

**A sociological analysis of science curriculum
and pedagogic practices**

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Introduction

The educational reform for compulsory schooling (6-15 years old), that was implemented in 2001/2002 in Portugal, aimed at unifying by themes and competences the whole primary, elementary and middle school and at putting into practice the flexible management of the curriculum, one of the main principles of the Basic Law of the Portuguese Educational System of 1986. The flexible management of the curriculum means finding appropriate answers to the real contexts and students with which teachers work and assumes that schools should have a greater power of decision with regard to the development and management of the curriculum.

The curriculum is institutionalised in two main texts: *Essential Competences* and *Curriculum Guidelines*. The former is a general document which contains the competences that should be developed in any of the teaching levels. The latter is a more specific document that gives the guidelines for each one of the disciplines of the curriculum.

Although the curricular documents are the organizing elements of many pedagogic decisions of teachers and authors of various pedagogic resources (textbooks, software), the autonomy that is accorded to them in a context of curriculum flexibility creates a greater space for recontextualizing the principles contained in those documents. Considering that teachers' pedagogic practices influence directly students' learning, the direction and degree of that recontextualization should be the object of analysis and problematization.

The study draws on Bernstein's theory of pedagogic discourse (1990, 2000). The text of any curriculum represents the Official Pedagogic Discourse that is produced in the official recontextualizing field (Ministry of Education and its agencies) and that is the result of the multiple influences of the field of the State and the fields of economy and symbolic control and also the international field. Teachers' pedagogic

practices are the Pedagogic Discourse of Reproduction put into practice and represent processes of reproduction/recontextualization of the official pedagogic discourse, influenced, in greater or smaller extent, by the fields of economy and symbolic control.

The implementation of a given pedagogic practice requires that the teacher possesses the specific coding orientation to the context of that practice. The *specific coding orientation (SCO)* contains two principles: the *recognition rules* that create the means for distinguishing between contexts and therefore for the recognition of the specificity of a given context; and the *realization rules* that create the means to select the meanings adequate to the context (*passive component*) and to the production of the legitimate text in that context (*active component*). Subject's performance, in this case teacher's performance, requires also the possession of favourable socio-affective dispositions (motivations, aspirations, values) for the context of the pedagogic practice. Recognition rules relate to *classification (C)* that measures power relations i.e. the degree of maintenance of boundaries between categories (subjects, discourses and spaces), within the organizational dimension of education. Realization rules relate to *framing (F)* that measures control relations i.e. the communication between subjects, within the interactional dimension of education. Specific values of classification and framing define specific contexts and therefore specific forms of acquisition and transmission. In this study four scales of classification (C^{++} , C^+ , C^- , C^{--}) and framing (F^{++} , F^+ , F^- , F) were used to indicate decreasing degrees of power and control respectively.

Within this theoretical framework, teachers' pedagogic practices can be analysed as scientific learning *contexts* that generate *texts*¹ and that represent given levels of teachers' performances, i.e. given levels of specific coding orientation to the implementation of pedagogic practices with given sociological characteristics (Morais & Neves, 2006).

This study is part of a broader study (Alves, 2007) that was focused on the context of middle school Natural Sciences and that analysed the sociological message transmitted by: (a) the Official Pedagogic Discourse of the Natural Sciences curriculum; (b) the Pedagogic Discourse of Reproduction of educational software constructed on the basis of the curriculum; and (c) the pedagogic practice of science

teachers. It also analysed the recontextualizing processes that occurred between the three levels. The study presented in this paper is focused on scientific literacy and addresses the following problem: *What is the extent to which the sociological message transmitted by the teachers' pedagogic practice recontextualizes the Official Pedagogic Discourse (OPD)?* From this problem derived the following research questions: (1) What is the sociological message of the OPD? (2) What is the sociological message transmitted by teachers' pedagogic practices? (3) What is the direction and degree of the recontextualizing processes that teachers make of the OPD? Answers to these questions may give a contribution to the study of students' scientific literacy.

The analysis of the pedagogic discourse considered *the what* and *the how* of scientific learning. With regard to the categories related to *the what*, the study was focused on metascientific knowledge (science construction)² and on scientific knowledge and competences. With regard to the categories related to *the how*, the study was focused on relations between discourses - intradisciplinary relations between scientific and metascientific knowledge and between distinct kinds of scientific knowledge -, and on evaluation criteria in the transmitter-acquirer relation - degree of explication of intradisciplinary relations and of scientific and metascientific knowledge and competences. The level of conceptual demand was another important dimension of the analysis. These were the dimensions of scientific literacy considered in the study.

The selection of these characteristics was directed by research results. With regard to the importance of a contextualised integration of science construction on the teaching-learning process, studies in this area (e.g. McComas, Clough & Almazroa, 1998) have shown that scientific education should contain a metascientific perspective which, according to Ziman (1984), has various dimensions (philosophical, historical, psychological and internal and external sociological). Former studies (Domingos, 1989; Morais & Neves, 2001; Morais, Neves & Pires, 2004) have suggested that the promotion of a high level of scientific development implies a pedagogic practice which, among other important features, is characterized by a high level of conceptual demand, intradisciplinary and explication of the evaluation criteria. A high level of conceptual demand is also pointed out by Vygotsky (1978) when he talks about the development of high mental processes,

and is also based on the hierarchical structure of scientific knowledge (Bernstein, 1999). These ideas also support a high degree of intradisciplinarity that “can be achieved when strong and complex relations between organizing themes are established and knowledge learning is unified around a structuring idea of great broadness and conceptual complexity” (Neves & Morais 2006, p.8). With regard to the explicitness of evaluation criteria, research has shown that explicit evaluation criteria is the most crucial condition for an effective scientific learning, particularly in cases of high levels of conceptual demand and in the case of the socially disadvantaged students (e.g. Morais, Neves & Pires, 2004). These characteristics of a pedagogic practice will be referred, in this study, as the reference theoretical model towards which teachers’ SCO will be evaluated.

The model of figure 1 contains the characteristics and relations that were selected for the study.

