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Conceptual demand of science curricula
A study at the middle school level

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INTRODUCTION

At the beginning of the 21 century, the issue of the quality and success of students' science learning remains at the centre of research and practice, in the hope that the school, as a social institution, will be able to educate scientifically literate citizens. To educate scientifically literate citizens means, according to OECD (1999), to prepare individuals with "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity" (p.60). Changes occurring in today's society have led to the re-conceptualizing of science education. All over the world science curricula have been placing more emphasis on the development of scientific literacy (BouJaoude, 2002). Initially used by Hurd (1958) – to highlight the importance of *science for all* in a more and more technological and scientific society –, the concept of scientific literacy has been seen in terms of various and distinct dimensions (e.g., Dillon, 2009; Feinstein, 2010; Kemp, 2002; Laugksch, 2000). However, and despite the diversity of meanings accorded to the concept of scientific literacy, some authors (e.g., DeBoer, 2000) believe that it should imply a broad and functional understanding of science. This idea leads to the statement that all citizens need to develop scientific literacy so that knowledge and skills can be mobilized and applied to the present scientific-technological world.

When studying scientific literacy in curricula and in pedagogic practices, it is important to analyze their level of conceptual demand, as explained in the Theoretical Framework below. The study presented in this article is focused on the conceptual demand of science curricula and takes as the object of analysis the current Portuguese Natural Sciences curriculum for middle school.

The curricular reorganization of the educational system for compulsory school (7^- - 15^+ schooling ages), that occurred in Portugal in 2001/2002, introduced new organizational guidelines and new curricula, all based on a project of curriculum flexibility working within a centralized educational system. In this context, two main documents were delivered by the Ministry of Education and Science (MES): *Essential Competences* (DEB, 2001) and *Curricular Guidelines* (DEB, 2002). These documents were constructed within the field of the MES by teams of mostly invited external experts, namely university teachers. Some authors were involved in both documents but some authors were involved in only one of the two and additional authors were involved. The expectation of the Ministry of Education and Science is that textbook authors and teachers will develop their work on the basis of the principles defined in both documents. The *Essential Competences* document sets out the general skills and knowledges that are considered as essential by the National Curriculum to define a profile for the compulsory education output and also the specific skills[1] and knowledges to be developed in each discipline or disciplinary area. The *Curricular Guidelines* document, more specific, derives from the *Essential Competences* document and guides the knowledge selection and sequencing and the implementation of educational experiences for each discipline or disciplinary area. In the particular case of middle school education (13^- - 15^+ schooling ages), where the present study is focused, the Curricular Guidelines for the discipline of Natural Sciences are structured around four organizational themes: 'Earth in Space', 'Earth in Transformation', 'Sustainability in the Earth' and 'Living Better on Earth'. According to the sequence referred in the curriculum documents, the first two themes are to be taught in the first year of middle school (age 13^+). The 'Sustainability in the Earth' theme is to be taught in the second year of middle school (age 14^+) and the ‘Living Better on Earth’ theme is to be taught in the last year of middle school (age 15^+). This fourth theme is considered as:

> "the culmination of all prior learning and aims at enabling the student to evaluate the importance of individual and collective intervention in the Earth balance [...]" (DEB, 2001, p.146).

The study presented in this article is part of a broader investigation (Calado, 2007) which involved the analysis of the pedagogic discourse contained in both the Portuguese Natural Sciences curriculum for middle school and the respective textbooks, with regard to the ‘Living Better on Earth’ theme. The analysis of the curriculum contained in this study was complemented by another study, focused on the ‘Sustainability in the Earth’ theme, which was carried out by another researcher (Ferreira, 2007). Reference to the respective results will be made at relevant points in this article.

This article focuses on an analysis of the official pedagogic discourse (OPD) that is part of the two official documents of the current curricular reorganization – *Essential Competences* and *Curricular Guidelines* - with respect to their level of conceptual demand. Through this analysis it is also possible to discuss recontextualizing processes that may have occurred within the Ministry of Education and Science, when the message contained in the *Essential Competences* document moves to the *Curricular Guidelines* document. The problem addressed by the study is the following: *What is the level of conceptual demand of the two official documents of the current Natural Sciences curriculum for middle school and what is the extent to which the messages of those documents evidence recontextualizing processes*? From this problem the following objectives were derived: a) analyze the OPD contained in the two curricular documents with regard to the level of conceptual demand; b) characterize the extent and direction of the recontextualizing of the OPD of the *Curricular Guidelines* document in relation to the OPD of the *Essential Competences* document; and c) offer a reflection on the consequences of the level of conceptual demand and of the recontextualizing processes of the curriculum on scientific literacy of *all* students. A further and fundamental objective of this article is to highlight methods and concepts that may be used to identify the level of conceptual demand in science curricula.

THEORETICAL FRAMEWORK

The curriculum, as an official text with a set of principles that directs the teaching/learning process at the various levels of the educational system (syllabuses, textbooks, pedagogic practices) reflecting ideological and political positions about the meaning accorded to that process, has been the object of large and varied research (e.g, Apple, 2004; Young, 2008; Wheelahan, 2010). Such research has been guided by theoretical perspectives from the areas of epistemology, psychology and sociology and has fundamentally focused on the kind of knowledge that should be valued throughout the school curriculum and also on the ideological, political, sociological options underlying curriculum organization. The present study is psychologically and sociologically grounded and is specifically focused on the message of the official pedagogic discourse conveyed in the curriculum of a given discipline addressing in particular the level of conceptual demand.

Within a sociological perspective, the study makes use of Bernstein's model of pedagogic discourse (1990, 2000). Through this model it is possible to understand the relationships that lead to the production and reproduction of the official pedagogic discourse (OPD) along the pedagogic device. The OPD is construed as containing directions about school organization and management and about curricula and assessment. According to the model, the OPD results from the recontextualization of the General Regulative Discourse (dominant principles of society) that occurs in the Ministry of Education and Science and its agencies, under the influence of the economy, symbolic control and international fields and also influenced by curriculum authors' ideologies. The curriculum/syllabus for a given discipline or disciplinary area is then produced by the Ministry of Education and Science in the official recontextualizing field and integrates '*the what*' and '*the how*' of the OPD, i.e. the knowledge and the relationships to be transmitted and how they should be transmitted. The OPD is further transformed in the pedagogic recontextualizing field to produce the pedagogic discourse that is conveyed, for example, by school textbooks. This discourse becomes the pedagogic discourse of reproduction at the classroom level where it may be the object of various further recontextualizations.

According to the model, the recontextualizing processes that occur at the level of the pedagogic discourse, whenever this discourse moves from one context to another, introduce changes whose direction and extent may reflect, among other factors, the ideological and pedagogical principles of the curriculum' authors and the influences of their social interactions while constructing the curriculum (Ferreira, Morais, & Neves, 2011).

The pedagogic discourse, conveyed in texts produced at various levels of the educational system, contains a sociological message that translates power and control relations between categories such as *discourses* (e.g. intra-disciplinary relations), *spaces* (e.g. teacher/student) and *subjects* (e.g. Ministry's agents/teacher). In order to characterize the various power and control relations, Bernstein uses the concepts of classification and framing, respectively. Classification (C) refers to the degree of maintenance of boundaries between categories (discourses, spaces and subjects), assuming strong values when there is a clear insulation between categories and weak values when there is a blurring of boundaries between categories. Framing (F) refers to social relations between categories, i.e. to communication between those categories. It is strong when the higher category has more control in the relationship and it is weak when the lower category has some control in the relationship. The present study uses the concept of classification for analyzing the intra-disciplinary relations between distinct knowledges within the same discipline (Natural Sciences for middle school education) (see Methodology).

From a psychological point of view, and given its particular focus on the importance of teaching/learning processes that promote a high level of conceptual demand, the study is strongly informed by on Vygotsky's ideas (1978). According to Vygotsky, education should go beyond students' actual level of cognitive development and, as such, the teaching/learning process should provide, in our terms, a level of conceptual demand higher than the level at which students can operate alone. Following these ideas, a highly conceptualized scientific learning plays an important role in the promotion of scientific literacy. Science education should not be restricted to the simple understanding of concepts but it should also foster the development of high level cognitive skills and knowledge.

