Chapter 26
The Nature of Science in Secondary School Geology: Studying Recontextualizing Processes

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26.1 Introduction

The introduction of the nature of science (NOS) into science education has been defended by many authors.[1] There is today a broad definition of NOS that contains aspects such as the characteristics of scientific research, the process of construction of scientific theories, the social and intellectual circumstances where scientific knowledge has been developed, the way in which scientists work as a social group and the way in which science influences and is influenced by the social context (Hodson 2014). Mostly in its dimensions of history of science, philosophy of science, and sociology of science, NOS has been part of scientific literacy and consequently an important objective of the teaching–learning processes of the science curricula of many countries (Millar and Osborne 1998; Osborne and Dillon 2008; Hodson 2014). The Program for International Student Assessment (PISA) 2015 has also followed this direction by giving further weight to a component associated with NOS. When defining scientific literacy, "the notion of 'knowledge about science' has been specified more clearly and split into two components – procedural knowledge and epistemic knowledge" (OCDE 2016, p. 22).

John M. Ziman's conceptualization of NOS (1984, 2000) is, in epistemological terms, an important theoretical support of the study described in this chapter. Ziman

[1] E.g., Lederman (2007), Clough and Olson (2008), Matthews (2009), McComas (2014), and Taber (2017).

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characterized science as a complex system, which should be analyzed in terms of four metascientific dimensions: philosophical, psychological, historical, and sociological. This multidimensional theorization of science has allowed an interrelated analysis of the various metascientific disciplines.

The philosophical dimension of science refers to the methods used by scientists to make science, as is the case of observation, formulation of hypotheses, experimentation, and theorization. Science is characterized as a dynamic process of knowledge construction, which has diverse methodologies. The psychological dimension respects the psychological characteristics of scientists that influence their work such as curiosity and perseverance, but others to, not so noble but also proper to the human condition, such as intellectual dishonesty. The historical dimension of science respects the accumulation of scientific knowledge, organized in coherent theoretical schemes and divulged in publications (science archive). The sociological dimension refers to the relations among the members of the scientific community (internal sociology) and to the inter-relations between science and the society at large (external sociology). The science/technology/society (STS) relationship is, according to this conceptualization, part of the external dimension of sociology.

Basil Bernstein's model of pedagogical discourse (1990, 2000) is, in sociological terms, the main theoretical framework of this study. Through this model, Bernstein seeks to understand how the pedagogical discourse, determined by a complex set of relationships, which presuppose the intervention of various fields and contexts, is produced and reproduced.

Even though the pedagogical discourse reflects the dominant principles of society, which constitute the general regulative discourse (GRD), that discourse is not the immediate result of those principles, as recontextualizing processes may occur at the various levels of the pedagogical device. As a result of the official recontextualizing of the GRD, the official pedagogic discourse (OPD) is produced, which is part for example of curricula and syllabuses. The OPD may also be the object of a second recontextualizing process in the pedagogical recontextualizing field (e.g., departments of education, teachers' education schools, and institutions for the production of pedagogical materials). This process leads to the construction of the pedagogical discourse of reproduction (PDR), which is present for example in textbooks. The official and pedagogical recontextualizing fields are influenced by the fields of economy and symbolic control and on the whole, they define the *what* and the *how* of pedagogical discourse. The *what* refers to the knowledge and skills to be the object of the teaching–learning process and the *how* refers to the way in which the knowledge and skills are transmitted in the teaching–learning context.

The present study is part of broader research (Castro 2017) that took place in Portugal and that focused on the analysis of NOS in the curriculum and textbooks of biology and geology[2] of the tenth grade (age 15–16), i.e., of the first year of secondary school. The study follows former research developed by the ESSA

[2] Biology and Geology, although epistemologically distinct, have traditionally been part of the same discipline in Portugal (often but not always called Natural Sciences).