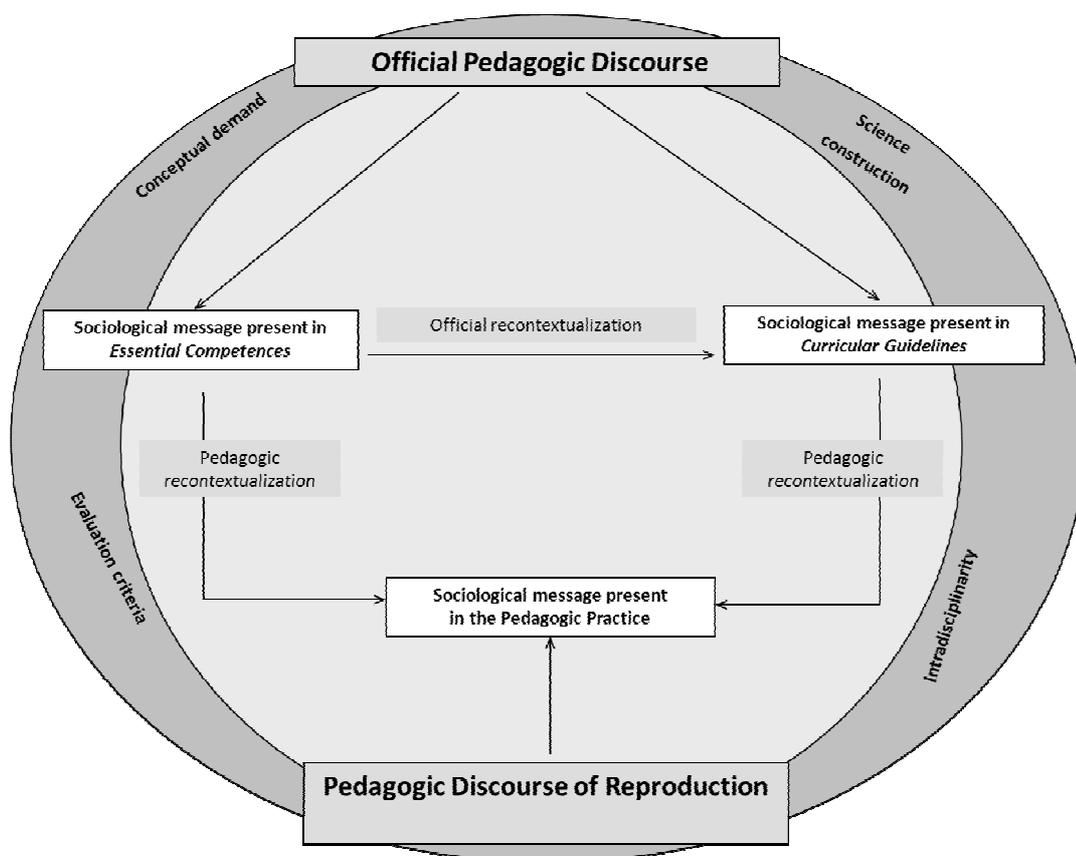


Figure 1 - Model of analysis

Methodology

General aspects

The study is interpretative within a mixed methodology that combines quantitative and qualitative approaches (Tashakkori & Creswell, 2007; Morais & Neves, 2010). The quantitative approach was used when, in the instruments construction, categories of analysis were derived from educational theories, therefore following a rationalist mode of analysis. The qualitative approach was used in the analysis of curriculum texts, interviews, classroom observation and redefining categories. The system of categories and indicators was the result of a dialectical relation between the theoretical and the empirical. By following a mixed methodology, the study considered an explicit theoretical perspective where the empirical data were analysed on the basis of a strong theoretical framework. All research studies are explicitly or implicitly theoretically guided and the theoretical principles are essential to according coherence to the collection and analysis of data (Bogdan & Biklen, 1994). According to Burkhardt and Schoenfeld (2003), a good research model in education should have among other characteristics a relatively stable theoretical basis. For these authors, research in education should give a contribution to the development of “more robust, more encompassing theories and in understanding which aspects of which theories apply strongly in which contexts” (p.10).

Whereas the *Essential Competences* document was analysed on the whole, the analysis of the *Curriculum Guidelines* document was limited to the sub-theme “Human Organism in Equilibrium” of the theme “Living better on Earth”, which constitutes the 9th year of schooling. The analysis of teachers’ pedagogic practice in the classroom was focused on one of the teaching units - “The Human Digestive System” – which is part of that sub-theme. The selection of the sample of teachers was limited by their use of ICT in the classroom and was made up of two teachers: Sofia - teaching in a private school outside Lisbon; and Carla - teaching in a public school located in a city in the country. Both teachers Sofia and Carla got their first degree in Biology and Geology Education and obtained their teacher training in

these disciplines. They were both around forty years of age and had about twelve years of teaching experience.

In order to analyse the curriculum and the teachers' pedagogic practices, instruments of analysis were constructed, piloted and applied. These instruments were based on models/instruments developed by former studies (e.g. Castro, 2006; Morais & Neves, 2001; Morais, Neves & Afonso, 2005; Neves & Morais, 2001a) but went further to reach higher levels of conceptualization, broadness and precision.

The instruments for the analysis of the curriculum and of teachers' pedagogic practices were focused on the four pedagogic characteristics selected for the study – science construction, conceptual demand, intradisciplinarity and evaluation criteria.

In order to analyse the two curricular documents, the following nine instruments were constructed³:

Two for science construction: Metascientific knowledge and competences (1); Complexity of metascientific knowledge (2).

Two for intradisciplinarity: Relations between scientific and metascientific knowledge (3); Relations between distinct kinds of scientific knowledge (4);

Three for evaluation criteria: Evaluation criteria of the metascientific knowledge (5); Evaluation criteria of the relation between scientific and metascientific knowledge (6); Evaluation criteria of the relation between distinct kinds of scientific knowledge (7).

Conceptual demand was analysed by using the instrument 4 and two other instruments: Complexity of scientific cognitive competences (8); and Complexity of scientific knowledge (9).

Instrument 1 contained a list of competences and of various kinds of knowledge with regard to science construction, and was constructed to be a support of analyses when using instrument 2. Instruments 2, 8 and 9 used a scale of increasing degrees of complexity. Instruments for analysing intradisciplinarity used a decreasing degrees scale of classification (C^{++} , C^+ , C^- , C^{--}) and instruments for analysing evaluation criteria used a decreasing degrees scale of framing (F^{++} , F^+ , F^- , F^{--}). The instrument for analysing the complexity of scientific cognitive competences used a four degree scale running from very simple competences (SC^-) to very complex competences (CC^+). In the case of scientific knowledge a three degree scale was used from very low knowledge level (Degree 1) to very high knowledge level (Degree 3). In order to analyse the level of conceptual demand of scientific knowledge, a composite index was constructed on the basis of the

degrees of complexity of scientific knowledge and of scientific competences and also the intradisciplinarity between distinct kinds of scientific knowledge.

Teachers' pedagogic practice was analysed in terms of teachers' specific coding orientation (SCO), i.e. their possession of recognition and realization rules for the context of scientific learning with regard to the same characteristics that were used on the curriculum analysis: science construction, conceptual demand, intradisciplinarity and evaluation criteria. For that, a semi-structured interview and an instrument to characterize the classroom pedagogic practice were constructed. The interview⁴ would give data about recognition, passive realization and active realization at the level of argumentation and the instrument to characterize teachers' classroom pedagogic practices⁵ would give data about active realization at the level of implementation. Active realization at the level of argumentation means that the teacher can tell what to do in the classroom, with reference to a given pedagogic characteristic, and the level of implementation means that the teacher can behave according to what s/he tells.⁶

Curriculum analysis

In order to make the analysis of the two curricular documents, units of analysis were created and were organized in four sections - Knowledge, Aims, Methodological Guidelines and Evaluation. Each one of the units of analysis – excerpt of the curricular text with a specific semantic meaning – was analysed by using the various instruments.