In order to analyze the complexity of science curricula, the study uses a model of analysis of conceptual demand which has been developed through different studies focused on curricula and pedagogic practices[2]. The concept of conceptual demand was firstly used by Morais (Domingos, 1989a, b) to refer to the complexity of the teaching/learning process in terms of cognitive skills. Later on, on the course of jointly work by Morais and Neves (e.g., Morais, Neves, & Pires, 2004), the concept evolved to integrate the complexity of scientific skills and of scientific knowledge and, more recently (e.g., Ferreira, 2007; Ferreira & Morais, 2012), to integrate intra-disciplinarity within a scientific discipline, that is the degree of relation between distinct scientific knowledges of that discipline. This subsequent reformulation of the concept of conceptual demand represents a considerable step forward when compared to the former definition based on the complexity of skills only. For this reason, the study described in this article makes use of the most recent perspective of the concept. Conceptual demand is then defined as the level of complexity of science education as given by the complexity of scientific knowledge and of the strength of intra-disciplinary relations between distinct knowledges within a scientific discipline and also by the complexity of cognitive skills (Morais & Neves, 2012). It is important to note that a concept of conceptual demand was used in several international studies in the 1970's and 1980's, where it was associated with Piagetian development stages (e.g. Shayer & Adey, 1981). The present study departs from this perspective to follow the perspective described above and in doing so offers a deeper and richer analysis.

Bybee and Scotter (2007) emphasize that, among other aspects, the science curriculum must be rigorous and coherent. With regard to the first aspect, the authors believe that the science curriculum should emphasize learning which is conceptually demanding. In this perspective, the science curriculum should help students to achieve a general and broad understanding, within a given conceptual structure, of the fundamental ideas of science and also an understanding of the scientific procedures that have a fundamental impact on today's world (Millar, & Osborne, 1998). With regard to the coherence of the curriculum, Bybee and Scotter (2007) refer to the organization of concepts and processes to be developed throughout the school, as well as to the "connectivity" of science concepts and processes that students must experience along the science teaching/learning process.

Making relations between distinct knowledges is therefore essential for a more meaningful understanding of science. Keeping in mind that knowledge has a given structure that contain distinct levels of abstraction and organization, the teaching/learning process should lead to the understanding of concepts and big ideas, rather than focusing on a more factual domain (Erickson, 2007). Considering the hierarchical structure of scientific knowledge, characterized by integrating propositions that operate at increasing levels of abstraction, the development of a theory requires a new theory that is more general and more inclusive than the previous theory (Bernstein, 1999). Following these ideas, understanding scientific knowledge at a high level implies that science education should consider the relationship between distinct knowledges, in a way simulating the integration that characterizes the structure of scientific knowledge. Thus, by promoting intra-disciplinary relations, the teaching/learning process may lead to the understanding of high order concepts, with greater power of description, explanation, prediction and transference. In this study, intra-disciplinary relations are defined as the relations between distinct knowledges within a given discipline, either of the same or of distinct levels of complexity, and either within the same teaching unit or between teaching units. These relations can range from very tight to very loose, that is from very weak boundaries between distinct knowledges (weak classification), to very strong boundaries between distinct knowledges (strong classification).

On the basis of the ideas provided above, the authors of this article argue that it is important to raise the level of conceptual demand in science education. A decision about the level of conceptual demand that is to be valued in science education depends, to a great extent, on the ideological and pedagogical positioning of the educational agents (curricula and textbook authors, teachers). For some of them – for instance, science educators without a broad perspective of the transmission-acquisition process or with ideological principles which fail to engage with the fundamental social inequalities in school – lowering the level of conceptual demand may represent a better way for helping disadvantaged students, given the assumption that they are incapable of acquiring conceptualized scientific knowledge. For others – more acquainted with the sociological meaning and consequences of students' inequalities – it is crucial that the level of conceptual demand is not lowered. This is based on the assumption that socially disadvantaged students (likewise the socially advantaged students) have potentialities for acquiring conceptualized scientific knowledge, provided teachers' pedagogic practice takes into consideration their socio-cultural characteristics. To keep social equality in science learning contexts means to create conditions for *all* students to have access to a pedagogic discourse that expresses the structure of scientific knowledge. And to lead *all* students to access the structure of scientific knowledge means to give them the opportunity to learn science in a conceptually demanding context.

At a time when the worldwide belief of *education for all* leads many to defend a school based on simple knowledge and general skills we call for a conceptually demanding education with the goal of decreasing the gap between advantaged and disadvantaged students.

METHODOLOGY

General aspects

The study uses a mixed research methodology (e.g. Tashakkori, & Creswell, 2007; Morais, & Neves, 2010). On the one hand, the study contains a theoretical framework to guide the construction of instruments of analysis where the categories and indicators have been previously defined (a characteristic more associated with quantitative methodologies). On the other hand, empirical data, obtained in exploratory analyses of the documents, were used for the construction of the instruments' descriptors (a characteristic more associated with qualitative methodologies). In terms of data analysis, methodological procedures of a fundamentally qualitative character were used by carrying out an interpretative content analysis. Our mixed methodological approach uses an external language of description (the instruments) derived from an internal language of description (e.g. Bernstein's theory) on the one hand, and it is based on the empirical data on the other hand. A constant dialectical relation is established between the external language of description and the empirical data. This dialectic relation is made possible by the strong grammar of the internal language of description, created by Bernstein's theory, that allows the development of rigorous external languages of description which, in turn, provide guidance for more systematic empirical analyses.

The text of the two curricular documents (*Essential Competences* and *Curricular Guidelines*) was segmented into units of analysis. Following Gall, Borg and Gall (1996), a unit of analysis corresponds to an excerpt of the text with a given semantic meaning. A unit of analysis can, therefore, have one or more periods. In the case of lists of items (e.g. objectives), each one of the items was considered as a unit of analysis. The *Essential Competences* document was divided into 73 units of analysis and the *Curricular Guidelines* document was divided into 80 units of analysis. The text of both documents was organized into four sections – 'Knowledge', 'Aims', 'Methodological guidelines' and 'Evaluation' - according to the nature of the information it contained. Each unit of analysis was associated with one of the four sections and was analyzed using the various instruments constructed to appreciate the level of conceptual demand of the curriculum.

The level of the conceptual demand of the curriculum was determined by three dimensions: (i) the complexity of cognitive skills; (ii) the complexity of scientific knowledge; (iii) the intra-disciplinary relations between distinct scientific knowledges. Thus, the analysis of the OPD present in the two curricular documents focused on two aspects of the teaching/learning process: '*the what*' valued by the Ministry of Education in terms of skills and scientific knowledge, and '*the how*' that is how this knowledge is to be taught in terms of intra-disciplinary relations.

The level of conceptual demand was analyzed in terms of each one of the three dimensions and also by taking the three dimensions together (see Data Analysis).

Diagram of Figure 1 shows the relations analyzed in the study with regard to the conceptual demand of the curriculum[3].

(Insert figure 1 about here)

Construction and implementation of instruments

Instruments[4] for analyzing the two curricular documents were constructed, piloted and implemented. Models/instruments developed on earlier studies of the ESSA Group (e.g., Castro, 2006; Neves, & Morais, 2001) were used as the basis for the construction of the instruments of this study and the entire process of their construction and application was carried out jointly by three researchers. The instruments and the analyses of texts were validated by two researchers who analyzed about 30% of the units of analysis randomly chosen within each one of the curriculum sections.

The instruments refer to the complexity of cognitive skills, to the complexity of the scientific knowledge and to the intra-disciplinary relations between distinct scientific knowledges.

Complexity of cognitive skills

The instrument for analyzing the complexity of cognitive skills was based on categories presented in the revised version of Bloom's Taxonomy of Educational Objectives (Krathwohl, 2002)[5]. It contains, as categories of analysis, four levels of complexity of cognitive processes. The first two levels refer to what are called, in this study, simple skills (SSk) and cover psychological processes such as remembering and understanding at the most elementary level. The last two levels refer to more complex skills (CSk) that involve a level of complexity higher than that of simple skills, such as the highest level of understanding, application, analysis, evaluation and creation.