Group[3] (e.g., Calado and Neves 2012; Ferreira and Morais 2013). This chapter is centered on the geology section of those texts and addresses the following general research problem: What is the extent to which the message contained in the official pedagogical discourse of the syllabus of secondary school geology with regard to NOS is recontextualized in the pedagogical discourse of textbooks? From this problem, the following research questions were derived:

1. What is the message about NOS that is transmitted by the geology syllabus?
2. What is the message about NOS that is transmitted by the geology textbooks?
3. What are the recontextualizing processes that may have occurred between the pedagogical discourse of the syllabus and the pedagogical discourse of textbooks with regard to NOS?

The analysis of the message about NOS that is transmitted by the geology syllabus and textbooks, and of the recontextualizing processes that might have occurred between the message of the syllabus and the message of the textbooks, provides the basis for a reflection on the consequences of those processes for the teaching–learning of NOS in science education.

26.2 Methodology

The biology and geology syllabus for the tenth grade (DES 2001) is divided into two main sections that correspond to the scientific areas of biology and geology. Each one of these sections contains two parts: the "syllabus presentation," with the general guidelines and the "development of the syllabus," with specific guidelines to operationalize the general principles. The analysis of the syllabus was centered on both parts for the area of geology, so that a comparison between them could be made.

The analysis of textbooks was centered on the area of geology of the two textbooks for tenth grade biology and geology (textbooks A and B), which had been more widely selected across the whole country by the teachers/schools, in the academic year 2013/2014. That analysis included both the part that was directed to the students (corpus of the textbook) and the teachers' support materials. This chapter gives global results of these two parts of each one of the textbooks.

The NOS was therefore analyzed in the area of geology of the discipline of biology and geology of the tenth grade, both at the level of the official pedagogical discourse present in the syllabus and at the level of the pedagogical discourse of reproduction transmitted in textbooks. Figure 26.1 shows the various dimensions of analysis that were considered in the study described in the chapter. The analysis was focused on dimensions related to the *what* and the *how* of pedagogical discourse, where the *what* refers to the metascientific knowledge to be transmitted-acquired

[3] The ESSA Group – Sociological Studies of the Classroom – is a research group of the Institute of Education, University of Lisbon. http://essa.ie.ulisboa.pt

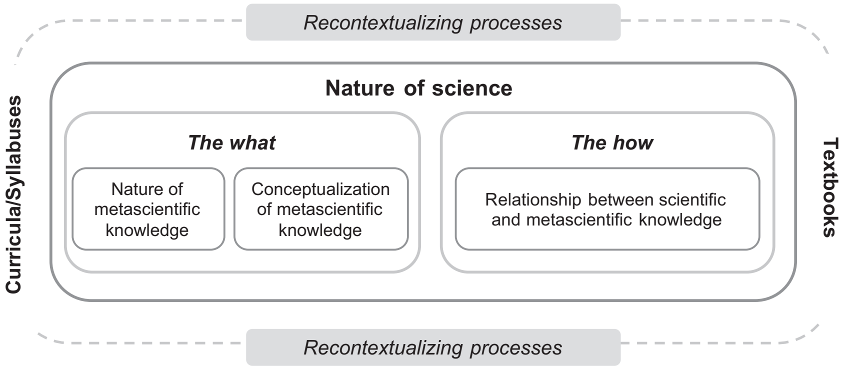

Fig. 26.1 Dimensions of analysis of the nature of science in curricula/syllabuses and textbooks. (Adapted from Castro 2017)

and the *how* refers to the way in which the transmission–acquisition of that knowledge should take place. The analysis of metascientific knowledge took into account the nature of that knowledge, which is the dimension of science construction to which it refers, and also its conceptualization level. The analysis of the *how* took into account the degree of relation between scientific knowledge and metascientific knowledge when representing a relationship between knowledge within a same discipline (intradisciplinary relationship).

To characterize the message contained in the syllabus and in the textbooks these texts were divided into units of analysis.[4] A unit of analysis was considered as an excerpt of the text with one or more sentences which together have a given semantic meaning (Gall et al. 2007). Segmentation of text into units of analysis differed according to the nature of that text – syllabuses and textbooks. In the case of textbooks broader units of analysis were considered. On the basis of the trend shown by the analysis of all units of analysis of each syllabus section and of each one of the textbooks, it was possible to infer their respective messages about the NOS in the various dimensions under study (Fig. 26.1). The study follows an approach that combines quantitative and qualitative methods of analysis (Morais and Neves 2010).