In order to show how this analysis was made, we present, for two of the characteristics of the study – Intradisciplinary relations between distinct kinds of scientific knowledge and Complexity of scientific knowledge –, an excerpt of the respective instrument (Tables I and II) and units of analysis classified according to the scales of that instrument.

Table I – *Excerpt of the instrument to characterize the intradisciplinary relations between distinct kinds of scientific knowledge*

C ⁺⁺	C ⁺	C ⁻	C ⁻⁻
<p>A relation between low order concepts, within the same theme, is made. [alternative 1]</p> <p>Or</p> <p>Some scientific knowledge which is needed to the understanding of the relation between concepts within the same theme is missing. [alternative 2]</p>	<p>A relation between low order concepts of distinct themes is made. [alternative 1]</p> <p>Or</p> <p>Some scientific knowledge which is needed to the understanding of the relation between concepts of distinct themes is missing. [alternative 2]</p>	<p>A relation between high order concepts, or between these and simple order concepts, within the same theme, is made.</p>	<p>A relation between high order concepts, or between these and simple order concepts, of distinct themes, is made.</p>

Examples of units of analysis:

“Students should learn basic morphological and physiological aspects of systems in order to understand the importance of blood circulation, lung respiration, digestion, absorption and elimination of the substances produced by the organism, and should understand the functioning of human systems in an integrated way”. (*Curriculum Guidelines*, Section *Aims*) - Degree C⁺ - alternative 2.

“Using of technological knowledge – water treatment: physical and chemical processes, particular cases of water treatment (as in hemodialysis), water transport, profitability mechanisms at home, in agriculture, gardening and industry”. (*Essential Competences*, Section *Aims*) - Degree C⁻.

The first unit seems to value intradisciplinary and yet the omission of the concept of homeostasis in the curriculum limits that supposed intradisciplinary. The second unit contains knowledge of a complex order (e.g. physical and chemical processes of water treatment) related to knowledge of a simple order (e.g. water transport), within the same theme.

Table II – *Excerpt of the instrument to characterize the complexity of scientific knowledge*⁷

Degree 1	Degree 2	Degree 3
<p>The scientific knowledge refers to generalized facts and/or simple order concepts, of a low abstraction level (1st order concepts).</p>	<p>The scientific knowledge refers to complex concepts, with a level of abstraction higher than the simple order concept level and which are made of non perceptible attributes (2nd order concepts).</p>	<p>The scientific knowledge refers to unifying themes, involving a very high abstraction level (3rd order concepts).</p>

Examples of units of analysis:

“The suggestion is to raise questions like ‘Why heart beating increases in some situations?’, ‘Why are we hungry or thirsty?’ [...]. Looking for answers to these questions will lead to inquiry activities or to debates that, based on various resources (films, internet, slides, books, journals), may promote the clarification of morphological and physiological aspects of the systems involved in the question under study”. (*Curriculum Guidelines*, Section *Methodological Guidelines*) - Degree 2.

“Understand that the human body is organized in hierarchical levels which work in an integrated way and develop specific functions”. (*Essential Competences*, Section *Aims*) - Degree 3

The first unit involves second order concepts as their understanding presupposes the understanding of first order concepts. The second unit involves third order concepts as it refers to unifying themes, in this case to generalizations about the human body.

Analysis of teachers' SCO - Interview

For each one of the pedagogic characteristics under analysis, the interview started (Question 1) by asking the teacher to select one of three options (one of which contained the pedagogic characteristic that has been suggested by research as being more favourable to scientific learning), in order to get the first data about recognition rules.

The interview proceeded by asking teachers to give explanations to two distinct questions – Question 2 (*reasons/arguments given for the selection made*) and Question 3 (*justifications given for the situation presented as the closest to the theoretical model*) - , in order to get data about the possession of passive realization rules. The answers to these questions provided also data to solve ambiguities and unsolved issues about a real possession of recognition rules.

A last question (Question 4) was focused on putting into practice in the classroom the characteristic of the pedagogic practice under analysis and provided data about the possession of active realization rules at the level of argumentation (see Figure 2).

The interview excerpts that follow refer to the characteristic *Evaluation Criteria*.

Question 1: Success and failure in science education have many causes. Select, from the following situations of the classroom context the one with which you identify.

- 1) When teaching a scientific or metascientific knowledge, the teacher gives detailed explanations but does not create moments for syntheses, leaving this task to the students' criteria in order to respect their individuality.
- 2) When teaching a scientific or metascientific knowledge, the teacher gives detailed explanations and creates whenever needed moments for syntheses, in order to explicate the essential aspects of the activities.
- 3) When teaching a scientific or metascientific knowledge, the teacher gives detailed explanations and makes a synthesis at the end of the teaching unit only, in order to explicate the essential aspects of the activity.

Question 2: Why did you choose option 1? (or 2 or 3)

If the teacher selected the option 1 in Question 1, the excerpt that follows should be given. If this is not the case the interview should proceed with Question 3.

The evaluation criteria are a crucial characteristic of the pedagogic practice. When the evaluation criteria are explicit, this means that the teacher leaves it clear for the students the appropriate text to be produced at a given time, as a result of the learning process (Morais, 2002).

After reading this excerpt, do you think you should change the selection you made in Question 1?

Question 3: According to the present perspectives of science education, option 2 is the most accepted in terms of promoting a good scientific learning.

How can you justify this fact?

Question 4: Are you concerned in your lessons with promoting a teaching-learning process that makes clear the correct text that you wish that your students learn or produce?

If the teacher answers affirmatively: How do you make it? Can you exemplify?

If the teacher answers negatively: What would you do to explicate clearly in your lessons what you intend that your students learn or produce, for example, during a given task?

Analysis of teachers' SCO - Classroom observation

In order to characterize teachers' pedagogic practices, in terms of active realization at the implementation level, their lessons (sixteen) were observed, audio recorded and transcribed. The instrument used for this characterization contained, for each one of the characteristics under analysis, various indicators and, for each indicator, descriptors that correspond to the degrees of the scales constructed in terms of the nature of that characteristic.

Table III shows an excerpt of the instrument that is related to the characteristic *Complexity of Competences*, for the indicator "Exploration / discussion of the themes under study"⁸. This is followed by an excerpt of a classroom interaction which illustrates one of the scale degrees.

