epistemological obstacle common to both situations (historical and didactical), namely, analogism, which is manifested in the abusive over-use of reasoning by analogy. However, P. Crépin-Obert contrasts the simplistic reasoning of the pupils, which is characterized by the resonance of the present in the search for explanations, with the reasoned hypotheses of palaeontologists. This work is based on an in-depth analysis of the two corpora of empirical data: a corpus of historical controversy (the archives of the weekly minutes of the sessions of the *Académie des sciences de Paris*) and a corpus of school situational debate (the transcription of a teaching sequence in a lower secondary school class). P. Crépin-Obert’s choice — recourse to first-hand historical sources — enables her to place her historical enquiry within a genuinely didactical historical perspective and to free herself of the choices which govern currently available historical reconstructions on this theme.

1.1.2. Identifying productive problems and/or encouraging the instauration of debate within the class

Apart from revealing analogism as an obstacle to the construction of the concept of the fossil, the bringing together of the historical and didactical corpora enables P. Crépin-Obert to identify a category of situations which can encourage the emergence of debates within the science classroom: the identity of fossil fauna in relation to current fauna and the historicizing of living beings on Earth. Once more, the author uses historical archives to identify the nature of the empirical, explanatory and theoretical arguments employed in the reasoning of scientists as well as in their interactions. She proposes a classroom debate, the purpose of which is “*to pose and clarify problems linked to biology and geology by becoming aware of a specific methodology*”. Although, as a researcher, her prime objective is to compare two types of debate (historical and classroom), she simultaneously shows how such a debate can lead to learning science by means of a co-construction of argumentation by the pupils.

Using the field of history as a source for identifying problems in the science class often constitutes an extension of studies which aim to reveal the difficulties associated with the construction of a given element of knowledge. This involves choosing an issue which can be expected to give rise to a debate within the class and using this debate to conceive a learning itinerary which leads the pupils towards the construction of

a given element of scientific knowledge (Merle, 2002; Guedj, 2005; de Hosson & Kaminski, 2006). This way of using the history of science requires a prior knowledge of the conceptual profile of the pupils, particularly the ideas and reasoning which might present an obstacle to the envisaged learning. It also requires that the historical issue should make sense in the class, not only to facilitate its devolution and appropriation by the pupils but also to provoke the emergence of propositions for its resolution. The choice of the problem to be extracted from historical ecology is thus subjected to the fundamental constraints of didactical ecology (the difficulties which are specific to the knowledge to be taught, the pre-existing ideas of the pupils, didactical time, etc.). Within such a perspective, the extraction from the historical sphere primarily concerns the problem to be solved. By extension, the historical enquiry may serve as the material for the creation of learning sequences conceived as didactical reconstructions based upon the historically productive ideas. This is the third direction of research associating the didactics of science and the history of ideas.

1.1.3. Conceiving an itinerary for learning

This perspective envisages the history of science not as an object of teaching *per se* but as a means of acquiring an element of knowledge (Galili & Hazan, 2001; de Hosson & Kaminski, 2006). This definition embraces historically productive ideas in order to provide assistance; it also establishes the hypothesis that a historical exposition can contribute to the individual and collective appropriation of elements of scientific knowledge. The dialectic which we evoked at the beginning of this introductory article enables one to: 1) specify the didactical constraints to which the knowledge is subjected within the school framework; 2) subject the historical enquiry to these constraints so as to extract the historical information to be re-organized; and 3) ensure that this information takes its place within the didactical system in order to encourage the acquisition of the target knowledge. This last stage requires accepting that this information is presented in a form which is dissimilar to that adopted in the historical sphere (de Hosson, 2011): the processes which led to the elaboration of elements of knowledge are not “*erased*” but re-examined in the light of pupils’ difficulties. This aspect protects the researcher in didactics from any “*recapitulationist*” excess. We should note that the perspective which sees the history of science as an inspiration for learning itineraries is not represented within this issue of RDST.

1.2. Studying the contribution of the history of science in order to approach the nature of science

A connection can be established between this axis and studies dealing with the pupils' as well as teachers' images of science (Brickhouse, 1990; Lederman, 1992). This axis defines historical exploration as a means available to the didactics specialist for the promotion of a more accurate idea of science and scientific activity.