Several instruments were constructed to analyze each one of the units of analysis. One of such instruments was developed to be a referential of analysis to identify the dimensions of science construction and the level of complexity of the metascientific knowledge related to each one of those dimensions. That knowledge was separated by its level of complexity into two groups, simple knowledge and complex knowledge, according to the distinction between facts, simple concepts, complex concepts and unifying themes/theories made by several authors (Anderson

[4] The general guidelines of the syllabus were divided into 44 units of analysis and the specific guidelines into 272. In textbook A 531 units were analyzed, 276 of which were part of the corpus of the textbook. In textbook B 426 units were analyzed, 360 of which were part of the corpus of the manual.

Table 26.1 Excerpt from the referential instrument for the nature of metascientific knowledge – philosophical dimension and external sociological dimension of science

Simple knowledge	Complex knowledge
(Facts and simple concepts)	(Complex concepts and unifying themes /theories)
Philosophical dimension	
Science as a dynamic process of knowledge construction that contains various methodologies	
The construction of scientific knowledge uses methods and principles based on gathering, organization, and interpretation of data obtained by various methods	The construction of scientific knowledge makes use of models that are representations of the world through which it is sought to simplify reality, so that such reality can be analyzed
To answer the same problem distinct hypotheses may co-exist and through tests and/or analysis of data obtained from reality may be supported or refuted	All scientific knowledge is fallible, meaning that is only valid until it is not refuted by experience, and as a consequence scientific knowledge is not absolute
In science, new data lead to the reformulation of concepts and theories	The scientific knowledge produced is part of broader theoretical frameworks or unifying themes
External sociological dimension	
Inter-relation between science, technology and society	
Scientific research and also knowledge production and scientific predictions influence society and/or the environment/human species – Sc-S relationship	The inter-relation that develops between science, technology and society originates a STS cycle – Sc-T-S relationship
The development of scientific knowledge permits the development of new technologies – Sc-T relationship	Socio-scientific controversies are generated by social impacts of scientific and technological innovations which divide both science community and society in general and which involve scientists, political decision-makers and groups of citizens
The development of technology leads to further science research and consequently to the development of science –T-Sc relationship	

Source: Adapted from Castro (2017) and Ferreira and Morais (2013)

et al. 2001; Brandwein et al. 1980; Cantu and Herron 1978). Table 26.1 shows an excerpt of this instrument for the philosophical and external sociological dimensions.

The conceptualization of metascientific knowledge was analyzed by an instrument constructed with four degrees of complexity, related to the four dimensions of science construction. The descriptors of that scale, considered in an increasing order of complexity, are focused on factual knowledge (degree 1), simple concepts (degree 2), complex concepts[5] (degree 3), and unifying themes and theories (degree 4). The

[5] The simple concepts correspond to concrete concepts proposed by Cantu and Herron (1978) and are those that have a low level of abstraction, defining attributes and examples that are observable. The complex concepts correspond to abstract concepts and "are those that do not have perceptible instances or have relevant or defining attributes that are not perceptible" Cantu and Herron (1978, p. 135).

Table 26.2 Excerpt of the instrument for characterizing the conceptualization level of metascientific knowledge with regard to the philosophical dimension and examples of units of analysis

Degree 1	Degree 2	Degree 3	Degree 4
Factual metascientific knowledge of the philosophical dimension of science is referred to, corresponding to concrete, observable or perceptible information	Simple metascientific knowledge of the philosophical dimension of science is referred to, corresponding to concepts with a low level of abstraction and perceptible characteristics	Complex metascientific knowledge of the philosophical dimension of science is referred to, corresponding to concepts with a high level of abstraction and nonperceptible characteristics	Complex metascientific knowledge of the philosophical dimension of science is referred to, corresponding to structuring ideas and theories
Degree	*Units of analysis:*		
Degree 2	[1] The geologists work directly in all places they may have access, in the whole world: from the icy peaks of high mountains and the active volcanoes to the deep oceans. Moreover, the geologists have to rely on their indirect observations, by using sensible measurement instruments and creating models. (*Syllabus, Geology section, 10th grade*)		
Degree 4	[2] The explanations given are part of a catastrophic line of thought. For some scientists, the dinosaurs' extinction would have been caused by the impact of a meteorite, whose crater would have formed near the Gulf of Mexico. […] However, some other scientists, namely the paleontologists, state that there is no need to use these catastrophic explanations to explain dinosaurs' extinction. (*Textbook, Geology section, 10th grade*)		