Table III – Excerpt of the instrument to characterize the complexity of scientific cognitive competences⁹

Degree 1 (Simple Competences ⁻)	Degree 2 (Simple Competences ⁺)	Degree 3 (Complex Competences ⁻)	Degree 4 (Complex Competences ⁺)
The teacher conducts the exploration/discussion of the themes under study by promoting the development of competences of a low level of abstraction and which involve processes that imply information acquisition and storing.	The teacher conducts the exploration/discussion of the themes under study by promoting the development of competences of a level higher than the SC ⁻ , as it is the case of understanding at the level of translation.	The teacher conducts the exploration/discussion of the themes under study by promoting the development of competences of a level higher than SC and that involve understanding at the level of interpretation and extrapolation and also competences of application at a lower level.	The teacher conducts the exploration/discussion of the themes under study by promoting the development of competences of a very high level of abstraction that involve application at a high level and competences of analysis, synthesis and evaluation.

Excerpt of classroom interaction

[Teacher and students were discussing the results of an experiment of enzymes action on digestion]

T- [...] which test tube showed a reaction in container C?

S- The test tube with proteins.

T- The test tube with proteins! It then means that pepsin and hydrochloric acid...Why hydrochloric acid? What's the stomach pH?

S- Acid.

T- Acid isn't it? So it means that here the pepsin breaks the...

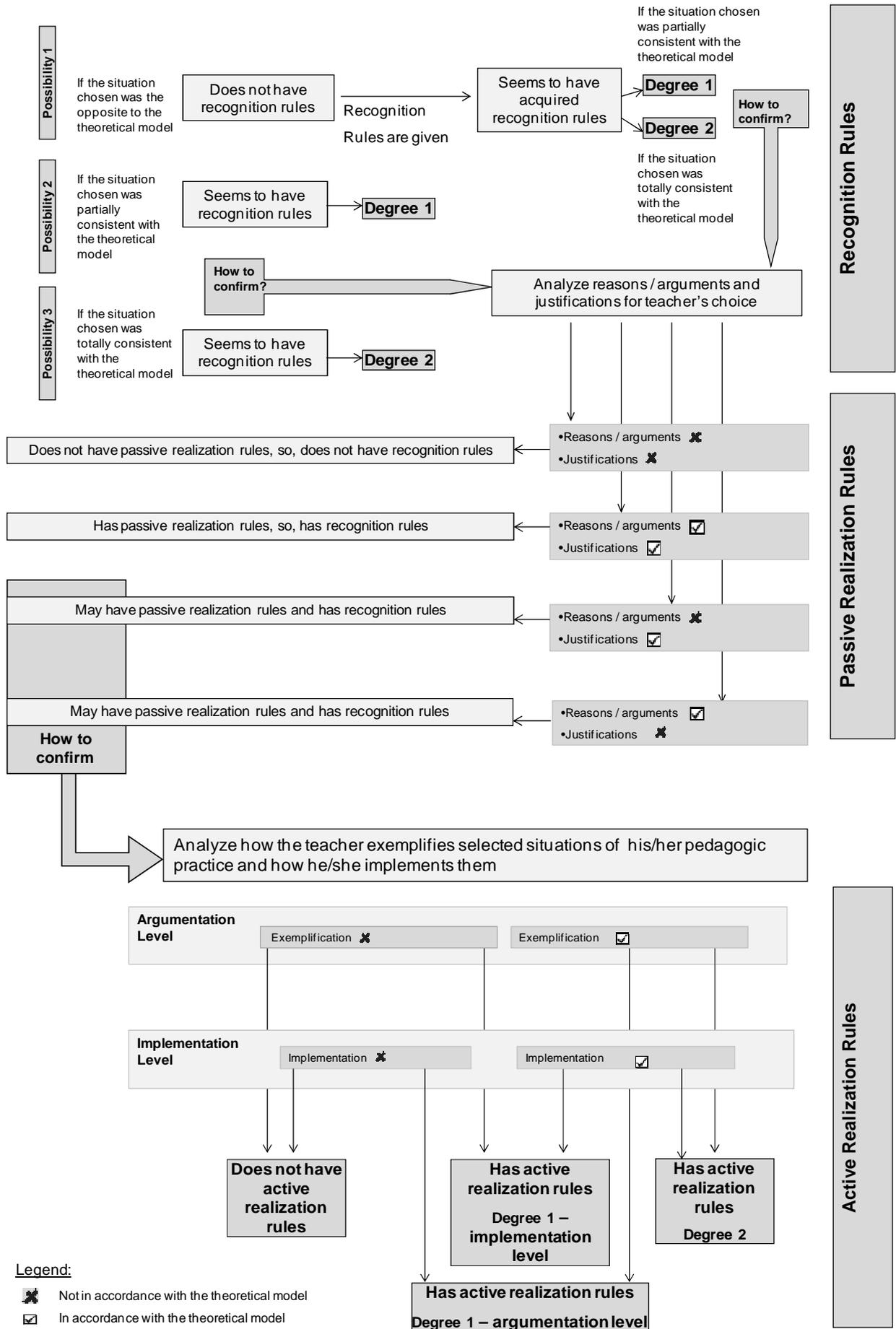
S- Proteins!

P- Proteins! Let's now look at container D [...]. – Degree 3

The students interpret the results by inferring simple relations between enzymes characteristics and their action in various situations.

The possession of active realization rules at the level of implementation was analysed by using a scale that measured the results obtained through the application of the instruments when characterizing the pedagogic practice. The value of 50% was defined as the reference. Exemplifying for the case of the evaluation criteria: evaluation criteria are considered explicit (a situation that is in accordance with the theoretical model) if the frequency of units of analysis classified with degrees F^{++} and F^+ is higher than 50%. This procedure allowed also the clarification of the ambiguous situations left in the interview. Finally, it is important to mention that the data obtained about both the argumentation and implementation levels clarified former ambiguous situations with respect to the possession of passive realization rules.

Figure 2 represents the model of analysis of teachers' SCO given by the data obtained through the interview (with regard to recognition rules, passive realization rules and active realization rules at the level of argumentation) and by the characterization of the pedagogic practice (with regard to active realization rules at the level of implementation). The complete application of this model of analysis is only made, effectively, when all the levels under study are analysed.



Figure– 2 Model of analysis of teachers' specific coding orientation

From the analysis of the data obtained by both the interview and classroom observation it became evident that the situations that follow could occur.

A – With regard to teacher's selection of the three given options:

Possibility 1. When the option selected is not in accordance with the theoretical model, the teacher shows not to have recognition rules. In this situation, the interview proceeded by giving the interviewee the recognition rules. At this step two situations could occur: if the option now selected was partially in accordance with the theoretical model, the teacher might have recognition rules in a low level (Degree 1); if it was totally in accordance with the model, the teacher might have recognition rules in a high level (Degree 2).

Possibility 2. When the option selected is partially in accordance with the theoretical model, the teacher might have recognition rules in a low level (Degree 1). This should be confirmed by analysing reasons/arguments and justifications, which support the selected option and explain why a given option is the most accepted by current perspectives of science education, respectively.