Within the simple skills, the instrument contains two levels of complexity: the SSk^- which involve the lowest level of complexity referring to the retrieving of relevant knowledge from long-term memory, such as recalling; and the SSk^+ which imply a level of complexity higher than that of SSk^- such as understanding at the level of exemplification. Within the complex skills the instrument also contains two levels of complexity: the CSk^-which involve understanding at the highest level, as is the case of inferring or explaining, and the cognitive process of application; and the CSk^+ which involve the highest level of complexity, including cognitive skills that range from analysis and evaluation to creation.

Based on the four levels of complexity of cognitive skills, a four degree scale was organized for each section of the curriculum. While representing a gradient of complexity from degree 1 (SSk^-) to degree 4 (CSk^+), the scale provides an increasing level of conceptual demand. It should be noted that the definition of degrees in a scale does not exclude a continuum between mental processes involved in distinct skills (Andrich, 2002). Rather it seeks to offer some categorization of skills in a given teaching/learning context.

Table I presents an excerpt of the instrument, for the section 'Methodological guidelines'. It is followed by examples of units of analysis from different curriculum sections and their respective classification according to the four degree scale of the instrument.

Table I – *Excerpt of the instrument for characterizing the complexity of cognitive skills*

Section	**Degree 1** (SSk^-)	**Degree 2** (SSk^+)	**Degree 3** (CSk^-)	**Degree 4** (CSk^+)
Methodological guidelines	Strategies/methodologies that call for mobilizing skills of a low level of complexity, involving processes that require the retrieving of relevant knowledge from long-term memory	Strategies/methodologies that call for mobilizing skills of a level of complexity higher than that of SSk^- such as the understanding of simple instructional messages like exemplification	Strategies/methodologies that call for mobilizing skills of a level of complexity higher than that of SSk^+, such as the understanding of complex instructional messages, like explanation, and the application	Strategies/methodologies that call for mobilizing skills of a very high level of complexity such as analysis, evaluation and creation

Units of analysis

Degree 1 (SSk^-): "The students should learn the location of genetic material inside the cell and this can be achieved by using schemes representing the cell structure" (*Curricular Guidelines* document, p. 33 – 'Methodological guidelines' section)

Degree 2 (SSk^+): "Representations of the inside of the human body may be explored [...] so that students can identify the relative position of the various organs and tissues [...]" (*Curricular Guidelines* document, p. 32 - 'Methodological guidelines' section)

Degree 3 (CSk^-): "Students should understand the interactions between the various human systems rather than studying them in an isolated way [...]" (*Curricular Guidelines* document, p.33 – 'Aims' section)

Degree 4 (CSk^+): "Planning and developing research activities. Problem-solving situations, while requiring different ways of searching, collecting, analyzing and organizing information, are fundamental to understanding science." (*Essential Competences* document, p. 131 – 'Methodological guidelines' section)

Complexity of scientific knowledge

The study considered that scientific knowledge could be classified either as simple knowledge, involving generalized facts and concepts of first order, or as complex knowledge, involving concepts of second and third orders. A generalized fact results from the association of various facts of the same kind, and a fact 'is an observable phenomenon' (Brandwein, Watson, & Blackwood, 1958, p.112), corresponding to a very specific situation. A concept is a 'mental construction, a group of elements or attributes shared by certain objects or events' (Brandwein *et al*, 1980, p.12) and represents an idea which results from the combination of several facts or other concepts. The categorization of concepts in several orders is the result of a hierarchy between levels of abstraction and perception. Thus, concepts of a first order refer to simple concepts, which have a low level of abstraction, defining attributes and examples easily perceptible (Cantu, & Herron, 1978). Second order concepts are complex concepts, which have no perceptible examples or which have relevant defining attributes that are not perceptible (Cantu, & Herron, 1978). Finally, third order concepts respect to unifying themes, theories, structuring ideas, representing generalizations about the world as accepted by scholars in the area of science. There is a hierarchy between the concepts of different orders whereby the level of complexity increases from the first to the third orders.

The instrument used to analyze the complexity of scientific knowledge contains a three degree scale. Degree 1 corresponds to simple knowledge (generalized facts and first order concepts) and degrees 2 and 3 refer to complex knowledge in which degree 2 includes second order concepts and degree 3 includes third order concepts. The scale represents an increasing gradient of conceptualization of scientific knowledge and therefore an increasing level of conceptual demand.

Table II presents an excerpt of the instrument, for the 'Methodological Guidelines' section, followed by examples of units of analysis classified according to the scale of the instrument.

Table II – *Excerpt of the instrument for characterizing the complexity of scientific knowledge*

Section	**Degree 1**	**Degree 2**	**Degree 3**
Methodological guidelines	Suggestions of strategies/methodologies that aim at the transmission/acquisition of generalized facts and/or simple concepts, with a low level of complexity (concepts of 1st order)	Suggestions of strategies/methodologies that aim at the transmission/acquisition of complex concepts, with a level of complexity higher than that of simple concepts. These concepts are mental constructions without easy perceptible examples (concepts of 2nd order)	Suggestions of strategies/methodologies that aim at the transmission/acquisition of unifying themes/theories, involving a very high level of complexity (concepts of 3rd order)

Units of analysis

Degree 1 (Concepts of 1st order): "Representations of the inside of the human body (CD-Rom or three-dimensional model) can be explored so that students can identify the relative position of different organs and tissues […]." (*Curricular Guidelines* document, p. 32 - Methodological guidelines' section)

Degree 2 (Concepts of 2nd order): "[…] within a general approach of some aspects of inheritance, students should be faced with concrete situations of the transmission of characteristics along generations (eye and hair colour)." (*Curricular Guidelines document*, p. 33 - Methodological guidelines' section)

Degree 3 (Concepts of 3rd order): "Taking into account the Curricular Guidelines for middle school education, it is important to investigate problems from the perspective of individual health (the human body, its functioning and balance), global security and health in interaction with each other and with the environment". (*Essential Competences* document, p. 146 - Methodological guidelines' section)

Intra-disciplinary relations between distinct scientific knowledges

The instrument for analyzing the relations between distinct scientific knowledges was based on the theoretical meaning of intra-disciplinary relations given by using Bernstein's concept of classification of discourse relations (1990). As said before, strong values of classification correspond to well defined boundaries between distinct knowledges (no relations are made) whereas weak values of classification correspond to a blurring, or even absence, of boundaries between distinct knowledges (relations are present). The study assumes that the presence, in the teaching/learning context, of relations between distinct scientific knowledges lead to higher levels of conceptualization and to more effective understanding of science. This position reflects the organizational nature of science knowledge itself as this knowledge corresponds, as it was said earlier, to a discourse characterized by a hierarchical structure.

Based on these theoretical assumptions, a four degree scale of classification (C^{++}, C^{+}, C^{-} , C^{--}) was constructed and descriptors for each curriculum section were defined. The scale considered not only the level of complexity of knowledge (simple and complex) but also the relations between scientific knowledges within the same teaching unit and of distinct teaching units. Establishing relations between knowledge of distinct teaching units represents a higher level of intra-disciplinarity than relation between knowledge within the same teaching unit. The level (simple or complex) of the knowledge involved in the relation contributes more to the degree of intra-disciplinarity than the fact that the relation occurs within the same teaching unit or between distinct teaching units. Therefore the highest two degrees of the scale - corresponding to the strongest values of classification (C^{++} and C^{+}) - refer to situations in which there is a relation between simple knowledge whether the knowledge refers to the same teaching unit (C^{++}) or to distinct teaching units (C^{+}). The lowest degrees of the scale - corresponding to the weakest values of classification (C^{-} and C^{--}) - refer to situations in which there is a relation between complex knowledge or between this and simple knowledge whether the knowledge respects to the same teaching unit (C^{-}), or to distinct teaching units (C^{--}).

The piloting of this instrument led to the addition to degree C^{++} of a descriptor that portrayed a situation where scientific knowledge (e.g. the concept of homeosthasis[6]) essential to the understanding of the relationship between knowledge is missing.

Table III presents an excerpt of the instrument for the 'Methodological Guidelines' section. It is followed by examples of units of analysis from different curriculum sections with respective values of classification.