Source: Adapted from Castro (2017)

descriptors are similar for all dimensions of science construction. Table 26.2 shows an excerpt of the instrument for the philosophical dimension of science and examples of units of analysis classified by making use of this instrument.

Excerpt [1] presents simple metascientific knowledge (see Table 26.1), at the level of simple concepts (degree 2) associated with the philosophical dimension, namely the following: the construction of scientific knowledge is made with the help of practical or field work, which implies the use of measurement instruments and/or equipment and/or specific technics. Excerpt [2] is focused on complex knowledge associated with the philosophical dimension with the highest degree of complexity (degree 4): the scientific knowledge produced is inserted in broader theoretical frameworks or in unifying themes (see Table 26.1). Knowledge associated with the internal sociological dimension, but with a lower degree of complexity is also present in this excerpt: there are sometimes different theories to answer the same problem inside the scientific community (Castro 2017).

The analysis of the relationship between scientific and metascientific knowledge was made through an instrument with a four-degree scale constructed on the basis of Bernstein's concept of classification (1990, 2000). In this particular case, classification refers to the existence of fairly strong boundaries between scientific and metascientific knowledge. The extreme value of the strongest classification (degree

Table 26.3 Excerpt of the instrument for characterizing the relationship between scientific and metascientific knowledge and examples of units of analysis

Degree 1	Degree 2	Degree 3	Degree 4
C^{++}	C^{+}	C^{-}	C^{--}
There is a focus on scientific knowledge only	There is a focus on metascientific knowledge, but the relationship between that knowledge and the scientific knowledge is not made	There is a relationship between metascientific and scientific knowledge where scientific knowledge is given more status in that relationship	There is a relationship between metascientific and scientific knowledge where both types of knowledge have the same status in that relationship
Degree	*Units of analysis:*		
C^{++}	[3] The remains of the dinosaurs' presence on Earth's surface can be found in sedimentary rocks. These rocks are characterized by their frequent presence in layers. It should be referred to that there are other rocks such as magmatic and metamorphic rocks, which together with the sedimentary rocks are part of the rocks cycle. (*Syllabus, Geology section, 10th grade*)		
C^{--}	[4] […] we know that the temperature increases with the increasing of depth, that the temperature inside the Earth is high and we believe that we also know the internal structure and composition of our planet. This knowledge is a result of the interpretation of data obtained by geophysical methods: electrical (conductivity), magnetic (magnetism), radioactive (radioactivity), gravimetric (isostasy and gravity anomalies), seismic (behavior of seismic waves) and geothermic (volcanism, Earth's internal heat). These are the indirect methods that the geologists and the geophysicists use to study the Earth's crust, mantle, and core. (*Syllabus, Geology section, 10th grade*)		

Source: Adapted from Castro (2017)

1/C^{++}) corresponds to a situation where there is no relationship between these two types of knowledge to a point that there is not even reference to metascientific knowledge. The extreme value of the weakest classification (degree 4/C^{--}) corresponds to a situation where there is a strong relationship between these two types of knowledge, which are given equal status. Table 26.3 shows an excerpt from the instrument and examples of units of analysis classified with this instrument.

Excerpt [3] is only focused on scientific knowledge, related to sedimentary rocks, and for that reason it was classified with degree 1 (very strong classification – C^{++}). Excerpt [4] calls for a relationship between scientific and metascientific knowledge, at the level of the philosophical dimension, respectively related to Earth's internal structure and indirect methods used by geologists. Both types of knowledge have the same status in the relationship and for that reason this excerpt was classified with degree 4 (very weak classification – C^{--}).