Possibility 3. When the option selected is totally in accordance with the theoretical model, the teacher might have recognition rules of a high level (Degree 2). This should be confirmed by analysing reasons/arguments and justifications, which support the selected option and explain why a given option is the most accepted by current perspectives of science education, respectively.

B – With regard to the reasons/arguments given by teachers to support the selected option and to the justifications to explain why a given option is the most accepted by current perspectives of science education:

Possibility 1. When reasons/arguments and justifications given are not in accordance with the theoretical model, the teacher does not have passive realization rules. These data allows also to clarifying doubts about recognition rules in the cases where their possession was not certain. When the teacher does not give explanations in accordance with the theoretical model, either at the level of reasons/arguments or at the level of justifications, it is possible to conclude that s/he does not have both passive realization and recognition rules.

Possibility 2. When reasons/arguments and justifications are in accordance with the theoretical model, the teacher has passive realizations rules. This allows also to conclude that the teacher has recognition rules.

Possibility 3. When reasons/arguments are not given but justifications are in accordance with the theoretical model or vice versa¹⁰, we can also clarify previous doubts about recognition rules and assume that the teacher possesses those rules. However, as only one part of the answer was correct, we can conclude that the teacher may or may not possess passive realization rules. This must be further clarified through the exemplification of pedagogic practice situations and, when doubts persist, by their implementation.

C – With regard to teacher's exemplification of situations of his/her pedagogic practice and how they are implemented:

C 1 – Argumentation level that presupposes understanding of the pedagogic practice:

Possibility 1A. When the teacher exemplification is not in accordance with the theoretical model, the teacher does not have active realization rules at the level of argumentation. This data allows also the clarification of doubts left about passive realization rules – the absence of active realization rules indicates that the teacher does not have passive realization rules.

Possibility 1B. When the teacher exemplification is in accordance with the theoretical model, the teacher has active realization rules at the level of argumentation. This data allows the clarification of

doubts left about passive realization rules – the possession of active realization rules implies that the teacher has passive realization rules.

C 2 – Implementation level:

Possibility 2A. When the teacher implements a pedagogic practice with characteristics distinct from those of the theoretical model, the teacher does not possess active realization rules at the level of implementation. When possibilities 1A and 2A coexist in the teacher's pedagogic practice, the teacher does not have active realization rules. When possibilities 1B and 2A coexist, the teacher has active realization rules only at the argumentation level (Degree 1).

Possibility 2B. When the teacher implements a pedagogic practice with characteristics of the theoretical model, the teacher possesses active realization rules at the level of implementation. When possibilities 1A and 2B coexist in the teacher's pedagogic practice, the teacher has active realization rules only at the implementation level (Degree 1). When possibilities 1B and 2B coexist in the teacher's pedagogic practice, the teacher has active realization at the argumentation and implementation levels (Degree 2).

The following are examples of answers given in the interview by one of the teachers and their interpretation in terms of recognition, passive realization and active realization at the argumentation level, when the characteristic 'evaluation criteria' is considered.

The teacher began by selecting the option totally in accordance with the theoretical model. She might have therefore recognition rules in Degree 2 (Possibility A.3). With regard to reasons/arguments, the teacher valued moments of synthesis as a way of making more explicit the legitimate text to be learned. She reinforced the importance of keeping a conceptual unifying line across the exploration of the various themes in order to lead the students to a more significant understanding of the scientific phenomena. All this led us to consider that reasons/arguments were in accordance with the theoretical model.

Excerpt: "[...] These moments of synthesis, at given points, allow me to get feedback, if they are really following, or not. If we let it to the end of the unity, some knowledge, some things that they didn't understand well may restrain the learning of the next step. For me this is always the ideal one," [referring to the chosen option]. (*Teacher Carla, Interview*)

With regard to justifications, the teacher did not explain clearly the importance, for an effective and significant learning, of syntheses and other strategies of clarification of the legitimate text. However, as in the reasons/arguments the teacher has answered in accordance with the theoretical model, we consider that justifications were partially in accordance with the theoretical model (Possibility B3). A clarification of this situation will be made at the time of the analysis of the active realization rules at the level of the argumentation.

Excerpt: “[...]and we started from the assumption that all of this has a conducting line, that all of this is a construction, so (...), for example, I can’t start a house from the roof if I don’t know if the rest is well sustained, isn’t it? I think that, at the level of the theory is the same thing... [...] Because if something has failed, how can we construct on something that isn’t safe?” (*Teacher Carla, Interview*)

With respect to how the teacher exemplifies what she would do to make syntheses and to clarify the text to be acquired, she showed some difficulties in verbalizing how she operationalizes such procedures, referring only to the construction of maps of concepts. However, she pointed out the importance of the intradisciplinarity, which is also a way to clarify the legitimate text to be learned. We consider that the teacher has active realization rules at the level of argumentation (Possibility 1B).

Excerpt: “[...] whenever I think it’s important to stop – they are always them who make it [she refers to the concept maps], of course with my help; with the construction of those concept maps, for example [...] in the case of the body systems, they link the organ to the physical and chemical processes that occur here and there, so, trying to make that connection in order to see if they can make it or not”. (*Teacher Carla, Interview*)

On the whole, the data collected through the interview for the characteristic ‘evaluation criteria’ led to the suggestion that the teacher *possesses recognition rules in degree 2, passive realization rules and active realization rules at the level of argumentation (degree 1)*. The analysis of the data related to the possession of active realization rules at the level of implementation showed that the frequency of units of analysis classified with degrees F^{++} and F^+ was lower than 50%, which suggested that the teacher *did not possess active realization rules at the level of implementation*.

Analysis of results

Curriculum analysis

The results of the analysis of the curriculum with regard to the pedagogic characteristics related to *the what* of the OPD – *metascientific knowledge (science construction) and scientific knowledge and competences* – are shown on the graph of figure 3. The results represent the frequency of units of analysis (UA) of the curriculum (*Essential Competences and Curriculum Guidelines*), classified according to each one of the degree scales (crescent levels of complexity) of the respective instruments of analysis. The reading of the graph should take into account that metascientific knowledge and scientific competences were evaluated in a 1-4 degree scale and scientific knowledge was evaluated in a 1-3 degree scale.