The avenue opened in the early 1990s by the Anglo-Saxon educational research movement, Nature of Science (NOS), has enabled the emergence of research projects aimed at the construction of a more appropriate image of science by pupils. Several comparative studies have shown that the vision pupils have of science is modified when the teaching embraces the history of science (Allchin *et al.*, 1999; Irwin, 2000; Höttecke *et al.*, 2010). This can involve various cases: having pupils relive a historical controversy by analyzing the nature of the arguments employed, by presenting the actors, the links between these actors and the tools used for the exchange (Albe, 2009; Maurines & Beaufils, 2010); reproducing historical experiments in the classroom (Riess, 1995); or placing pupils in the situation of exploring the diversity and adequacy of the models as regards the empirical data (Laugier & Dumon, 2000). This is the perspective of the work proposed in this issue of RDST by H.R. Dahmani and P. Schneeberger.

The authors analyze two situations conceived for pupils in the fifth year of secondary education (*seconde*) and constructed so as to have the pupils experience an investigative approach of a scientific nature. First, they use the history of science to show how researchers worked on the construction of the double helix model of DNA. Having no experimental data enabling them to elucidate the structure of DNA, Watson and Crick imagined models of the organization and pairing of the nitrogenous bases in the molecular edifice of DNA, models which could satisfy the coded message and copy functions DNA is likely to assume. This construction therefore involved theoretical modelling controlled by verifying its coherence with empirical data. In this way, different models, the fruit of theoretical speculation, were successively rejected before the current model of the structure of the DNA molecule was retained. Inspired by the specifics of this piece of history, H.R. Dahmani and P. Schneeberger propose the transposing to the classroom of this type of practice so that pupils can have access to more "*authentic*" approaches. The situations they describe present: graphic modelling activities as intellectual research tools enabling pupils to objectivize their reasoning; and discursive

activities as social practices employed in the scientific community for linguistic exchanges directed towards the production of argumentation. One of the two situations invites the class to undertake a critical comparative analysis of the current Watson and Crick graphic model of DNA and its precursors. The other situation invites pupils of another class to undertake the gradual and negotiated construction of different evolving graphic models leading to the organizational model of the pairs of nitrogenous bases matching the structure of DNA. These activities begin with empirical data provided by the teacher and take into account — as didactical constraints — the functional aspects of DNA (coding and replication). These activities break with the usual approaches of teachers which consist in providing the pupils with computer graphic representations of the molecule before identifying the relationships between the structure of DNA and its functional particularities. The comparison of these two situations involving different teachers enables the authors to envisage to what extent and under which conditions pupils are able to efficiently invest in speculative work by exploring a set of possibilities collectively subjected to critical analysis.

The role of the teacher appears to be essential. Beyond the epistemological quality of the sequence, there is a risk that the very epistemology of the teacher (that is, how the teacher sees the activity of producing scientific knowledge) might condition the epistemology of the pupil (Brickhouse, 1990). But, as J.Y. Cariou reminds us, the “*spontaneous*” epistemology of teachers is heavy with empiricism and inductivism. He sees in this a resurgence of the impact of the much debated position of Newton and his followers concerning the place of the hypothesis in the production of scientific knowledge. J.Y. Cariou’s study shows that the reticence of that time towards the recourse to the hypothesis persists in the classroom whereas the use of the hypothesis is unanimously recognized in the scientific community. This author finds evidence of the influence of this empiricist epistemology in the approaches which are favoured by teachers, approaches in which the speculative dimension is often absent. He advances the idea that this epistemology could be remodelled by bringing teachers more frequently into contact with the history of science. This idea is also advanced by P. Crépin-Obert for whom the history of palaeontology offers “*fundamental episodes*” which could be used to study the modes of construction of scientific knowledge. This history enables a questioning of the “*epistemological base*” of knowledge and leads to a better definition of certain essential competences for scientific work.