The following illustrative example shows how the same unit of analysis was classified in terms of all metascientific dimensions:

> [5] "The idea that Man's history on Earth had been preceded by another one history, previous to man's existence, began to become evident by the end of the XVIII century. The stratified sedimentary rocks contained often a thickness and richness of fossils which suggest an extremely slow deposition, which on its turn implied the acceptance of long chronologies. However not all defenders of a long scale of time accepted the sole acting of slow and gradual causes. For many that immense period of time might have been interrupted by

violent catastrophes. […] Recalling the main ideas defended by Cuvier may raise some questions with educational interest: how is it possible that the same objects and phenomena can be interpreted by two distinct models? […] There is nowadays a renovated interest for the catastrophist conceptions under the designation of neocatastrophism: what is the reason for that reappearance?" (*Syllabus, Geology section, 10th grade*)

On the basis of the referential instrument for metascientific knowledge (of which Table 26.1 is an example), this unit of analysis contains, with regard to the *what* of the OPD, knowledge of the philosophical and historical dimensions. For each one of these dimensions, excerpt [5] calls for simple metascientific concepts and for this reason both dimensions were classified with degree 2. With regard to the *how* of the OPD, excerpt [5] calls for a relationship between scientific and metascientific knowledge where both have the same status and for this reason that relationship was classified with degree C^{--}.

26.3 Results

The graph of Fig. 26.2 shows the results of the analysis of the metascientific knowledge in the geology syllabus section and also of textbooks with regard to the dimensions of science construction: philosophical (PhD), historical (HD), psychological (PD) and sociological, internal (SID) and external (SED).

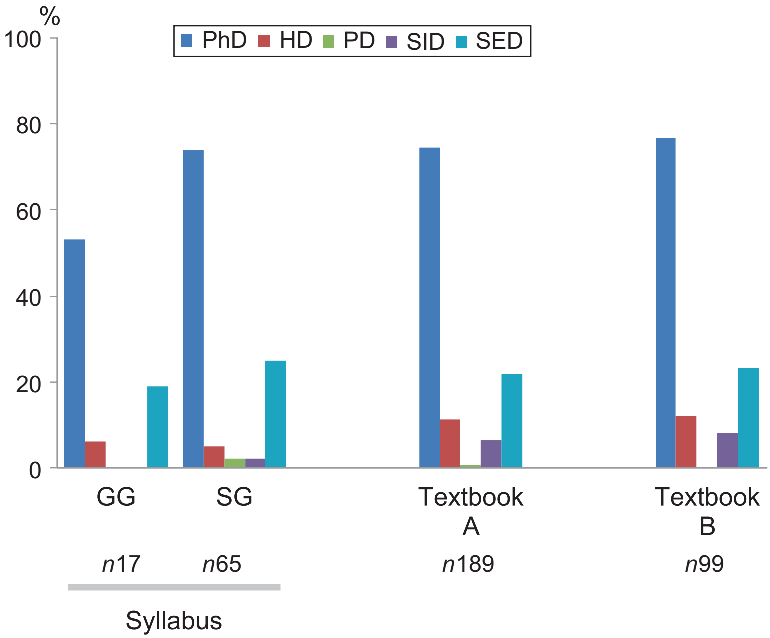

Fig. 26.2 Nature of metascientific knowledge in the geology section of the general (GG) and specific (SG) guidelines of the syllabus and of textbooks. *n* total number of units of analysis studied. (Adapted from Castro 2017)

These results show the prevalence of the philosophical dimension in both the syllabus and the two textbooks. Science methodologies are the most relevant aspects of science construction in the texts analyzed. They are followed by the science, technology and society relationships, i.e., the external sociological dimension, which comes out as the second most present dimension of science construction. The historical dimension of science comes out as the third most represented dimension. In general, the relationships inside the scientific community (internal sociological dimension) and mostly the scientists' psychological characteristics (psychological dimension) are the less valued dimensions.