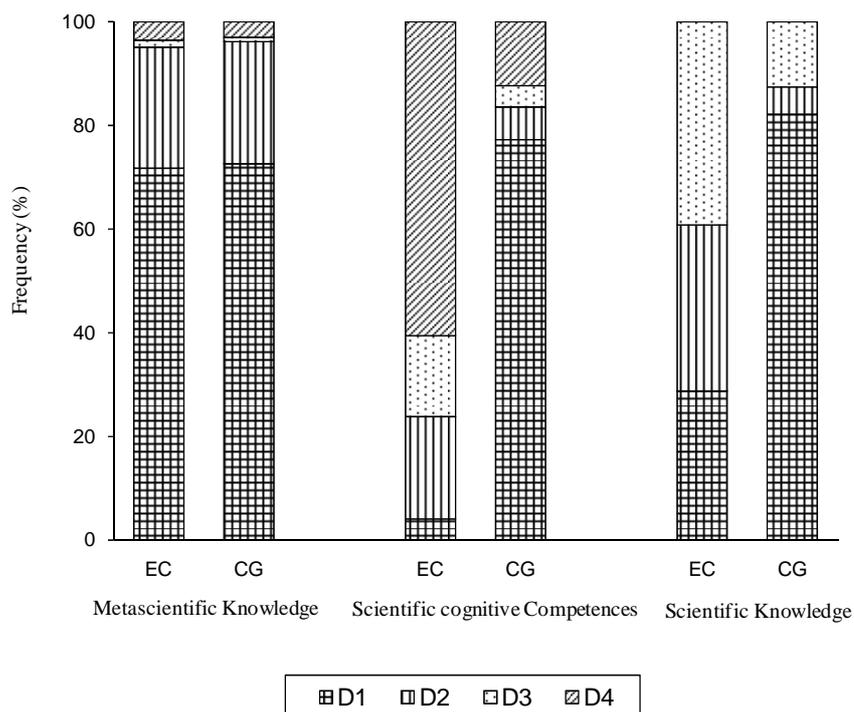


Figure 3 – The what of OPD: Complexity of metascientific knowledge, of scientific cognitive competences and of scientific knowledge.

The analysis of the OPD of the curriculum, when its two main documents (*Essential Competences* and *Curriculum Guidelines*) are considered, shows that the level of complexity of metascientific knowledge is low - 71.7% of the UA of *Essential Competences* and 72.5% of UA of *Curriculum Guidelines* were classified with the lowest level of the scale. The level of complexity of scientific knowledge and cognitive competences is on the whole relatively higher when compared with the metascientific dimension but follows a pattern that depends on the messages of each one of the two curricular documents. With regard to the complexity of scientific cognitive competences, whereas the *Essential Competences* contain 60.8% of UA of the highest level and only 3.9% of UA of the lowest level, the *Curriculum Guidelines* contain only 12.5% of UA of the highest level and 77.1% of UA of lowest level. With regard to the complexity of scientific knowledge, it is clear that the *Essential Competences* have higher levels of complexity (39% of UA were classified with degree 3) than the *Curriculum Guidelines* (only 12.8% of UA were classified with degree 3). This last document had most of its UA classified with degree 1, i.e., it was focused on low order concepts. This discrepancy supports former studies (Neves &

Morais, 2001a; Neves & Morais, 2006) which have highlighted the recontextualizing processes that may occur between documents produced within the official recontextualizing field¹¹.

Figure 4 shows the results of the analysis of the curriculum with regard to two pedagogic characteristics related to *the how* of the OPD - *intradisciplinary relations between scientific and metascientific knowledge* and *intradisciplinary relations between distinct kinds of scientific knowledge*. The results represent again the frequency of units of analysis (UA) of the curriculum (*Essential Competences* and *Curriculum Guidelines*), classified according to each one of the four degree scales (crescent levels of classification) of the respective instruments of analysis.

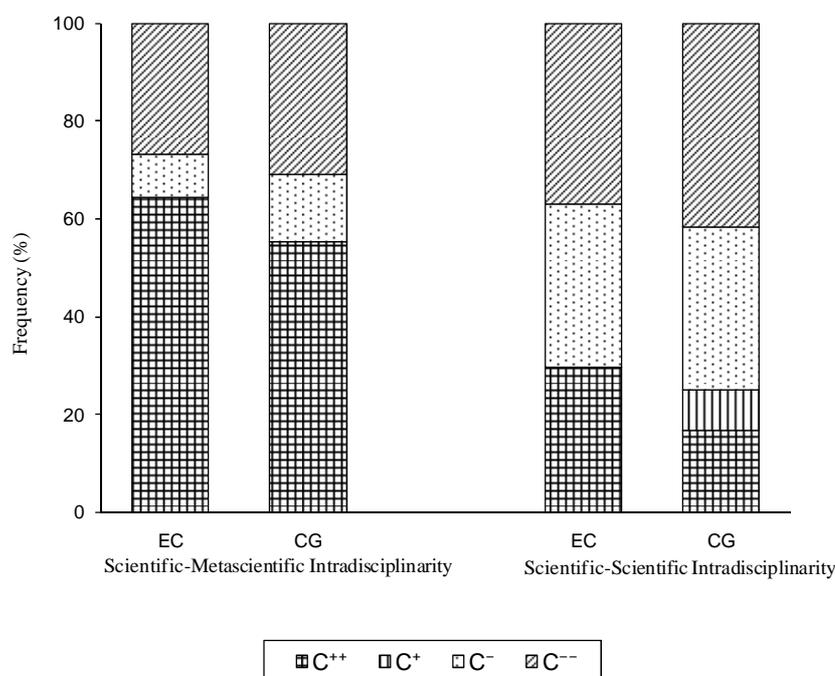


Figure 4 – *The how* of OPD: Intradisciplinary relations between scientific and metascientific knowledge (Scientific-Metascientific Intradisciplinary) and intradisciplinary relations between distinct kinds of scientific knowledge (Scientific-Scientific Intradisciplinary)

These results show that there are very weak intradisciplinary relations between scientific and metascientific knowledge in both documents (64.3% of UA of *Essential Competences* and 55.2% of UA of *Curriculum Guidelines* were classified with values of C⁺⁺). The intradisciplinary relations between distinct kinds of scientific knowledge are somehow more evident (only 29.6% of UA of *Essential Competences* and 16.7%

of UA of *Curriculum Guidelines* were classified with values of C⁺⁺) but yet unable to reach a high level.

For the other pedagogic characteristic related to *the how* of the OPD – *evaluation criteria* in the transmitter-acquirer relation (degree of explication of intradisciplinary relations and of scientific and metascientific knowledge and competences) –, the results showed that the curriculum is characterized by a very low degree of explicitness. That is, guidelines for the text to be transmitted/acquired are mostly unclear, particularly in the *Curriculum Guidelines*. All units of analysis were classified with F⁻ and F⁻⁻ in both curricular documents and for all dimensions of analysis of the evaluation criteria.

Analysis of teachers' pedagogic practices

Table IV gives a synthesis of the results (in terms of teachers' specific coding orientation) of the analysis of teachers' pedagogic practices.