Bringing both lower and upper secondary school teachers closer to the history of science seems to be even more necessary since they are encouraged to devote more and more space to historical information within their lessons. The present official curricula of lower secondary education state that *“the historical perspective gives a coherent vision of science and technology and their joint development. It enables the presentation of scientific knowledge as a progressive human construction rather than as a set of revealed truths”* (MEN, 2008, p. 1). In the new upper secondary education curricula, the clear objective of dynamically and culturally presenting science envisages the history of science as a means of reconciling pupils with science. In the penultimate year of the science option (*première S*, 6th year of secondary education), *“the teacher can use the historical approach as a didactical means destined to place science within context and culture”*¹ (MEN, 2010b, p. 4). In the 5th year of secondary education (*seconde*) the *“putting into historical perspective”* (as the *“history of the construction of scientific knowledge”*) is presented as the avenue of choice to approach the nature of the *“universality”* of the laws and models and bears witness to the human qualities underlying scientific activity: *“Bringing the pupils to know about the history of the construction of scientific knowledge is a source of inspiration for intellectual freedom, the critical spirit and the will to persevere. This is also the school of humility and patience”* (MEN, 2010a). Generally, the authors of the official curricula envisage the contribution of historical information as an opportunity to approach the nature of science with the pupils, on the one hand, and as a way of making scientific learning more attractive and motivating, on the other. But which history are we really talking about? And, more specifically, how are these recommendations conjugated within the scientific content to be taught?

1.3. Studying the historical approach in the institutional instructions and the textbooks

In his article, P. Savaton discusses the nature of the history of science proposed for teaching and the scope of the institutional instructions. As regards plate tectonics, the new curriculum (from Sept 2011) of the penultimate year of the science option (*première S*) suggests relying on a historical approach to facilitate understanding of *“how this model was constructed little by little over the course of the history of science”*. The avowed objective is to use this example in order to enable pupils *“to*

¹ In this sentence, the adjective “didactical” is probably used to signify “conceived with a view to teaching”.

understand several characteristics of the mode of construction of scientific theories“. However, the construction of the model is presented as a series of successive advances based on the use of new techniques without mention of the work of de-construction and re-construction which has punctuated this history in its entirety. P. Savaton’s article shows that the history of the construction of the tectonic plate model is more complex than the linear and progressive vision featured in this curriculum. His analyses underline the importance given in these texts to the “*accumulation of observations*” and technical progress, which, thanks to the discovery of new facts which these techniques allow, would go hand in hand with the perfecting of the model. This case study enables the author to show that the history of science can be used as a tool to serve a school epistemology which is founded on shared representations of the emergence of scientific ideas. P. Savaton indicates historical errors (the origins of the ideas utilized), omissions (the names of researchers, such as Alfred Wegener) and the absence of a presentation of the discussions within the geology community. Moreover, these texts do not define the respective theoretical frameworks used in the work of the various researchers, even though they are essential for an understanding of the paradigmatic oppositions from which the controversies originated. In this way, invoking the impossibility of an extensive historical study, the curricula conceal the influence of the context and present a truncated reconstruction of the construction of scientific knowledge with no genuine reference to work in the history of science.

For his part, J. Lebeaume, analyses the official texts in order to grasp the aims and directions associated with the introduction of the historical dimension of technical objects. He also examines what four textbooks for the *cycle central* (5^e and 4^e — secondary years 2 and 3) and, using a detailed study of the activities proposed, he identifies dominant tendencies of the historical approach exploited. He uses this study to reveal a set of elements which enable the school conception of the technical object to be characterized. He notes that the instructions are focused on a “*vertical*” history of technical objects which emphasizes the description of the differences and solutions over the identification of the advantages and the drawbacks. Such an approach remains relatively closed to “*horizontal coherences*” which relocate objects in their technical, industrial, social and economic milieus.

The specific aim of the Institution — to open science and technology classes to the history of these subjects — is supported by a cumulative vision of the history of science. This non standard vision conflicts with the

idea (at the source of the institutional aim) that a historical presentation of the scientific concepts and laws could contribute to improving the image which pupils have of science. There is therefore a major risk of seeing perverted science entering the classroom — perverted in both its nature and its history. What is more, the institutional arguments tend to place the contribution of historical information in the role of an addition to the traditional lesson, which is still organized independently to the historical organization of the ideas to which it refers. As underlined by P. Savaton, although the relevance of the history of science is constantly asserted, the place given historical elements in the curricula is derisory. This is confirmed by J. Lebeaume who notes that the historical dimension of techniques is weakly implemented in technological education although the curricula demonstrate an ever-increasing desire to introduce the history of techniques into teaching. The tasks proposed are mainly directed towards the identification of the changes in objects (essentially materials and energy) and therefore leave little space for the analysis of the evolution of technical solutions. Consequently, programmatic directions (in science and technology) are considerably restricted in their implementation in terms of the curriculum. Such a choice persists in placing the history of science as “*the icing [...] on the cake of teaching*” (Guedj & Dusseau, 1999, p. 996), as a “*plus*” which teachers often consider as being time-consuming and not as a constitutive element of the teaching itself.