The results also show that recontextualizing processes occurred within the syllabus and between the syllabus and the textbooks. When passing from general to specific guidelines of the syllabus, there is a valuing of the philosophical dimension and the presence, although small, of the psychological and internal sociological dimensions. When passing from the syllabus' specific guidelines to the textbooks, the emphasis given to the philosophical and to the external sociological dimensions is similar, but there is a valuing of the historical and internal sociological dimensions of science.

The results on the degree of conceptualization of metascientific knowledge in the syllabus and textbooks are shown in Fig. 26.3, when metascientific knowledge is considered as a whole, independently of the dimension of science construction to which those results refer.[6] The results show that in all texts analyzed most metascientific knowledge corresponds to simple concepts (degree 2). In the syllabus and in textbook B there is no reference to metascientific knowledge with a factual character (degree 1) nor to complex metascientific knowledge relative to structuring ideas and theories (degree 4).

These data show some discontinuities between the messages of the various texts, when the level of conceptualization of metascientific knowledge is considered. In the syllabus, when passing from the directions given on general guidelines to their concretization at the level of the specific guidelines, decreases the level of conceptualization of knowledge with a lower percentage of complex metascientific knowledge (degree 3). On the other hand, when the message contained in the specific guidelines of the syllabus is compared with the textbooks' message, the level of conceptualization tends in general to be lower in textbooks, particularly in textbook B.

The graph of Fig. 26.4 shows the results of the analysis of the relationship between scientific and metascientific knowledge. The results of this analysis refer only to the cases where metascientific knowledge is present and for that reason classification C^{++} is not considered (this value refers only to scientific knowledge).

In the case of the syllabus, the relationship between scientific and metascientific knowledge (weaker classifications, C^{-} and C^{--}) is mostly present in the specific

[6] When a same unit of analysis contained references to several dimensions of science construction, each one of them was considered as a separate reference. When a same unit of analysis contained several references to the same dimension of science construction with different degrees of complexity, the reference with the highest degree was considered.

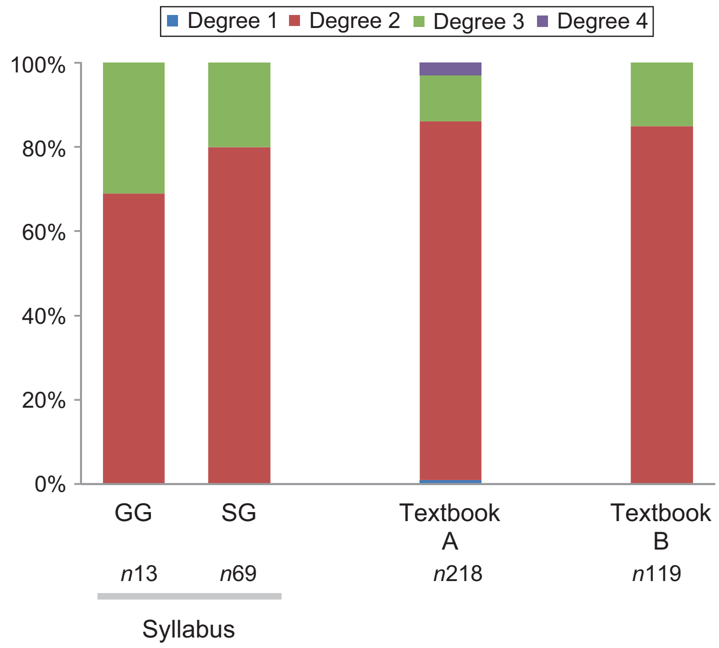

Fig. 26.3 Conceptualization of metascientific knowledge in the geology section, in general (GG) and specific (SG) guidelines of the syllabus and also in textbooks. *n* total number of references to metascientific knowledge. (Adapted from Castro 2017)