Table IV – *Results of teachers' specific coding orientation*

Practice Characteristics / Teachers		Recognition Rules	Passive Realization Rules	Active Realization Rules			
				Argumentation	Implementation	Total characterization	
Metascientific Knowledge	Sofia	✗	✗	✗	✗	✗	
	Carla	✓ ₂	✓	✓	✗	✓ ₁	
Intradisciplinary Relations S-M	Sofia	✗	✗	✗	✗	✗	
	Carla	✓ ₂	✓	✓	✗	✓ ₁	
Conceptual Demand	Intradisciplinary Relations S-S	Sofia	✗	✗	✗	✗	✗
		Carla	✓ ₂	✗	✗	✗	✗
	Complexity of scientific cognitive competences	Sofia	✗	✗	✗	✗	✗
		Carla	✓ ₂	✓	✗	✗	✗
	Complexity of scientific knowledge	Sofia	✗	✗	✗	✗	✗
		Carla	✗	✗	✗	✗	✗
Evaluation Criteria	Sofia	✗	✗	✗	✗	✗	
	Carla	✓ ₂	✓	✓	✗	✓ ₁	
✓	Possesses	✓ ₁ Possesses Degree 1		✓ ₂ Possesses Degree 2			
✗	Does not possess						

The results suggest that Sofia *does not possess recognition rules, passive realization rules and active realization rules at both argumentation and implementation levels*, i.e. her specific coding orientation is very limited, for all the pedagogic characteristics under analysis. Sofia was unable to recognize the contexts specific of each characteristic of the study and to select the text appropriate to those contexts. She was also unable to give reasons / arguments / justifications that could support the legitimate text to the context. She could not tell what she would do to implement a pedagogic practice with the characteristics of the theoretical model of the study and was also unable to implement it.

The specific coding orientation of Carla varied according to the characteristics studied. For the characteristics 'science construction', 'intradisciplinary relations between scientific and metascientific knowledge' and 'evaluation criteria', Carla showed to possess *recognition rules* in a high degree (*Degree2*), to possess *passive realization rules* and *active realization rules* in a low degree (*Degree1*). This was a consequence of the importance accorded by this teacher to the introduction of science construction in the teaching-learning process and of the reasons and justifications she gave for such introduction (possessed recognition and passive realization rules). She was also able to exemplify what she would do to introduce science dimensions in her practice (possessed active realization rules at the level of argumentation), but was unable to implement the principles she said she valued (did not possess active realization rules at the level of implementation).

The situation similar to the one mentioned above, that occurred at the implementation level in the case of 'intradisciplinary between scientific and metascientific knowledge', is a consequence of the fact that the teacher never made a relation between these two types of knowledge in any of the units of analysis. However, this teacher was already able to relate scientific knowledge to the development of competences associated to the dimensions of science, something that although valuable is not enough for good scientific learning. With regard to the evaluation criteria, the teacher left implicit to students the aspects related to the characteristics selected for this study, whenever these characteristics were present in her teaching-learning process. The teacher used to make worksheets to guide the lesson and she often used to write down notes on the blackboard in order to emphasise the legitimate text she valued. However, the text

highlighted by the teacher was limited to scientific knowledge only, and a knowledge of a very low conceptual level. This situation was evident when the characteristic 'complexity of scientific knowledge' was analysed. Carla showed *not to have rules of recognition, passive realization and active realization at both levels of argumentation and implementation.*

With regard to the characteristic 'complexity of cognitive scientific competences', the results showed that, although Carla *possessed recognition rules* at a high level and *passive realization rules*, she *did not possess active realization rules*. Although she valued and justified the importance of a high level of conceptual demand of the scientific competences, she was unable to exemplify what she would do to put this into practice during her lessons and she did not do it either. With regard to the characteristic 'intradisciplinarity between distinct kinds of scientific knowledge', although Carla *possessed recognition rules* at a high level she *did not possess passive and active realization rules*.

It should be noted that the analysis of teachers' SCO evidenced differences between them at the level of the several characteristics under study. However, something is common to both teachers – the lack of active realization rules at the level of implementation for all characteristics. This means that teachers mostly fail where they directly influence students' learning.

Conclusions

Considered on the whole, the study suggests that recontextualizing processes occurred at two levels, within the official recontextualizing field when passing from the general to the specific principles of the curriculum and between the official recontextualizing field and the pedagogic reproduction field when passing from the curriculum to the teachers' practice.

The analysis of the general principles of the curriculum (*Essential Competences*) shows in general a very low level of conceptualization of metascientific knowledge and competences (science construction), a high level of conceptualization of scientific competences, a medium level of conceptualization of scientific knowledge, weak intradisciplinary relations between scientific and metascientific knowledge, strong

intradisciplinary relations between distinct kinds of scientific knowledge and implicit evaluation criteria of the text to be transmitted-acquired. With the exception of the level of conceptualization of scientific competences and the intradisciplinary relations between distinct kinds of scientific knowledge, the general section of the curriculum contains characteristics that, according to former research (e.g. Morais, Neves & Pires, 2004; Morais & Neves, 2011), do not promote the development of an effective scientific learning. The recontextualization that occurred between the general and the specific principles of the curriculum, in terms of scientific learning, goes in the direction of the reinforcement of less positive characteristics (more implicit evaluation criteria) and the decreasing of the emphasis given to more positive characteristics (lower level of conceptualization of scientific knowledge and competences). These recontextualizing processes are deeper and extended to other characteristics when the whole 9th year curriculum is considered (Calado & Neves, 2011).

Teachers' pedagogic practices showed differences depending on the pedagogic characteristics under study and their analysis points to a recontextualization of the curriculum that followed a trend similar to the process observed between the two curricular documents. For example, when we consider the characteristic 'complexity of scientific knowledge' the data shows that, despite the relatively high level of conceptualization of the *Essential Competences*, both teachers valued and implemented a teaching-learning process of a low level of conceptualization. They did not possess recognition and passive and active realization rules for this micro context of scientific learning. With regard to the characteristic 'complexity of scientific competences', whose level of conceptualization was also high in the curriculum document *Essential Competences*, Carla recognized and understood its importance for science learning (she possessed recognition and passive realization rules) but neither of them implemented it in the classroom - they did not possess active realization rules.

With regard to the other characteristics of the study, both teachers showed to be unable to recontextualize the principles of the curriculum, i.e. to improve the curriculum, in the direction of implementing practices that could minimize the less positive aspects it contained. For example, with respect to the characteristics 'science construction', 'intradisciplinary between scientific and metascientific knowledge', 'intradisciplinary between distinct kinds of scientific knowledge' and 'evaluation

criteria', both teachers implemented a practice in the classroom where metascientific knowledge and its relation with scientific knowledge were absent, where the level of intradisciplinary relations between distinct kinds of scientific knowledge was very low and where the evaluation criteria of the text to be learned by students were implicit. In spite of this, Carla showed to be able to recognize and understand the importance, for students' learning, of the teaching of metascientific knowledge and of its relation to scientific knowledge. She also recognized and understood the importance of the explication of evaluation criteria of the text to be learned by students. She possessed recognition and passive realization rules. She was also able to recognize the importance of strong intradisciplinarity between distinct kinds of scientific knowledge. In theoretical terms, Carla possessed recognition rules.