Table III – *Excerpt of the instrument for characterizing the intra-disciplinary relations between distinct scientific knowledges*

Section	C^{++}	C^{+}	C^{-}	C^{--}
Methodological guidelines	The strategies/methodologies suggested contain the relationship between simple knowledge within the same teaching unit *Or* Scientific knowledge essential to the understanding of the relationship between knowledge is missing in the strategies/methodologies suggested	The strategies/methodologies suggested contain the relationship between simple knowledge of distinct teaching units	The strategies/methodologies suggested contain the relationship between complex knowledge, or between this and simple knowledge, within the same teaching unit	The strategies/methodologies suggested contain the relationship between complex knowledge, or between this and simple knowledge of distinct teaching units

Units of analysis

C^{++}: "The students may look for the energetic value of various foods on labels or on dietary lists and interpret data that relate energy costs of the body in different physical conditions." (*Curricular Guidelines* document, p. 36 - Methodological guidelines' section)

C^{+}: "Understanding the basic concepts related to health and environmental protection that should be on the basis of human action, individually and in the community". (*Essential Competences* document, p.144 - Aims' section)

C^{-}: "Starting from familiar situations to the students (bites, burns, anxiety in evaluation moments) and focusing voluntary and involuntary reactions, the role of the nervous system (central and peripheral) and of the hormonal system in the coordination of the organism should be highlighted"[7]. (*Curricular Guidelines* document, p. 34 - Methodological guidelines' section)

C^{--}: "The exploration of a former question about changes in heart rhythm implies knowledges of the circulatory and respiratory systems and the metabolism (e.g. in the case of sport) or of the circulatory, nervous and hormonal systems (e.g. in the case of a situation that causes anxiety or fear)". *Curricular Guidelines* document, p. 34 – 'Knowledge' section)

The analysis of all units of both curricular documents (*Essential Competences* and *Curricular Guidelines*), through the use of each instrument, was followed by the computing of the results obtained. For each one of the dimensions of the level of conceptual demand, the frequency of units of analysis (in relative percentage), classified according to the scalar degrees of the respective instrument, was computed. Frequency refers both to each one of the curriculum sections separately ('Knowledge', 'Aims', 'Methodological guidelines' and 'Evaluation') and to the curriculum text taken as a whole.

Some units of analysis were classified as ambiguous and in this case they were not considered in the computing of frequencies. Units of analysis were taken as ambiguous whenever the degree of complexity of skills, the degree of complexity of scientific knowledge or the degree of intra-disciplinarity was not explicit in the excerpt, and as such impossible to determine. The following unit of analysis illustrates a situation where the degree of complexity of scientific knowledge was taken as ambiguous.

> "Some behaviours that interfere with the balance of the organism (alcohol, tobacco, drugs, hygiene, physical activity) may be studied simultaneously with former questions […]" (*Curricular Guidelines* document, p.35).

In order to get a measure of the level of conceptual demand of each one of the official documents, global and partial indices were computed. The global index[8] was the result of considering jointly the three dimensions of the level of conceptual demand - complexity of cognitive skills, complexity of scientific knowledge and intra-disciplinary relations between distinct scientific knowledges. The partial indices[9] were the result of considering each one of the three dimensions separately.

DATA ANALYSIS

Complexity of cognitive skills

The results of the analysis of curricular documents with regard to the complexity of cognitive skills are shown in Figure 2.

(Insert figure 2 about here)

The analysis shows that, on the whole, both curricular documents tend to emphasize the development of high cognitive processes. In the *Essential Competences* (*EC*) document, 76% of the text contains directions related to the development of complex cognitive skills (degrees 3 and 4), 55% of which refer to the highest degree of complexity. Only 24% of the directions refer to simple cognitive skills (degrees 1 and 2) and within them only 4% refer to the lowest degree of complexity. In the *Curricular Guidelines* (*CG*) document, 67% of the text contains directions related to the development of complex cognitive skills (degrees 3 and 4), 40% of which refer to the highest degree of complexity. Simple cognitive skills (degrees 1 and 2) are present in 33% of the statements and within them 20% refer to the lowest degree of complexity. These results show that, in both documents, cognitive skills of higher complexity predominate, although this is more evident in the case of the *EC* document.

The comparative analysis of the two documents shows that the *Curricular Guidelines* (*CG*) document increases the reference to complex skills of low level and the reference to simple skills of low level and decreases the reference to complex skills of high level. This evidences recontextualizing processes within the official recontextualizing field in the direction of decreasing the complexity of the cognitive processes at the level of the *CG*.

The analysis of the results obtained for each curriculum section separately shows a considerable percentage of ambiguous statements (units of analysis) and therefore a small percentage of statements with the potential to be analyzed. This was particularly evident in the case of the *CG* document that presents 22% of ambiguous statements, when the document is taken as a whole.

Given the low number of units to be analyzed in the case of 'Knowledge' section, for both documents, and in the case of 'Aims' and 'Evaluation' sections, for the *CG* document, and given also the absence, in the *EC* document, of directions about the evaluation of skills, the analysis of recontextualizing processes at this level of analysis can only be conclusive for the 'Methodological Guidelines' section. In this section there is considerable change when moving from the *EC* document to the *CG* document. Contrary to the *CG* document, the *EC* contains complex skills of high level only (degrees 3 and 4) which indicates that special attention is being given by curriculum authors to strategies and methodologies that promote the development of complex cognitive processes

Complexity of scientific knowledge

The results of the analysis of the two curricular documents, in terms of the degree of complexity of scientific knowledge, are shown in Figure 3.

(Insert figure 3 about here)

The *EC* document shows a balanced distribution of the emphasis given to distinct levels of complexity of scientific knowledge - 39% of the units of analysis mention 3rd order concepts, such as unifying themes/theories (degree 3), 32% mention 2nd order concepts (degree 2) and 29% refer to generalized facts and simple 1st order concepts (degree 1). In the *CG* document, only 25% of the units of analysis mention unifying themes (degree 3), and there is considerable attention given to generalized facts and first order concepts (43% of degree 1). It seems then that the recontextualizing processes that occurred in the OPD, during the construction of the *CG* document, led to a decreasing of the level of conceptualization of scientific learning.

The results obtained for each one of the sections of the two curricular documents, show that in the case of the *CG* document, the 'Knowledge' and the 'Methodological Guidelines' were the sections that mostly contribute to the trend found in the document as a whole. In the case of the *EC* document as a whole, the trend found is mostly an expression of the 'Aims' section. This makes it impossible to reach any conclusion about recontextualizing processes within the various curriculum sections. This was a result of either the low number of units of analysis found in one of the two documents, when considering the 'Knowledge', 'Aims' and 'Methodological guidelines' sections, or the absence of statements in the 'Evaluation' section.

Intra-disciplinary relations between scientific knowledges

The analysis of intra-disciplinary relations between distinct scientific knowledges took into account the complexity of the knowledge involved in such relations and the teaching unit to which the knowledge belonged. Figure 4 presents the results obtained for the two curricular documents and their respective sections.

(Insert figure 4 about here)

In the case of the *EC* document, weak classifications (C^- and C^{--}) predominate. This means that relations between complex knowledge or between it and simple knowledge prevail (69% of the analyzed text) either within the same teaching unit (35% C^-), or between distinct teaching units (34% C^{--}). In this document, 31% of the text involves relations between simple knowledge (C^{++} and C^+), where relations between knowledge of the same teaching unit (C^{++}) prevail over relations between knowledge of distinct teaching units (C^+) - 27% and 4% respectively. These results show that, in the *EC* document, relations between scientific knowledge (either of the same teaching unit or distinct teaching units) with a high degree of conceptualization and broadness predominate, thus reflecting a high level of conceptual demand with respect to ‘intra-disciplinarity’.

When the *CG* document is compared with the *EC* document, there is a decrease in the relations between complex knowledge or between it and simple knowledge (52% of the text), whether they relate to knowledge of the same teaching unit (33% C^{-}), or to knowledge of distinct teaching units (19% C^{--}). At the level of simple knowledge there are only relations between knowledge of the same teaching unit (48% C^{++}) which also shows a decreasing of intra-disciplinarity when it is compared with the *EC* document.