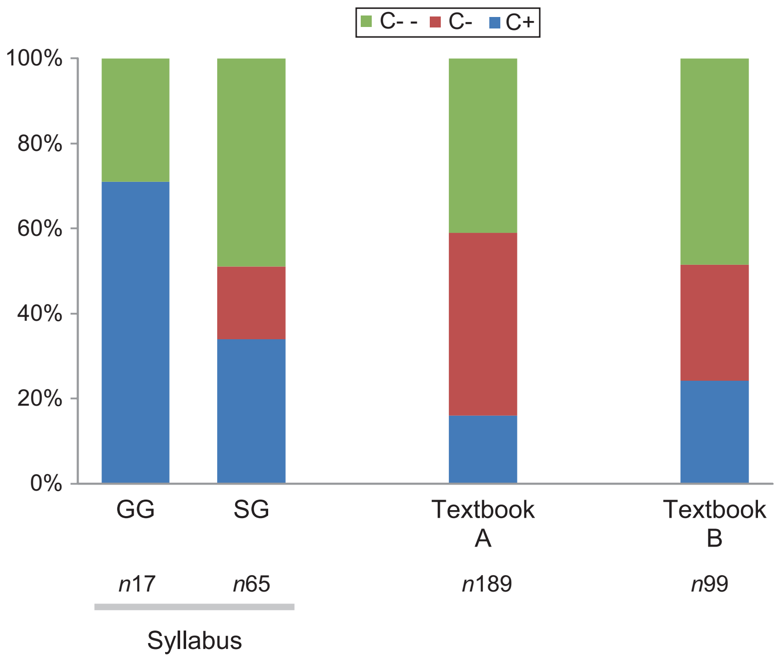

Fig. 26.4 Relationship between scientific and metascientific knowledge in the geology section, in general (GG) and specific (SG) guidelines of the syllabus and also in textbooks. *n* total number of units of analysis studied. (Adapted from Castro 2017)

guidelines having less expression in the general guidelines. In the case of textbooks, this intradisciplinary relationship is a little better represented in textbook A. Thus, when passing from the general guidelines to the specific guidelines of the geology syllabus a recontextualization of the pedagogical discourse did occur, in the direction of a strengthening of the relationship between scientific and metascientific knowledge (a smaller percentage of units classified with C^+ and a greater percentage of units classified with C^- and C^{--}). The relationship between these two types of knowledge is further strengthened when passing from the syllabus to textbooks, something that is more evident in textbook A. It is important to point out the situation where there is a relationship between the two types of knowledge, but where higher status is given to scientific knowledge (C^-). This situation is either absent (general guidelines) or undervalued (specific guidelines) in the syllabus and it is better represented in textbooks, particularly in textbook A.

26.4 Conclusions

This study was centered on NOS in the teaching/learning context of geology of the Portuguese secondary school. The message contained in the pedagogical discourse of the syllabus and textbooks was analyzed to characterize the nature and conceptualization of the metascientific knowledge and of its relationship with scientific knowledge, and to evaluate the recontextualizing processes that might have occurred between and within those texts.

The results of the study show that, with regard to geology of both the syllabus and textbooks of the discipline of biology and geology of tenth grade, the global message about NOS privileges the methodology of science (an aspect of the philosophical dimension) followed by its external sociology. Little emphasis is given to other important aspects of the NOS, particularly at the level of the psychological and internal sociological dimensions. The results also show a low level of conceptualization of the metascientific knowledge, which mostly corresponds to simple concepts with a low level of abstraction. These results are similar to the results of other national studies (Calado and Neves 2012; Castro 2006; Ferreira and Morais 2013) that have shown that, whenever the NOS is present in science education, the external sociological (STS) and the philosophical dimensions tend to be the most valued perspectives, although having, in general, a low level of conceptualization in the curriculum. Furthermore, international studies (McComas and Olson 1998; Vesterinen et al. 2009) have shown that in the science curricula of several countries the most emphasized aspects of the NOS are those related to philosophy and history of science.

Whenever the NOS is present in the syllabus and in textbooks, the results show an intradisciplinary relation between scientific and metascientific knowledge, namely in the cases of the syllabus-specific guidelines and in textbooks. These results are in accordance with the ideas of several authors (Aydin and Tortumlu 2015; Taber 2017), when they point out the integration of the NOS into the teaching–learning process of scientific knowledge as the most favorable approach to promoting the understanding of the NOS by students.

