Scientific and technological education in compulsory schooling: purpose, content and teacher training

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1. Introduction

Numerous reports and institutional plans of action aimed at improving the teaching of sciences and technology in compulsory schooling have been published at the international level over the last few years. However the locating and identifying of these reports have been made difficult by the varied origins of their instigators – ranging from political deciders (the European Commission, education ministries, for example) to associations or foundations influencing ministerial decisions (the *Académie des sciences* in France for example). The European Commission instituted workgroups which have published several documents on this theme (High Level Group on Science Education, 2004, 2007; Working Group *Increasing participation in Maths, Sciences and Technology*, 2003, 2004; Eurydice, 2006). For its part, the *Organization for Economic Cooperation and Development* (OCDE, 2006a) has organized the *Global Science Forum* for several years.

In France, besides the publication of official curricula, the ministry of education has published several reports on this theme (Bach, 2004; Inspection générale, 2001, 2006, 2007). Moreover, the recently created *Haut conseil de la science et de la technologie* participates in this reflection (2007) as do both chambers of the French parliament, the *Sénat* and the *Assemblée nationale* (Blandin & Renar, 2003; Rolland, 2006). The *Académie des sciences* is also an acknowledged participant (2004, 2005, 2006).

Both the origins and the authors of these reports are highly varied. They may belong to the world of politics, ministries, the world of research and occasionally the teaching profession. In most cases, the readers targeted by these reports are political or institutional deciders, although reports might be aimed at researchers, professors and teachers, or even occasionally parents but practically never at students or pupils.

Educational research is not to be outdone. The GRID project (*Growing interest in the development of teaching science*), funded by the European Commission, presents an overview of educational policies aimed at improving the teaching of sciences in schools (GRID, 2006). To do so, the research teams of this project analyze institutional reports and plans of action and recommendations advanced throughout Europe. Moreover, using surveys undertaken in several European countries, this project has elaborated a memorandum on the difficulties relating to improving the position of the teaching of sciences at school (Moebius & Magrefi, 2006).

The ambition of this project is the improvement of science teaching at primary and secondary levels by attempting to identify certain models which could become the object of large-scale diffusion. To achieve this, the project team wishes to create a network for the exchange of good practices in the area of the teaching of sciences in Europe at the level of the deciders and schools directly implicated in these innovative experiments[1]. Taking as their starting point the results of the reflection of the representatives of nine European countries at seminars organized by the Nuffield foundation, Osborne and Dillon (2008) identify points of convergence and divergence in the forms of science education deployed in secondary education in the participating European countries. The authors locate defects in the fields of curricula, pedagogy and evaluation, but the main problem is to be found in one of the fundamental aims of science education.

The finalities of the teaching of sciences in curricula and training standards have undergone large-scale evolutions. Under societal influence, the taking into consideration of the nature of science and its practices in teaching occupies an important position, as important as the learning of scientific knowledge. These evolutions have particularly changed the role of experimental activities and underlie the appearance of the teaching of sciences through scientific inquiry in the United States from the early 1960s (Schwab, 1962). This teaching practice has re-appeared explicitly in numerous curricula in the United States as well as other Anglo-Saxon countries: *Science for All Americans* (AAAS, 1989); *National Science Education Standards* (NRC, 1996); *English National Science*

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[1] GRID website: http://www.grid-network.eu

Curriculum[2]; *Pan Canadian Science Project*[3]. This aims at constructing a scientific culture which provides a richer and more diversified image of scientific reasoning. Greater autonomy is given to the pupils by using more open tasks and activities with a higher cognitive level. "Hands-on" or scientific investigation tasks are thus often used, since they play an important role in motivating and interesting pupils in science through the (not always explicit) use of socioconstructivist and real-life-situation didactical models. Activities focusing on learning manipulations or concepts and organized around stereotypical approaches give way to open investigative approaches involving the elaboration of questions, the formulation of hypotheses etc.

The objectives of the teaching of sciences and technology thus appear to be multiple: offering all pupils the basics of a scientific and technical culture; increasing the interest in sciences, scientific and technological studies and scientific careers. These recommendations or commands are often based on training standards aimed at basic skills. However, basic skills can cover a range of different meanings according to the particular educational system and can be based on contradictory references (human and management sciences).

Moreover, one can detect tensions or certain paradoxes underlying the stakes of this teaching in primary and lower secondary education:

- As far as the finalities of this learning is concerned: is the socioeconomic aspect being developed (more skills, more progress, more employment) or is the social, cultural and political aspect being favoured (more knowledge, a greater critical spirit, a more developed sense of citizenship, more democracy)?