These results show that the recontextualizing processes that occur in the transition of the *EC* to the *CG* documents give origin to lesser intra-disciplinarity, therefore to a lower level of abstraction, evidenced by greater percentage of relations between simple knowledge, within the same teaching unit, and smaller percentage of relations between complex scientific knowledge.

Similarly to the findings about the level of complexity of scientific knowledge, the ‘Knowledge’ and the ‘Methodological Guidelines’ were the curriculum sections that mostly contribute to the trend found at the level of the *CG* document as a whole and the ‘Aims’ was the section that mostly contributed to the trend found in the case of the *EC* document. Again in this case, there are a small number of excerpts in one of the two documents, when considering the ‘Knowledge’, ‘Aims’ and ‘Methodological guidelines’ sections. This is mostly as a consequence of the ambiguity found at the level of intra-disciplinary relations. References to the evaluation of relations between distinct scientific knowledges are absent in the case of the *EC* document and are ambiguous in the case of the *CG* document. As in the previous analyses, there are no conclusive data about recontextualizing processes between the *EC* and the *CG* documents, when the analysis is focused on the curriculum sections.

Level of conceptual demand

The level of conceptual demand for each one of the official documents was determined by making a composite index of the results obtained for the three dimensions of that level: degree of complexity of cognitive skills, degree of complexity of scientific knowledge and degree of intra-disciplinarity between distinct scientific knowledges (see Methodology). Figure 5 shows the level of conceptual demand of each curricular document, *EC* and *CG,* and the partial index for each one of the dimensions so that it is possible to see which dimension has contributed more to the level of conceptual demand of each one of the two documents.

(Insert figure 5 about here)

The global composite index for the *EC* document is 0.76 which evidences a considerable level of conceptual demand. All the three dimensions show a relatively high value of conceptual demand – 0.82 for 'complexity of cognitive skills', 0.70 for 'complexity of scientific knowledge' and 0.69 for 'intra-disciplinarity between distinct scientific knowledges'.

The average value of 0.59 of the global composite index of the *CG* document represents a low level of conceptual demand of this document when compared with the level of the *EC* document. The value of the 'complexity of cognitive skills' dimension is high (0.72), much higher than the values of the dimensions of 'complexity of scientific knowledge' and 'intra-disciplinarity between distinct scientific knowledges' which are low (0.50 and 0.56, respectively).

Recontextualizing processes between the contexts of the two documents are stronger at the level of the 'complexity of scientific knowledge'. There are several possible explanations for this pattern of recontextualisation. It may be the result of the very nature of the *CG* document where greater specification of the teaching-learning processes is required. In this move towards specification, curriculum authors seem to have forgotten to mention in this document something they had mentioned in the *EC* document; that is they seem to have forgotten to mention the concepts of higher order and the relations between these that can lead to comprehensive and integrating ideas. Curriculum authors' inability to give specific directions related to complex ideas may be another possible explanation.

The analyses show, as discussed above, the presence of ambiguous units of analysis at the level of some sections of the curricular documents. This ambiguity indicates that curriculum authors fail to give clear directions to teachers and textbooks authors with regard to the central skills, knowledges and relations between scientific knowledges. In fact, this absence of clarity may lead to different interpretations from the part of those whom the curriculum directly addresses (i.e. teachers and textbook' authors), depending on their scientific/pedagogic education and interest. Given the degree of ambiguity found, and in order to test the validity of the conclusions reached about the curriculum conceptual demand, it was decided to analyze the level of conceptual demand of the curricular documents by considering two hypothetical opposite situations: a situation which translates an undervaluing of the information contained in the ambiguous units and a situation which translates an overvaluing of the information contained in the ambiguous units. In order to study the undervaluing of the information contained in ambiguous units, the lowest degree for each dimension (i.e. the first degree of each instrument) was assigned to these units. In order to study the overvaluing of the information, the highest degree for each dimension (i.e. the last degree of each instrument) was assigned.

When the information in the ambiguous units was undervalued, the level of conceptual demand decreased from 0.76 to 0.60 in the case of the *EC* document, and from 0.59 to 0.50 in the case of the *CG* document. When the information contained in the ambiguous units was overvalued, the level of conceptual demand changed from 0.76 to 0.85 in the *EC*, and from 0.59 for 0.71 in the *CG*. These results show that, in the case of the undervaluing, the level of conceptual demand of the *EC* document does not reach very low levels (0.60) whereas the level of conceptual demand of the *CG* document reaches relatively low values (0.50). Even in the case of overvaluing, the level of the conceptual demand of the *CG* is consistently lower than the level of conceptual demand of the *EC*. This reinforces the finding of recontextualizing processes occurring between the two documents, in terms of extent and direction.

CONCLUSIONS

This study analyzed the official pedagogic discourse of the Natural Sciences curriculum for middle school education with regard to the level of conceptual demand. It focused on the theme 'Living Better on Earth'. The analysis intended also to make visible the recontextualizing processes that may occur between the two curricular documents, the *Essential Competences* and the *Curricular Guidelines*.

According to the results obtained, the level of conceptual demand of the official pedagogic discourse of the science curriculum is higher at the level of the *Essential Competences* when compared with the *Curricular Guidelines*. This conclusion is based on a composite index that incorporated three dimensions of conceptual demand: level of complexity of cognitive skills, level of complexity of scientific knowledge and level of intra-disciplinarity between distinct scientific knowledges.

With regard to the complexity of cognitive skills, complex skills predominate in both documents particularly in the *Essential Competences* document. This is the dimension that, in both documents, contributed mostly to the high value of the composite index of conceptual demand. This result might be explained by the fact that the theme analyzed is studied in the final year of middle school, where it is assumed that students can develop complex skills such as application of concepts to new situations and making judgments based on criteria and standards. In this perspective, special emphasis is given to problem-solving, decision making, project planning and investigations. However, as it is shown by Ferreira's study (2007), the level of complexity of cognitive skills is also high in both documents and higher in the *Essential Competences* when the analysis focused on the theme 'Sustainability in the Earth'. In this theme, particular emphasis is also given to investigations, problem solving and decision making. These are skills that have been emphasized in current science education discourses and which tend to be reproduced in curricular documents.

With regard to the complexity of scientific knowledge, the science curriculum emphasizes complex knowledge. However, whereas the *Essential Competences* document contains a balanced distribution of knowledges with distinct levels of complexity, the *Curricular Guidelines* document gives a greater emphasis to simpler knowledge. These results are consistent with Ferreira's study (2007) by showing that complex knowledge is more valued in the *Essential Competences* than in the *Curricular Guidelines.* Taken together, these studies show that the high level of conceptual demand required by the general principles of the curriculum is devalued in the process of moving towards specification of these principles.

With regard to the third dimension that was used to analyze the level of conceptual demand – intra-disciplinarity between distinct scientific knowledges - the science curriculum calls for relatively high intra-disciplinarity at the level of the *Essential Competences*. However, in the *Curricular Guidelines* the intra-disciplinarity, namely with respect to the relationships between knowledge of distinct teaching units, is very low. The discontinuity between the two curricular documents may be interpreted as a result of difficulties encountered by curriculum authors in making complex intra-disciplinary relations in a context where more specific guidelines should be given. Again these findings are consistent with Ferreira's study (2007) where she also shows a relative devaluing of intra-disciplinary relations between complex scientific knowledge of distinct teaching units when the curricular text moves from the *Essential Competences* to the *Curricular Guidelines.*

In the analysis of the recontextualizing processes that took place in the transition from the *Essential Competences* to the *Curricular Guidelines,* there is evidence that the directionality is one of a move towards a poorer approach to science education, particularly in terms of the complexity of scientific knowledge and of the intra-disciplinary relations between distinct scientific knowledges. These recontextualizing processes represent a decreasing of the level of conceptual demand of the *Curricular Guidelines* when compared with the *Essential Competences*. It should be noted that the particular directionality found – from more complex to more simple in the move from the *Essential Competences* to the *Curricular Guidelines* - cannot be accounted for by the need for greater specification. On the contrary, the specification should link given concrete situations of the science class with concepts at the most abstract level. Or they should suggest situations, like problem solving or investigative laboratory activities which are known to be promoters of high levels of scientific learning.