The conceptualization level of metascientific knowledge and the degree of relationship between scientific and metascientific knowledge, constitute a basis to appreciate the level of conceptual demand of scientific learning in the context of NOS (Ferreira et al. 2015; Morais and Neves 2016). The results of the present study could lead us to think that the valuing of the relationship between scientific and metascientific knowledge would have given a high contribution to raise the desirable level of conceptual demand of scientific learning. However, the low level of conceptualization of metascientific knowledge does limit that contribution. From this point of view, we can state that the curriculum texts analyzed in this study may limit the access of all students to a broad understanding of science construction, and, in this way, they do not promote a high level of scientific literacy.

The recontextualizing processes between the official pedagogical discourse (syllabus) and the pedagogical discourse of reproduction (textbooks), with regard to the dimensions of the NOS studied, vary in direction and degree. In terms of the nature of metascientific knowledge, there is a slightly valuing of some dimensions of science construction when passing from general to specific guidelines of the syllabus and from the syllabus-specific guidelines to the textbooks. In terms of the complexity of metascientific knowledge there is, in general, little difference between the two parts of the syllabus and between the syllabus and textbooks. The low level of conceptualization of metascientific knowledge is kept in all texts. However, stronger recontextualizing processes are evident at the level of the intradisciplinary relation between scientific and metascientific knowledge. This intradisciplinary relation becomes stronger when passing from general to specific guidelines of the syllabus and also when passing from the syllabus to textbooks. A recontextualization process also occurs when the reference is the status given to scientific knowledge in such relation. The case where scientific knowledge has more status in the relationship between scientific and metascientific knowledge (weak classification – C^{-}) is either absent or barely represented in the syllabus, but is valued in textbooks, particularly in textbook A. This situation, which was considered the most favorable to high science understanding according to the theoretical framework of the study, was therefore not valued by the authors of both the syllabus and one of the textbooks.

An important aspect that should be highlighted and which is related to recontextualization processes refers to the incoherence that may exist within the official pedagogical discourse between the two main sections of the syllabus and also between the official pedagogical discourse of the syllabus and the pedagogical discourse of textbooks. These incoherencies may be a cause of difficulty for textbook authors when interpreting the syllabus and for teachers when implementing the syllabus and textbooks. Textbooks authors' recontextualization of syllabuses can be a major problem in education whenever it decreases the scientific level in any of the dimensions of analysis of NOS (textbooks sometimes do increase that level), because, as research has been showing, teachers mainly base their practices on textbooks, rarely consulting syllabuses (Cavadas and Guimarães 2012; Valverde et al. 2002).

However, it should be stressed that a sound teachers' education focused on the integration of the NOS into science education and on the importance of conceptual demand in promoting scientific literacy may lead teachers to recontextualize the message of syllabuses and textbooks, in the direction of raising the conceptual level of these curriculum texts. In raising questions related to the construction of syllabuses and textbooks and their relationship with teachers' practices, the study points to the crucial importance of teachers' education. In this, it follows many other studies (Hodson 2014; Irzik and Nola 2011; McComas 2014).

In theoretical terms, the study raises questions related to the importance of refining the message related to NOS, which is contained in curricula, syllabuses, and textbooks, by pointing to the introduction in these texts of all aspects of NOS and also suggesting a conceptualized learning of metascience in its relation to science. It also points to the need for coherence not only inside each one of the pedagogical texts, but also between them (internal and external coherence).

In methodological terms, the study makes a contribution to the development of analyses centered on NOS. Contrary to other epistemological positions, Ziman's theorization about science contains a broad conceptualization, which allows a clear and detailed categorization of different aspects (metascientific dimensions) of NOS. The conceptual structure and broadness of Bernstein's theory of pedagogical discourse permit very rigorous and fine analyses of pedagogical texts and contexts, and their relationships, at different levels of the educational system. Despite the analysis focusing on the Portuguese educational system, the theorization and the instruments developed can also be used to appreciate NOS in international pedagogical texts. The use of the same methodological approach may allow comparisons between them.

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