2. Perspectives

Vowing to introduce into the science class a history of science which is both substantial and authentic means supporting the need for a more effective training of teachers in the history of science subjects. It also means supporting the idea — suggested by P. Savaton — of teaching the history of science. Finally, as a consequence, it means supporting the legitimacy of the didactics of the history of science (Guedj *et al.*, 2007). Nevertheless, the dialogue between didactics and the history of science remains open and could, in the coming years, contribute to:

- Assessing the impact of the use of the history of science on actual learning, the motivation of pupils and the image of the nature of science
- Assessing the impact of the use of the history of science on training
- Clarifying choices in didactic transposition according to the aims set by the researcher (this could lead to outlining a framework for the use of the history of science in teaching and training)

Maurines and Beaufiles explore several aspects of these avenues of

research in the final article of this survey. They present resources and activities in the field of optics which have been conceived with a view to transmitting a more authentic image of the nature of science and scientific activity to pupils.

The originality of this approach is threefold: documents of a historical nature are inserted into investigation situations; the historical information is spread over several texts distributed to different pupils and the synthesizing of this information gives rise to a collective task — the realization of a diagram or table. The initial feedback from teachers using these resources fuels the debate on the issue of the pertinence of the use — both in class and with pupils — of historical sources. While they do not lay down an exclusive framework for enquiry, these directions refer to aspects of the dialogue between didactics and history which are currently under-explored.

Cécile de HOSSON

cecile.dehossion@univ-paris-diderot.fr

Patricia SCHNEEBERGER

patricia.schneeberger@aquitaine.iufm.fr

BIBLIOGRAPHY

- ALBE V. (2009). *Enseigner des controverses*. Rennes: Presses universitaires de Rennes.
- ALLCHIN D. (1999). Values in science: an educational perspective. *Science & Education*, n°8, p. 1-12.
- ASTOFI J.-P. & DEVELAY M. (1989). *La didactique des sciences*. Paris: Presses universitaires de France, Que sais-je?, n° 2448.
- AUDIGIER F. & FILLON P. (1991). Enseigner l'histoire des sciences et des techniques, une approche pluridisciplinaire. Paris: INRP.
- BACHELARD G. (1938). La Formation de l'esprit scientifique. Paris: Vrin.
- BENSEGHIR A. & CLOSSET J.L. (1993). Prégnance de l'explication électrostatique dans la construction du concept de circuit électrique. *Didakalia*, n°2, p. 31-47.
- BRICKHOUSE N. (1990). Teachers' beliefs about the nature of science and their relationship to classroom practice, *Journal of Teacher Education*, vol. 41, n°3, p. 53-62.
- DORIER J.L. (2006). Recherches en histoire et en didactique des mathématiques sur l'algèbre linéaire - Perspective théorique sur leurs interactions. *Cahiers du laboratoire Leibniz*, n°12.
- GALILI I. (1996). Students' conceptual change in geometrical optics, *International Journal of Science Education*, vol. 8, n°7, p. 847-868.
- GALILI I. & HAZAN A. (2001). The effect of a history-based course in optics on students' views about science, *Science & Education*, vol. 10, n°1-2, p. 7-32.
- GIORDAN A., DEVECCHI G. (1987). Les origines du savoir. Des conceptions des apprenants aux concepts scientifiques. Neuchâtel, Paris: Delachaux et Niestlé.
- GOHAU G. (1995). Traquer les obstacles épistémologiques à travers les lapsus d'élèves et d'écrivains. *Aster*, n°20, p. 21-41.
- GUEDJ M. (2005). Utiliser des textes historiques dans l'enseignement des sciences physiques en classe de seconde des lycées français. *Didaskalia*, n°26, p. 75-95.
- GUEDJ M. & DUSSEAU J.M (1999). À propos d'une formation des enseignants de sciences physiques à l'épistémologie et l'histoire des sciences. *Bulletin de l'union des physiciens*, n°815, p. 991-1005.