According to a study carried out by Ferreira, Morais and Neves (2011), these recontextualizing processes may be a consequence of the difficulties felt by curriculum authors when putting into practice, in the form of a monologic text, some aspects of scientific learning, such as those related to the level conceptual demand. Another possible reason is related to the ideological and pedagogical principles of the curriculum authors. In fact, the results of that study, which was centered on the ideological and pedagogical principles of the curriculum authors, show that

> "options taken by the authors' team do not totally reflect the importance that they all accord […] to the promotion of a scientific literacy based on the development of skills and knowledge of various levels of complexity and on strong relations of intra-disciplinarity". (p. 152).

Considering the fact that some of the authors of the *Essential Competences* document were not authors of the *Curricular Guidelines* document, the recontextualizing that occurred in the curriculum construction may reflect the distinct ideological and pedagogical principles of the authors of the two curricular documents.

According to Vygotsky (1978) we can say that the directions given by the *Essential Competences* document, when compared with the *Curricular Guidelines* document, may lead to teaching/learning processes that promote high levels of scientific literacy, as students would be contextualized in cognitive demanding processes that contain the potential to push them beyond their actual stage of development.

Moreover, and according to some studies developed by the ESSA group (e.g. Morais, & Neves, 2001; Morais, Neves, & Pires, 2004), raising the level of conceptual demand, together with pedagogic practices with characteristics favourable to the learning of *all* children, may ensure that *all* children have access to high levels of scientific literacy. The authors consider that the message of the *Essential Competences* document, while containing a high level of conceptual demand, may have the potential to value the development of scientific literacy by all students, including the disadvantaged, since it has the potential to lead them to access to the text more valued by the scientific community and by society. However, the decreasing of the level of conceptual demand in the case of the specific guidelines of the curriculum may put at stake the success of *all* students, as recommended by the broad rationale of the curriculum and by current perspectives in science education, whereby a high level of scientific literacy is seen as essential.

The recontextualizing processes that were found in this study are in line with those found in simultaneous and previous studies (e.g. Alves, 2007; Ferreira 2007; Ferreira, & Morais, 2011; Neves & Morais, 2001). These studies showed that in the context of the production of official pedagogic discourse, recontextualizing processes occur in the direction of lowering the level of conceptual demand in shifts from general principles to the more specific guidelines of a curriculum. In particular, the research results of Ferreira (2007), which focused on the analysis of the theme 'Sustainability on Earth' (age 14^{+}) of the same middle school curriculum, and which also studied the level of conceptual demand in terms of the three dimensions used in the present study, show a similar trend. This allows a higher generalization of the conclusions.

These recontextualizing processes are of particular relevance when one considers that teachers tend to use the specific guidelines, in this case the *Curricular Guidelines* document, as one of their main sources of information for curriculum implementation, since these guidelines are directly related to what they are going to do in their teaching. In this way, the relatively high level of conceptual demand contained in the general principles may not be present in the classroom. This is compounded by the already known fact that teachers mostly make use of textbooks as another main source of information for guiding them in their teaching. In the broader research of which the present study is part (Calado, 2007), the analysis of the curriculum was complemented with the analysis of textbooks. This analysis showed that the message contained in textbooks recontextualizes the message of the two curricular documents (Calado & Neves, 2012) in the direction of lowering the level of conceptual demand. If the level decreases from the *Essential Competences* document to the *Curricular Guidel*ines document and also from the curriculum to textbooks, and if teachers tend to mostly make use of the *Curricular Guidelines* document and of the textbooks, then conditions are created for decreasing the level of conceptual demand on the context of the teacher's pedagogic practice. However, this is not an inevitable situation since it can be inverted, depending on the education of the teacher and on the control that is given to him/her in the educational system. A teacher with both a good preparation and an ideology that values the importance of providing high scientific literacy to *all* students can recontextualize the pedagogic discourse, to which s/he has direct access through the *Curricular Guidelines* document and the textbooks, in the direction of increasing instead of further decreasing the level of conceptual demand present in that discourse.

Teacher’s control over the implementation of the curriculum is more valued in the context of curriculum flexibility, on which the current Portuguese curricular reorganization is based. This implies that the Ministry for Education and Science gives to teachers more control over ‘*the what’* (knowledges and skills) and ‘*the how’* (nature of relations in the classroom) of the pedagogic discourse to be transmitted/acquired. The broader investigation of which this study is part (Calado, 2007) showed a reduced explicitness by the Ministry of Education and Science of ‘*the what’* and ‘*the how’* of the pedagogic discourse (see also Ferreira, 2007; Ferreira, & Morais, 2011). According to Ferreira, Morais and Neves (2011), this absence of explicit texts may be the result of the fact that the curriculum authors intend to give to teachers a greater degree of autonomy in the curriculum implementation, in a context of curriculum flexibility.

However, when curriculum authors fail to clarify some of the directions about the complexity of skills and of scientific knowledge to be learned and about the relations to be made between distinct scientific knowledges, teachers and textbooks authors may promote the development of teaching/learning processes with a low level of conceptual demand. Indeed, in the absence of explicit criteria with regard to the text to be implemented in schools, teachers, particularly those who have limited knowledge of science and science education, may be unable to 'build' a curriculum that takes into account results of research about the importance of increasing the level of conceptual demand in order to lead *all* students to a high level of scientific literacy (e.g., Morais, & Neves, 2001, 2011; Morais, Neves, & Pires, 2004). Whenever teachers adapt the curriculum to the specificities of students and schools, they tend to develop teaching/learning processes with different levels of conceptual demand and as such they may put at stake the high scientific literacy of *all* students. In fact, studies (e.g. Domingos, 1989 a,b) have shown that teachers tend to vary the level of conceptual demand of the teaching/learning process in accordance with the social context in which they teach, in a process that lowers that level whenever they teach disadvantaged children. This contributes to increasing the gap between students with different socio-economic backgrounds with regard to scientific literacy.

Following the results discussed in this paper, the authors believe that if teachers are to promote effective scientific learning, the curriculum must have explicit evaluation criteria at least in relation to the knowledges and skills to be acquired and the conceptual inter-relation between distinct knowledges (intra-disciplinarity). According to Neves and Morais (2006) if

> "the quality of education is to prevail for *all* students, to make the curriculum flexible does not mean leaving for teachers/schools (and textbooks' authors) the selection of concepts, skills and goals to be developed but the selection, in terms of students' specificities, of the activities that allow all of them to have access to the same concepts and skills, with similar levels of complexity."(p. 17).

On the other hand, the results of this study also point to the importance of teacher education, since the greater autonomy allowed to teachers, in order that they respond more adequately to the needs and interests of their students, also contains potentialities which are necessarily dependent on teachers' scientific and pedagogical education. Teachers with a sound background may provide more meaningful learning for their students by taking advantage of the space of autonomy they got to explore pedagogic characteristics that promote a high level of scientific literacy.

The study reported in this paper also makes a methodological contribution in two specific ways: at the level of the theoretical assumptions that guided the selection of the dimensions used for studying the level of conceptual demand and at the level of the instruments constructed for their analysis. The strong conceptual and explanatory power of the theory on which the study was based, and the constant dialectics between the theoretical and the empirical, enabled the construction of instruments with descriptors that made possible a detailed analysis of the various scientific learning characteristics theorized as dimensions of the level of conceptual demand. These instruments may prove useful in other curricular studies or may be adapted to other educational contexts.

Notes

1. In this study, skills are seen as cognitive mental processes which may have different levels of complexity, depending on the steps involved (Marzano & Kendall, 2007).

2. See Model of analysis of 'level of conceptual demand of science education' in <http://essa.ie.ul.pt/researchmat_modelsofanalysis_text.htm>

3. The structure of the coding scheme presented in Figure 1 is such that it may be used in further studies either of science disciplines or of social sciences disciplines. The level of conceptual demand of the curriculum of a discipline (as, for example, history in the field of social sciences) may be appreciated by analysing the complexity of knowledge and the complexity of cognitive skills that curriculum entails and also its intra-disciplinary relations. Such analyses may indicate the contribution of specific disciplines, as given by their curriculum, to students' development, in terms of knowledge and competences. Any given curriculum usually contains general and specific guidelines and as such its meaning is better understood by an analysis that discriminates between broad aims and particular objectives and tasks. Furthermore, the coding scheme is also useful to analyse conceptual demand at levels of science education other than curricula as it is the case of pedagogic practices and teacher education.