- As far as the content of teaching is concerned: on the one hand relevant and useful knowledge is sought while, on the other, the acquisition of a certain rationality related to the work of conceptualization is also sought

- As far as the evaluation of results is concerned: the PISA survey (OCDE, 2006b) measured skills in different areas and highlighted discrepancies between countries as well as between pupil populations coming from different sociocultural milieus. What is really sought in the implementation of these evaluations? Are the results used as tools of scientific knowledge or are they means of re-orientating educational policies and the functioning of education systems?

Several directions envisaged by various prescribers seem to particularly question the field of research into the didactics of sciences and techniques. This is the case of projects promoting the partial re-founding of school subjects or curricula reform: the integrated teaching of sciences and technology, education

[2] http://curriculum.qca.org.uk/

[3] http://www.cmec.ca/science/

for citizenship, health, environment, sustainable development etc. Moreover, these reports often emphasize the need for a necessary modification of teaching methods or the recourse to ICT.

In France, for example, the recently published curricula for primary education (France: MÉN, 2008a) advocate a *"return to the fundamentals"*. As far as lower secondary education is concerned, the official curricula (France: MÉN, 2008b) emphasize scientific and technological education through the investigative approach as well as emphasizing the inter-relating of subject-based knowledge through themes of convergence (themes which require teachers of several subjects to work together on the conception of projected classroom sequences). Moreover, the introduction of the *Socle commun des connaissances et des compétences* (Core of knowledge and skills) (France: MÉN, 2006) leads to the rethinking of the objectives of learning and evaluation procedures.

Behind these new prescriptions and their implementation one can perceive the question of the content of teaching and its transmission and appropriation. These two issues are at the heart of the reflection of this issue of *Aster*.

As far as knowledge is concerned, certain concepts which are common to biology or geology, physics and technology (energy, matter, information…) are studied at different levels of compulsory schooling in themes of convergence (that is, implying different subjects), but are also studied in themes which are specific to each subject. It is worth exploring the level of formulation, the appropriation by the pupils and the way they are approached in these different themes.

Moreover, the need to examine these transversal concepts and their "transversality" leads to the reflection on the teaching-learning procedures enabling the pertinent approach of these themes.

The creation of a historical and/or epistemological distance should facilitate the analysis of these different evolutions. This issue of *Aster* presents the reader with articles dealing with:

- A historical, epistemological and/or didactical reflection on the new directions of the prescriptions (Lebeaume; Coquidé, Fortin & Rumelhard; Lhoste & Peterfalvi)

- Practices implemented in primary and lower secondary classes and tools for the teacher relating to the evolutions of the prescriptions (Gardet & Caumeil; Marlot; Grugier)

- The links between teaching content within the framework of the quest for vertical and horizontal coherence (Coquidé, Fortin & Rumelhard; Lhoste & Peterfalvi; Lebeaume)

- The training of teachers, the aids and tools which seem necessary for teachers relating to these evolutions (Grugier, Gardet & Caumeil)

2. Mechanisms and approaches: unity or mere resemblance?

A quick glance at the approaches adopted in the teaching of sciences in different (Occidental) countries suggests a certain unity; investigation seems to be central with a constant concern: making pupils active in learning, motivating them, attracting more pupils to scientific studies. This unity is underlined in the article by Coquidé, Fortin & Rumelhard, for example, which deals with the generalized investigative approach in France in primary then lower secondary education. This is also dealt with in Lebeaume's article on the integrated teaching of sciences and technology (EIST). As far as technology is concerned, this unity seems less obvious on a worldwide level although the investigative approach is at present adopted in French education as the article by Grugier demonstrates.

Albeit with some difficulty, another aspect which seems to be imposing itself is the coherence of scientific construction despite the apparent division of school subjects: this concerns the current experimentation of integrated teaching and perhaps the teaching of sciences and technology in primary education, returning to issues raised previously by the implementation of experimental science work (TSE) or experimental science teaching (ESE). The historical light cast by Lebeaume's article raises the question of science teaching and subject non-differentiation. *"Is it a non-differentiated teaching or a coordinated teaching, that is, work and studies the horizon of which is the progressive differentiation of subjects or [on the contrary] a thematic teaching which enables the co-existence of activities or experiments with multiple subject labels?"* (p. 3).

However, behind this apparent unity, questions, tensions and contradictions emerge: they can be grouped into different categories.