The direction of these recontextualization processes raises serious concerns with respect to the way teachers may interpret and implement *Curriculum Guidelines*, particularly when the curriculum to be implemented is developed in a context of curriculum flexibility. Since in this context a greater space of intervention at the level of curriculum implementation is given to teachers, it would be important that the teachers would use this space to improve aspects poorly achieved in the curriculum message instead, as was seen in this study, of reproducing aspects of the curriculum which depart from research done in the area of science education. In order to use the great control that is given to teachers, in an effective way, "professional educators should provide leadership, offer suggestions about curriculum and pedagogy, and prepare instructional materials that can be used to address the various goals of science teaching [...] and teachers should act according to the highest standards of their profession" (DeBoer, 2000, p.598). As Roberts (2007) points out, teachers who intend to promote the development of scientific literacy, "have to learn and come to accept new types of discourse – not only to understand the discourse and grasp its significance, but also to comprehend and experience how to teach it" (p.774). This new need of teaching for scientific literacy presents "serious challenges in understanding, planning, and actually conducting activities" (Roberts, 2007, p.774). The present study may give a contribution in these directions.

Following the conceptual framework that guided the analysis of teachers' practices, it is possible to say that one of the factors that was responsible for the direction taken by the curriculum recontextualizing is the absence of recognition and/or passive

realization and/or active realization for the characteristics under study. It can be hypothesised that this absence might have been a consequence of a poor teacher education these teachers received and or their lack of socio-affective dispositions, i.e., their interest and motivation for implementing the characteristics under study. Teachers' personal, social and professional dimensions might have had a depressive influence on their professional performance. Former studies (e.g. Pires, 2001; Rosa, 2002) have shown that characteristics like engagement, dynamism, self confidence and socio-affective dispositions are determinant for the implementation of a given pedagogic practice.

The conclusions of this study are particularly relevant in the context of curricular flexibility that now exists in Portugal. If one considers that the curricular flexibility, that is on the basis of the present curricular reorganization, intends to "ensure that all students learn more and in a more significant way" (DEB, 1999, p.6), the results of this study leave some doubts about the consecution of this purpose. The greater power that is being given to teachers, the higher the risk that only some students will succeed because not all will have access to an education that promotes a high level of scientific literacy. The implementation of an efficient teacher education and the promotion of a significant professional development are urgent in order that, in contexts of greater pedagogic autonomy, teachers can recontextualize the curriculum in a direction that promotes scientific literacy for all students.

In methodological terms the study takes a step further by increasing the rigour and broadness of external languages of description previously developed for the analysis of teachers' pedagogic practices and of curricular materials (e.g. Castro, 2006; Morais, Neves & Afonso, 2005; Neves & Morais, 2001b). The rigorous theoretical and methodological model constructed in the present study deepened prior models used within the same line of research by introducing more detail in the study of teachers' recognition and realization rules to specific characteristics of pedagogic practice. As to other lines of research, the model explicates how to introduce detail in the study of teachers' pedagogic practices in terms of both their conceptions and their practice. This detail gives the possibility to highlight sociological messages that would not be uncovered otherwise and to deepen the understanding of teachers' practices so as to influence processes of teacher education.

The conclusions of this study should not go in the direction of generalising from recontextualization processes made by two teachers only, but instead, should raise questions related to teacher education and to the use teachers make of their space of change in the promotion of a better education. The study has limitations that are not only related to the small sample of teachers but also to the characteristics selected of both curriculum and pedagogic practices, that should be amplified in further studies.

Acknowledgements

The authors acknowledge to Isabel P. Neves for her suggestions to the study. They also acknowledge to the Foundation for Science and Technology (FACC program) for financing the study.

NOTES

1. In sociological terms, text is used to indicate monological or dialogical texts in the instructional or regulative contexts.
2. This study used Ziman's conceptualization (1984) about science construction, according to which science is seen as a social institution with various dimensions: philosophical (science methods), historical (science evolution), psychological (scientists' characteristics), internal sociological (relations inside scientific community) and external sociological (relations between science and society). This allowed a detailed analysis of science construction that is of metascientific knowledge, present in the curricular documents, by studying the various dimensions separately.
3. See instruments in Alves (2007). Also available in http://essa.fc.ul.pt/materiais_instrumentos_texto.htm#2
4. See interview in Alves (2007).
Also available in:
http://essa.fc.ul.pt/ficheiros/instrumentos/4_formacao_de_professores/4.1.questionarios_entrevistas/4.1.10.pdf
5. Instruments for the characterization of pedagogic practices can be seen in http://materiais_instrumentos_texto.htm#2
The instruments of this study can also be seen in Alves (2007).
6. In order to extend the external language of description and to better understand the various dimensions of the specific coding orientation, we established the argumentation and the implementation level of the active realization rules.
7. The conceptualization of this instrument was based on Cantu e Herron, among others (Cantu & Herron, 1978).
8. Other indicators of the instrument used in this study are: tasks' demand; students' questions/doubts; students' work presentation/conclusion of activities. The indicators selected refer to frequent and relevant situations in the classroom.
9. The conceptualization of this instrument was based on the ideas of Bloom (Bloom, Engelhart, Furst, Hill, & Krathwohl, 1972).
10. It had been anticipated that would be easier for the teacher to give the justification according to the theoretical model, because s/he already knew that was the correct situation. However, data showed cases where reasons/arguments were in accordance with the theoretical model and justifications were not.
11. Detailed results of these recontextualizing processes are shown in Alves (2007). The studies carried out by Calado and Neves (2011) and Ferreira and Morais (2010), within the same project of analysis of the Natural Sciences Curriculum for middle school, evidenced similar trends.

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A social analysis of science curriculum and pedagogic practices

Abstract

The study analyses the extent to which the sociological message transmitted by the teachers' pedagogic practice recontextualizes the Official Pedagogic Discourse of the Natural Sciences curriculum for Portuguese middle school. Theoretically, the study is based on theories of psychology (e.g. Vygotsky), epistemology (e.g. Ziman) and sociology, with a particular emphasis on Bernstein's theory of pedagogic discourse. A mixed methodology is used in the study.

The results suggest the existence of processes of transformation of the message within the Ministry of Education, when passing from the general principles to the specific principles of the curriculum. Transformation is in the direction of decreasing the quality of science education. The results of the curriculum analysis are discussed with regard to specific characteristics studied: metascientific knowledge, scientific knowledge and competences, intradisciplinary relations and evaluation criteria. The results also showed a decreasing of the quality of the teaching-learning process when recontextualizing curriculum into pedagogic practices. This is shown by the absence by teachers of recognition and passive and active realization rules in most of the characteristics under study. These processes of transformation of the message are discussed, as well as its consequences in terms of scientific literacy.

Keywords: Science education; Curriculum; Pedagogic Practice; Recontextualization