4. Available online in <http://essa.ie.ul.pt/materiais_instrumentos_texto.htm>

5. According to this Taxonomy, the cognitive domain involves six main categories of cognitive skills: remember, understand, apply, analyze, evaluate and create.

6. From a conceptual point of view the question is that the absence in the curriculum of the unifying concept of homeosthasis can compromise the understanding of relevant scientific knowledge when, studying the "*Human body in balance*", the students have to understand that the human body "is organized in a hierarchy of levels that function in an integrated way and perform specific functions" (DEB, 2001, p. 146).

7. The nervous and the hormonal systems are part of the same teaching unit this curriculum.

8. Computing the global index based on the three dimensions - degree of intra-disciplinarity between distinct scientific knowledges (IntraSK), degree of complexity of cognitive skills (CSk) and degree of complexity of scientific knowledge (SK):

$$\frac{(\text{total UA degree X IntraSK x X}) + (\text{total UA degree X CSk x X}) + (\text{total UA degree X SK x X})}{(\text{total UA IntraSK x highest degree}) + (\text{total UA CSk x highest degree}) + (\text{total UA SK x highest degree})}$$

Exemplifying with the data obtained in the study of the pedagogic discourse of the *Essential Competences*:

$$\frac{(7x1+1x2+9x3+9x4) + (2x1+10x2+11x3+28x4) + (8x1+9x2+11x3)}{104 + 204 + 84} = 0.76$$

9. Computing the partial index regarding intra-disciplinarity (IntraSK):

$$\text{IntraSK} = \frac{(\text{UAdegree1x1}) + (\text{UAdegree2x2}) + (\text{UAdegree3x3}) + (\text{UAdegree4x4})}{(\text{total UA x highest degree})}$$

Exemplifying with the data obtained in the study of the pedagogic discourse of the *Essential Competences*:

$$\frac{7x1+1x2+9x3+9x4}{26x4} = 72/104 = 0.69$$

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REFERENCES

Alves, V. (2007). *O currículo, o software didáctico e a prática pedagógica: Análise sociológica de textos e contextos do ensino das ciências*. Master's Dissertation, Portuguese Catholic University, Lisbon.

Andrich, D. (2002). A framework relating outcomes based education and the taxonomy of educational objectives. *Studies in Educational Evaluation, 28,* 35-59.

Apple, M. (2004). *Ideology and curriculum*. New York: Routledge.

Bybee, R., & Scotter, P. (2007). Reinventing the science curriculum. *Educational Leadership, 64*(4), 43-47.

Bernstein, B. (1990). *Class, codes and control: Volume IV, The structuring of pedagogic discourse*. London: Routledge.

Bernstein, B. (1999). Vertical and horizontal discourses: an essay. *British journal of Sociology of Education, 20* (2), 157-173.

Bernstein, B. (2000). *Pedagogy, simbolic control and identity: Theory, research, critique.* London: Rowman & Littlefield.

BouJaoude, S. (2002). Balance of scientific literacy themes in science curricula: The case of Lebanon. International *Journal of Science Education, 24* (2), 139-156.

Brandwein, P., Watson, F., & Blackwood, P. (1958). *Teaching high school science: A book of methods*. New York: Harcourt Brace Jovanovich.

Brandwein, P., Cooper, E., Blackwood, P., Cottom-Winslow, M., Boeschen, J., Giddings, M., Romero, F., & Carin, A. (1980). *Concepts in science* (Curie Edition). New York: Harcourt Brace Jovanovich.

Calado, S. (2007). *Currículo e manuais escolares: Processos de recontextualização no discurso pedagógico de Ciências Naturais do 3º Ciclo do Ensino Básico*. Master´s Dissertation, Department of Education of the School of Science, University of Lisbon.

Calado, S., & Neves, I. P. (2012). Currículo e manuais escolares em contexto de flexibilidade curricular: Estudo de processos de recontextualização. *Revista Portuguesa de Educação* (in print).

Cantu, L. L., & Herron, J. D. (1978). Concrete and formal Piagetian stages and science concept attainment. *Journal of Research in Science Teaching*, 15 (2), 135-143.

Castro, S. (2006). *A construção da ciência na educação científica do ensino secundário; Análise do programa de Biologia e Geologia do 10º ano*. Master´s Dissertation, Department of Education of the School of Science, University of Lisbon.

DEB (Department of Basic Education) (2001). *Currículo nacional do ensino básico – Competências essenciais*. Lisbon: Ministry of Education.

DEB (Department of Basic Education) (2002). *Ciências físicas e naturais – Orientações curriculares para o 3º ciclo do ensino básico*. Lisbon: Ministry of Education.

DeBoer, G. E. (2000). Scientific literacy: Another look at its historical and contemporary meanings and its relationship to science education reform. *Journal of Research in Science Teaching, 37* (6), 582-601.

Dillon, J. (2009). On scientific literacy and curriculum reform. *International Journal of Environmental & Science Education*, *4*(3), 201-213.

Domingos, A. M. (now Morais) (1989a). Conceptual demand of science courses and social class. *In* P. Adey (Ed.), *Adolescent development and school science* (pp. 211-223). London: Falmer Press.

Domingos, A. M. (now Morais) (1989b). Influence of the social context of the school on the teacher's pedagogic practice. *British Journal of Sociology of Education*, *10* (3), 351-366.

Erickson, H. (2007). *Concept-based curriculum ans instruction for the thinking classroom.* California: Corwin Press.

Feinstein, N. (2010). Salvaging science literacy. *Science Education*, *95*(1), 168-185.

Ferreira, S. (2007). *Currículos e princípios ideológicos e pedagógicos dos autores – Estudo do currículo de Ciências Naturais do 3º Ciclo do Ensino Básico*. Master's Dissertation, Departament of Education of the School of Science, University of Lisbon.

Ferreira, S., Morais, A. M., & Neves, I. P. (2011). Science curricula design. Analysis of authors` ideological and pedagogical principles. *International Studies in Sociology of Education*, *21* (2), 137-159.

Ferreira, S., & Morais, A. M. (2012). Conceptual demand of practical work: Studying the curriculum for high school Biology and Geology. *Science Education*. (proposed for publication).

Gall, M. D., Borg, W., & Gall, J. P. (1996). *Educational research: An introduction.* New York: Longman.

Hurd, P. D. (1958). Science literacy: Its meaning for American schools. *Educational Leadership*, *16*, 13–16.

Kemp, A. C. (2002). Implications of diverse meanings for "scientific literacy". In B. A. Crawford (Ed.), *Proceedings of the 2002 Annual International Conference of the Association for the Education of Teachers in Science* (pp. 1202-1229). Pensacola, FL: AETS. Recovered at 2011, December 03, from <http://www.eric.ed.gov/PDFS/ED465602.pdf>

Krathwohl, D. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice*, *41* (4), 212-218.

Laugksch, R. C. (2000). Scientific literacy: A conceptual overview. *Science Education*, *84*(1), 71-94.

Marzano, R. J., & Kendall, J. S. (2007). *The new taxonomy of educational objectives* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Millar, R., & Osborne, J. (1998). *Beyond 2000: Science education for the future*. London: King's College London School of Education. Recovered at 2005, December 19, from <http://www.kcl.ac.uk/depsta/education/publications/be2000.pdf >.

Morais, A. M. (2002). Basil Bernstein at the micro level of the classroom – Looking at results of research. *British Journal of Sociology of Education, 23*(4), 559-569.

Morais, A. M., & Neves, I. (2001). Pedagogic social contexts: Studies for a sociological of learning. *In* A. Morais, I. Neves, B. Davies, & H. Daniels (Eds.), *Towards a sociology of pedagogy: The contribution of Basil Bernstein to research*, 185-221. New York: Peter Lang.

Morais, A. M., Neves, I. P., & Pires, D. (2004). The *what* and the *how* of teaching and learning: Going deeper into sociological analysis and intervention. *In* J. Muller, B. Davies & A. Morais (Eds.), *Reading Bernstein, Researching Bernstein*, 75-90. London: Routledge & Falmer.