2.1. Foundations, stakes

The investigative approach or its equivalents in Anglo-Saxon countries was conceived in order to implicate and motivate pupils in scientific subjects which suffered from a certain disaffection, as the articles by Lebeaume and Coquidé, Fortin & Rumelhard underline. However, the official French instructions do not refer to a didactic model or a theory of learning, as Marlot or Coquidé, Fortin & Rumelhard point out. Although the stakes appear clear, one may wonder about the foundations, the origins of these approaches.

The epistemological approaches presented by Coquidé, Fortin & Rumelhard emphasize the possible origins of these current prescriptions. The investigative approach would be more inspired by Dewey's approach than the *Investigation structuration* model developed several years ago by the French INRP didactical research body. The difference would lie in the taking into consideration of pupil representations and the underlying obstacles to them, which is central to *Investigation structuration,* yet only evoked in the investigative approach (*"the teacher's guidance must not lead to the occultation of these initial conceptions, but, on the contrary, aims at bringing forth questioning*", France: MÉN, 2007, annexe 1.)

Nevertheless, these prescriptions concerning the investigative approach underline the importance of the construction of knowledge by the pupils: there is definitely a compatibility between the Dewey-inspired investigative approach and the constructivist idea if one conceives learning as a continuous process; however, the French didactical framework, especially that rooted in the *Investigation structuration* model, adopting the Bachelard concept of obstacle, envisages the construction of knowledge in terms of rupture rather than continuity. Three articles in this issue (Coquidé, Fortin & Rumelhard, Lhoste & Peterfalvi, and Marlot) use the term obstacle, either referring to Bachelard or to Astolfi & Peterfalvi. The epistemological analyses shed light on a certain number of epistemological obstacles which are envisaged as "*preventing the identification of problems*", or as "*non pertinent reasoning in the scientific area*" (Lhoste & Peterfalvi), or as a conception to be overcome (Coquidé, Fortin & Rumelhard). Marlot emphasizes the limits of a simplistic use of the concept of the obstacle, often seen by teachers as preventing learning. She does, however, underline its importance as a tool to aid teacher regulation.

It thus seems that although the Bachelard obstacle does not appear in the official texts recommending the recourse to the investigative approach, it is a useful concept that is used in research into the didactics of sciences (Earth and life sciences, in particular). However, the relationship between the *Investigation structuration* model and the investigative approach is not obvious given the absence of this important element in the latter.

Furthermore, Coquidé, Fortin & Rumelhard as well as Lhoste & Peterfalvi underline two important points of scientific investigation which are not explicitly identified in the prescriptions:

- The activities of pupils can be related to two types of operation: on the one hand, those related to the empirical (practical), and on the other hand, those related to the conceptual (elaboration of hypotheses, theories, and models). These two types of operations or activities (ideal or conceptual objects and activites implying practices and observations, empirical referent and construction of the concept) are both distinct and indissociable; this distinction refers to a rationalist framework and does not exist in empiricism.

- The control of the inquiry either through experimental testing or the use of norms, structuring principles, theoretical constraints.

Coquidé, Fortin & Rumelhard (p. 8) underline the empirical-deductivist nature of the investigative approach which strings together successive tests, as if the production of hypotheses by pupils was infinite and the production of knowledge came from experimentation alone.

Lhoste & Peterfalvi (p. 4) remind their readers of the importance, within the Bachelard rationalist framework, of the delimiting of the field of possibilities by other non-experimental elements (norms, theoretical constraints, structuring principles).

Although the investigative approach refers to a scientific investigation, focusing on a problem and an exploration of the possible solutions, can it be limited to a linear process (after the inductivist manner), on the one hand, and to a confusion between facts and theories, on the other (in an empiricist approach)?

This initial examination of the approaches analyzed by researchers highlights the absence in the prescriptions of epistemological elements of reference enabling teachers to understand the foundations. As Marlot asks, could the prescriptions concerning the investigative approach not include a search for an explanation of the foundations on which it is based? This would facilitate its understanding and perhaps its implementation.

Lebeaume shows the difficulties encountered by the innovations or institutional incitements when faced with the strong subject-structured French curricula. For this author, TSE, ESE and integrated teaching aim to help the pupil construct a more accurate representation of the functional unity of the sciences, but are hindered by the temporal dispersion of the subjects taught either at the same level of the curriculum or at different levels.

Is the functional unity of the sciences obvious? What, precisely, does it cover?