- GUEDJ M, LAUBE S., & SAVATON P. (2007). Vers une didactique de l'histoire des sciences. Éléments de problématiques et de méthodologie pour une didactique de l'épistémologie et de l'histoire des sciences et des techniques (EHST). *Actes du colloque AREF (Actualité de la recherche en éducation et en formation)*, Strasbourg.
- GUESNE E. (1984). Children's ideas about light. In E.J. Wenham (ed.), *New Trends in Physics Teaching*. Paris, UNESCO, vol. IV, p. 179-192.
- HOSSON C. de (2011). Una controversia histórica al servicio de una situación de aprendizaje: una reconstrucción didáctica basada en Diálogo sobre los dos máximos sistemas del mundo de Galileo. *Enseñanza de las ciencias*, vol. 29, n°1, p. 115-126.
- HOSSON C. de & CAILLAREC B. (2009). L'expérience de Blaise Pascal au Puy de Dôme, analyse des difficultés des étudiants de premier cycle universitaire et confrontation historique. *Didaskalia*, n°34, p. 105-130.
- HOSSON C. de & KAMINSKI W. (2006). Un support d'enseignement du mécanisme optique de la vision inspiré de l'histoire des sciences. *Didaskalia*, n°28, pp. 101-124.
- HÖTTECKE D., HENKE A. & RIEß F. (2010). Implementing history and philosophy in science teaching. Strategies, methods, results and experiences from the European project HIPST. *Science & Education*. Available online: <<http://dx.doi.org/10.1007/s11191-010-9330-3>>.
- HULIN N. (1984). L'histoire des sciences dans l'enseignement scientifique. Aperçu historique, *Revue française de pédagogie*, n°66, p. 15-27.
- IRWIN A.R. (2000). Historical case studies: teaching the nature of science in context. *Science Education*, vol. 84, n°1, pp. 5-26.
- KIPNIS N. (1992). *Rediscovering optics*. Mineapolis: Bena Press.
- LAUGIER A. & DUMON A. (2000). Histoire des sciences et modélisation de la transformation chimique en classe de seconde. *Bulletin de l'union des physiciens*, n°826, p. 1261-1283.
- LEDERMAN N. (1992). Students' and teachers' conceptions of the nature of science: A review of the research. *Journal of research in science teaching*, vol. 29, n°4, p. 331-359.
- MARTINAND J.L. (1993). Histoire et didactique de la physique et de la chimie: quelles relations? *Didaskalia*, n°2, p. 89-99.

- MAURINES L. & BEAUFILS D. (2010). Un enjeu de l'enseignement des sciences: l'image de la nature des sciences et de l'activité scientifique. Comment y répondre grâce à l'histoire des sciences et techniques? *Actes du colloque AREF (Actualité de la recherche en éducation et en formation)*. Genève.
- MERLE H.(2002). Histoire des sciences et sphéricité de la Terre. *Didaskalia*, n° 20, pp. 115-135.
- MEN (2008). Programmes de collège. *Bulletin officiel du ministère de l'Éducation nationale*, spécial n°6 du 28 août 2008.
- MEN (2010a). Programme de physique-chimie en classe de seconde générale et technologique. *Bulletin officiel du ministère de l'Éducation nationale*, spécial n°4 du 29 avril 2010.
- MEN (2010b). Programme de physique-chimie en classe de première scientifique générale et technologique. *Bulletin officiel du ministère de l'Éducation nationale*, spécial n°9 du 30 septembre 2010.
- RIESS F. (1995). Teaching science and the history of science by redoing historical experiments. In F. Finley *et al.* (ed.), *Proceedings of the Third International History, Philosophy, and Science Teaching Conference*, vol. 2, Minneapolis: University of Minnesota, pp. 958-966.
- ROMHDANE I. & MAURINES L. (2005). Coherence of light and interference: historical ideas and students' difficulties. *Actes de la cinquième conférence internationale de l'ESERA*, Barcelone, pp. 25 [CD-ROM].
- SALTIEL E. & VIENNOT L. (1985). *What do we learn from similarities between historical ideas and the spontaneous reasoning of students?* Colloque du groupe international de recherche pour l'enseignement de la physique, Utrecht: GIREP.
- VIENNOT L. (1979). Spontaneous reasoning in elementary dynamics. *European Journal of Science Education*, vol. 1, n°2, p. 205-221.