Is it only a question of limiting the compartmentalization of subjects with reference to the necessarily interdisciplinary nature of scientific initiation as Piaget recommended in 1973? What is there in common today between the methods and concepts constructed in molecular biology and those used in nuclear physics, between the processes of conception of technological objects and those used in the elaboration of models of animal physiology? If one admits that this unity exists, can it be constructed only from a model approach shared by all the different scientific and technological subjects?

The historical analysis of TSE and ESE developed by Lebeaume designates two aspects which could explain this quest for unity at the school level:

- The first (p. 8) is the focus on the activity of the pupil in his different dimensions, both against the supposed passivity of the pupil and also against exclusively manufacturing activity. This dimension can be attached to the constructivist framework of the present approach which emphasizes the construction of knowledge by the pupil.

- The second is more related to the unifying principle of scientific functioning, which does not correspond to a standardization of the subjects but rather to a quest for common notions throughout all scientific subjects – physics, chemistry, biology, geology and technology (p. 11).

To found such a representation, is it not necessary to use a vertical and horizontal coherence which would also be centred on subject content? We shall return to this point in section 3.

2.2. Classroom practices

Several articles deal with implementation difficulties, the characteristics of which need exploring in order to understand their origins and envisage appropriate training.

For Grugier, certain changes in the practices of technology teachers are difficult to effect. These teachers are more focused on the object to be constructed than on the approaches to be used. The project approach and the investigative approach are confused by these teachers and sometimes by their trainers as well. Nevertheless, as Coquidé, Fortin & Rumelhard underline, if the investigative approach is focused on a problem to be solved, is this not also a project approach, the project being to solve a practical or theoretical problem? In the conceptions of previous curriculum, was it not already the case that the project approach allotted the role of the conceiver to the teacher while the pupil was given the role of the underling implementing the specifications? If the finality of the project was to produce the object, the pupil's role could be restricted to simply following the specification conceived by the teacher. If, however, the finality of the project is the resolution of a (theoretical or practical) problem related to an object (built or to be built), the object takes second place and the problem to be solved first place.

In the new recommended approach, the finality of the project is the understanding of the object, as a complex system of which one problematic aspect will be explored. In this new approach, therefore, the technological object changes function: it is no longer a product to be manufactured but the object of an analysis aimed at understanding its working principles. Nevertheless, the idea of a collective realization does not seem to receive unanimous support among the teachers questioned by Grugier, since this is in opposition to the individual production to be found in the previous curriculum.

Marlot looks into the use of the investigative approach in elementary school science teaching. She demonstrates that the prescriptions are applied by her sample without these teachers distancing themselves from the recommendations although they follow various orientations: withdrawal into language practices which are disconnected from scientific knowledge, recourse to the epistemology of the true/false… related to an insufficient mastery of the knowledge being taught. Basing her study on the theoretical framework of joint action (Sensevy & Mercier, 2007), she highlights a phenomenon of the "*sliding of learning*" which provokes a "*fading of knowledge*". According to Marlot, this phenomenon is not solely related to the official curricula, but also to the fragility of the didactic and epistemological anchoring related to the socioconstructivist practices of the teachers.

In their article, Coquidé, Fortin & Rumelhard evoke certain difficulties in implementing the investigative approach in Earth and life sciences. Is the classification of living beings a theme which is suitable for the investigative approach with pupils? In their analysis, one can note that the investigation, if there is one, is extremely limited by the situation chosen by the teacher, whose target is the phylogenetic classification: under these conditions can one talk of investigation? And what about obstacles? The investigation, disconnected from the theoretical framework of evolution, cannot be an exploration of the area of possibilities but merely a line without ramifications, a single path which the pupils tread without understanding why.

2.3. Conditions of possibility of a school scientific investigation

The article by Coquidé, Fortin & Rumelhard insists on the necessity of not reducing the investigation to "*procedures of constructing knowledge and training [pupils] for a certain type of reasoning [to be used] for the construction of knowledge*", even if this solution enables the taking into account of various constraints (material, teaching time, etc). Can one envisage the workings of an investigation devoid of conceptual content?

This can only be done by working on teaching-learning situations to be proposed to pupils; these situations must, indeed, enable the pupils both to have a genuine activity of research and to also construct clearly identified scientific knowledge.

The article written by Lhoste & Peterfalvi focuses on the problem and the process of problematization, within the framework of the CREN. They envisage the relationships between subjects (chemistry and Earth and life sciences) taking as their starting point an in-depth analysis of the concepts at work using the theoretical framework of Orange (2000). This attempt is part of a research project which aims at reconciling working on the obstacles and focusing on problematization in learning approaches which emphasize the construction of the problem over its resolution. Along the lines of the work of Astolfi (Astolfi & Peterfalvi, 1993), this research seeks to return scientific knowledge to its entire apodictic dimension, that is, to maintain the strong relationship which links knowledge and problems.

Lebeaume underlines the tensions which exist in the interdisciplinary mechanisms installed to counter the representation of sciences as being too isolated from each other in teaching. The analyses which he proposes of initiatives such as TSE and ESE provide elements for the comprehension of the foundations of the investigative approach and avenues currently being explored in the integrated teaching of sciences and technology. Do the implementation of integrated teaching and the investigative approach across all the scientific subjects really constitute a new departure enabling the achievement of horizontal coherence? We intend to discuss this issue in relation to teaching content in the next section.

3/ Content

The content of the official instructions concerning the teaching of sciences and technology does not always clearly specify the objectives of this teaching:

- Should the pupils acquire a method of reasoning through investigative approaches or should they construct scientific concepts unrelated to those of common sense?

- Should they learn scientific results unlinked to the problems to which they are related or should they elaborate scientific explanations in response to problems which they have actually constructed?

- Should they have an image of the workings of science as being stereotyped and directed by underlying principles which are more often than not obscure (for them) or as a process in perpetual movement in various directions yet within a framework which has been chosen in a rational and conscious manner?

These very general and perhaps rather brutal questions can be subjected to two notions in the prescriptions which are far from unknown yet rarely put into practice:

- Vertical coherence concerns the way in which subject-related concepts are studied throughout schooling in each of the subjects.

- Horizontal coherence is applied to the coordination of subject teaching either by organizing thematic work involving two or more subjects, or by facilitating pluri-disciplinary teaching.

These two different types of coherence are, first and foremost, a construction of the prescribers (Lebeaume, p. 12), which appeared towards 1923 in terms of the concordance or coordination of teaching. Their ambition is to facilitate the ordering of the world by coordinating or bringing into convergence the three worlds of nature, both inert and living, and objects (Lebeaume, p. 13), but also to provide pupils with a more accurate representation of the unity of the workings of science in opposition to the compartmentalized image which existed at every level of teaching, above all, from lower secondary to university education.

Vertical coherence is envisaged in relationship to problems and obstacles in the article by Lhoste & Peterfalvi. The construction of the concept of nutrition at various levels of education is analyzed with reference to the problems which pupils can pose and construct. This study is also linked to the identification of the obstacles concerning this theme (Giordan & de Vecchi, Clément) and proposes levels of formulation for the concepts studied.

Vertical coherence is also explored, as a condition of possibility or a prerequisite, in the section of the article by Coquidé, Fortin & Rumelhard which is devoted to breathing, for example, as well as in the study devoted to the construction of classification.

The issue of horizontal coherence between scientific and technological subjects is raised by Lebeaume. Basing his work on the ESE and TSE experiment, he notes that the quest for horizontal coherence is in conflict with the vertical coherence of the subjects. This issue is also to be found in the articles by Lhoste & Peterfalvi and Coquidé, Fortin & Rumelhard. The first underline the important links which exist between biological knowledge constructed around the theme of nutrition and the physical-chemical knowledge which pupils must mobilize for this work. This raises the problem of the timing of teaching in both subject areas.

This quest for horizontal coherence thus leads the prescribers to write a common introduction for the curricula of sciences, technology and mathematics in French lower secondary education. Moreover, for Grugier, by introducing new approaches (investigation, problem solving), the new curriculum prescribed for the teaching of technology in France moves closer to the curricula for sciences. But this innovation questions the teacher training dispensed.

4. The teacher training issue

Teacher training encounters two types of difficulty:

- Either the teachers (or future teachers) are experts when they come form the scientific subjects but the compartmentalized university studies they have undertaken make them unlikely to be permeable to didactic and epistemological inter-disciplinary reflection.

- Or they are not scientifically expert and their tendency could be to apply prescribed practices to the letter while losing sight of the importance of the knowledge at stake, as Marlot shows.

Taking university courses into consideration is undoubtedly one of the conditions for conceiving training that is adequate for the needs identified. Looking into the finer detail, the obstacles and difficulties identified concern an aspect of training which is largely under-represented in present-day training (and, without doubt, in future training): the epistemology of scientific and technological subjects from both a general point of view and from the more particular point of view of the concepts employed.

4.1. Obstacles and difficulties

Lebeaume's article provides indications as to what could constitute an obstacle to change in science teaching, particularly as far as integrated teaching is concerned: the compartmentalization of subjects in lower secondary education but also in primary education arising from various causes (university training, timetables, etc).

Grugier's article indicates another source of difficulties: the conceptions and teaching habits installed in certain sectors, even the influence of the suppliers of textbooks. This latter source can be seen in the constitution of teaching kits dealt with by Gardet & Caumeil. In both cases, the material tends to erase all discussion, all in-depth reflection about content and the knowledge at stake among teachers, as if the objects themselves bore the knowledge to be taught.

Apart from the standard (initial and in-service) training mechanisms, specific assistance has been provided for teachers (particularly primary school teachers): this is the case of the accompaniment by a scientist discussed in the article by Gardet & Caumeil. Their study of the verbal exchanges between the scientist and the teacher spotlights the limits of this sort of mechanism, at least as far as the case analyzed is concerned (the scientists are students not experts). This study opens avenues of reflection concerning *"a problematical professional gesture"*, the educational partnership.

After these rather negative results, there are, however, some reasons for hope.

4.2. Desirable directions

In the background, behind the issues concerning pupils learning science, certain issues are being raised about the training of teachers particularly in the field of scientific and subject epistemology. Several avenues to explore can be found in the articles in this issue of *Aster*:

- The in-depth treatment of the epistemological issues necessary for the teaching of scientific concepts. Only in-depth epistemological research such as that of Coquidé, Fortin & Rumelhard, and Lhoste & Peterfalvi can forge tools that are usable in training programs, providing they are sufficiently widely diffused and adapted to the target audience. The use of didactical research results in another area (here that of training) is inevitably accompanied by a phenomenon of didactic transposition and thus a reorganization of these data (Schneeberger & Triquet, 2001).

- Historical analyses of innovation. These are tools for the understanding of the foundations and the stakes of the plans of action and mechanisms implemented by the prescribers (Lebeaume).

- A mechanism that undoubtedly deserves further investigation. The accompaniment of a teacher by a science student once the distribution of the respective roles and the status of the student have been rethought (Gardet & Caumeil).

However, the question of the training of the trainers implicated in these actions should also be posed. In order to propose training which is not limited to accompanying the teacher, but which aims at the real transformation of practices, we have to work on the necessary understanding by the trainers of the logic of teachers' actions and their conceptions of teaching and learning (Grugier; Marlot).

5. Conclusion

As we have seen, the evolutions of the finalities of the teaching of sciences and technology, in the curricula and in the standards of training are very great. The objectives of this teaching appear to be multiple: to propose the basics of a scientific and technical culture to all pupils; to increase the interest in sciences and scientific and technological studies as well as in scientific careers. The recommendations or commands promulgated in the official instructions are more often than not based on standards of training aiming at the acquisition of basic skills.

Yet, behind the stakes of this teaching in compulsory schooling, tensions or certain paradoxes can be perceived:

- As far as the finalities of this learning are concerned: is the aim to develop the socioeconomic aspect or to favour the social, cultural and political aspect?

- As far as the content of teaching is concerned: is the aim the appropriation of relevant and useful knowledge or is it also the acquisition of a certain rationality linked to the work of conceptualization?

- As far as the evaluation of these new mechanisms or that of pupils is concerned: what are we really seeking in the implementation of these evaluations?

The articles in this issue of *Aster* deal with some of these questions, particularly those concerning the content of teaching sciences and technology and its transmission-appropriation. The epistemological and didactic analysis of certain prescribed teaching content and approaches enables the identification and interpretation of often non-explicit orientations in the official instructions. Moreover, historical and epistemological distance facilitates the analysis of these different evolutions.

However, in the background of these choices of content or approaches, the definition of a scientific and technological culture is sought and the stakes of its acquisition can be identified. All the reports evoked earlier mention scientific culture, but, more often than not, do not specify the meaning given to this expression; this does not facilitate comparison and analysis. To this, one must add the difficulties linked to translation since we find such terms as scientific and technical culture, scientific reading or scientific literacy. This issue, which was dealt with by Fourez (1994), still seems to be relevant.

All the issues envisaged for research into the teaching of sciences and technology during compulsory schooling have not been dealt with in this issue. There still remain many avenues to be explored in future research into this theme, including the training of teachers - particularly the issue of the epistemological and historical training of teachers of sciences and technology. Moreover, it appears that the skills-based approach introduced in the new curricula questions the transmission-appropriation of knowledge all the more so as the notion of skill seems complex to apprehend (Rey, 2008) since the interpretative frameworks are numerous and not necessarily compatible.

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