Morais, A. M., & Neves, I. P. (2010). Basil Bernstein as an inspiration for educational research: Specific methodological approaches. *In* P. Singh, A. Sadovnik & S. Semel (Eds.), *Toolkits, translation devices and conceptual accounts: Essays on Basil Bernstein's sociology of knowledge* (Chap. 2). New York: Peter Lang.

Morais, A. M., & Neves, I. P. (2011). Educational texts and contexts that work: Discussing the optimization of a model of pedagogic practice. *In* D. Frandji & P. Vitale (Eds.), *Knowledge, pedagogy & society: International perspectives on Basil Bernstein`s sociology of education* (Chap. 12). London: Routledge.

Morais, A. M., & Neves, I. P. (2012, June). Vertical discourses and science education: Analyzing conceptual demand of educational texts. Paper presented at the *7th International Basil Bernstein Symposium*, Aix-en-Provence, France.

Neves, I., & Morais, A. M. (2001). Texts and contexts in educational systems: Studies of recontextualising spaces. *In* A. Morais, I. Neves, B. Davies, & H. Daniels (Eds.), *Towards a sociology of pedagogy: The contribution of Basil Bernstein to research*, 223-249. New York: Peter Lang.

Neves, I. P., & Morais, A. M. (2006). Processos de recontextualização num contexto de flexibilidade curricular – Análise da actual reforma das ciências para o 3º ciclo do ensino básico. *Revista de Educação, XIV* (2), 75-94.

OECD (Organisation for Economic Co-operation and Development) (1999). *Measuring student knowledge and skills – A new framework for assessment.* Paris: OECD.

Shayer, M., & Adey, P. (1981). *Towards a science of science teaching: Cognitive development and curriculum demand*. London: Heinemann Educational Books.

Tashakkori, A., & Creswell, J. W. (2007). The new era of mixed methods. *Journal of Mixed Methods Research, 1*(1), 3-7.

Vygotsky, L. (1978). *Mind in society – The development of higher psychological processes*. Cambridge: Harvard University Press.

Wheelahan, L. (2010). *Why knowledge matters in curriculum: A social realist argument*. London: Routledge.

Young, M. (2008). From constructivism to realism in the sociology of the curriculum. *Review of Research in Education*, *32* (1), 1-28.

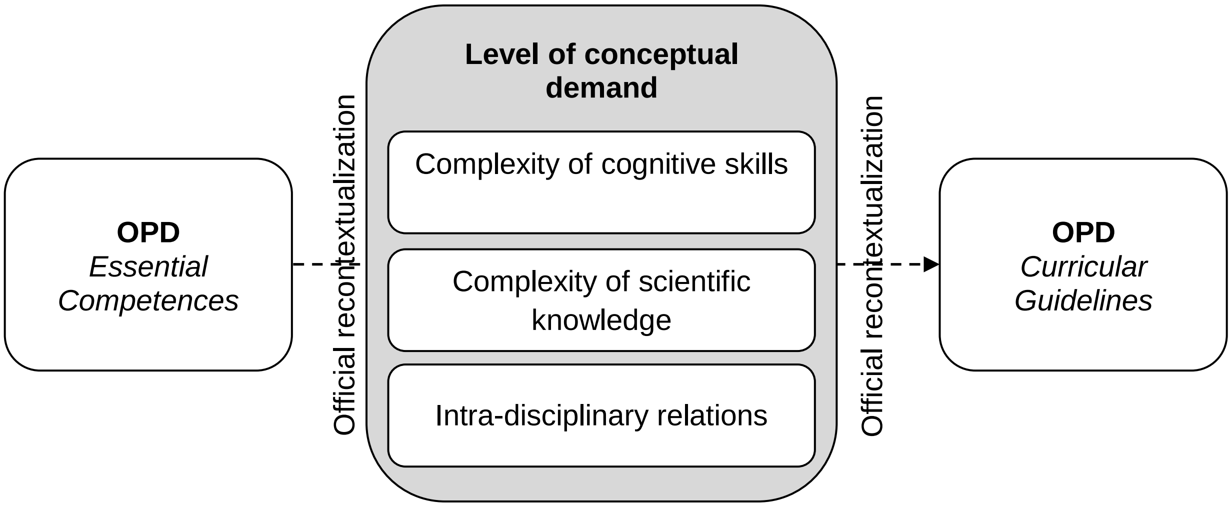
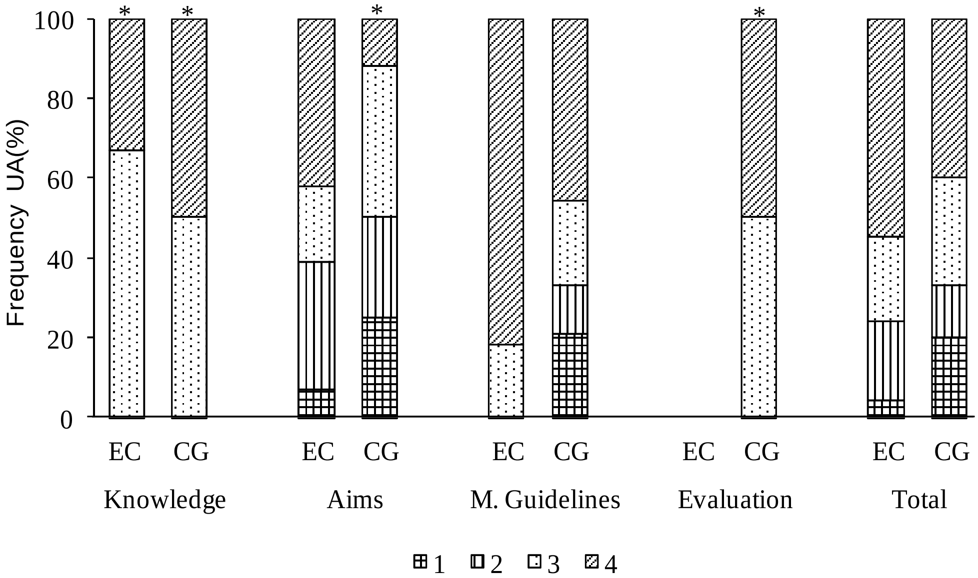
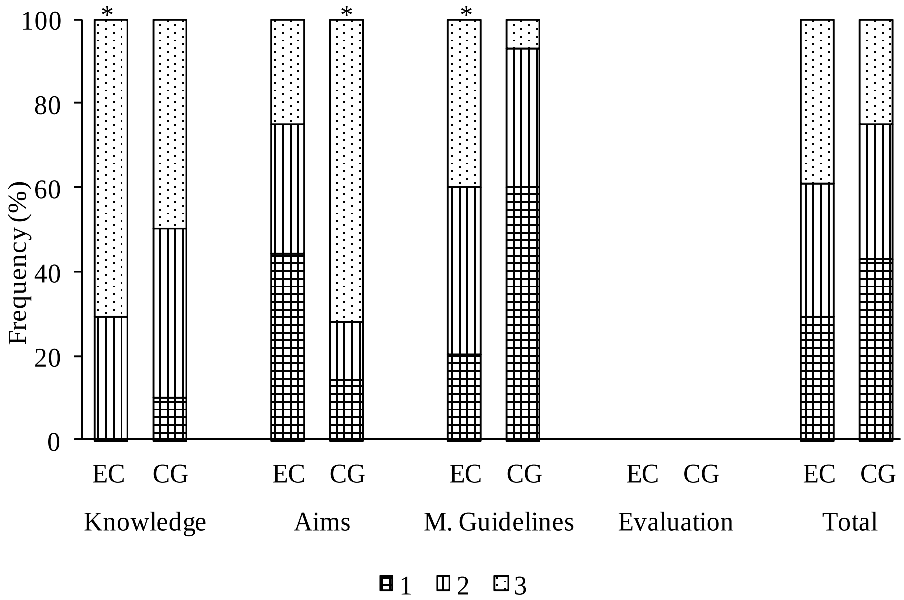


Figure 1 – Level of conceptual demand of the OPD present in the two curricular documents and respective recontextualizing processes.



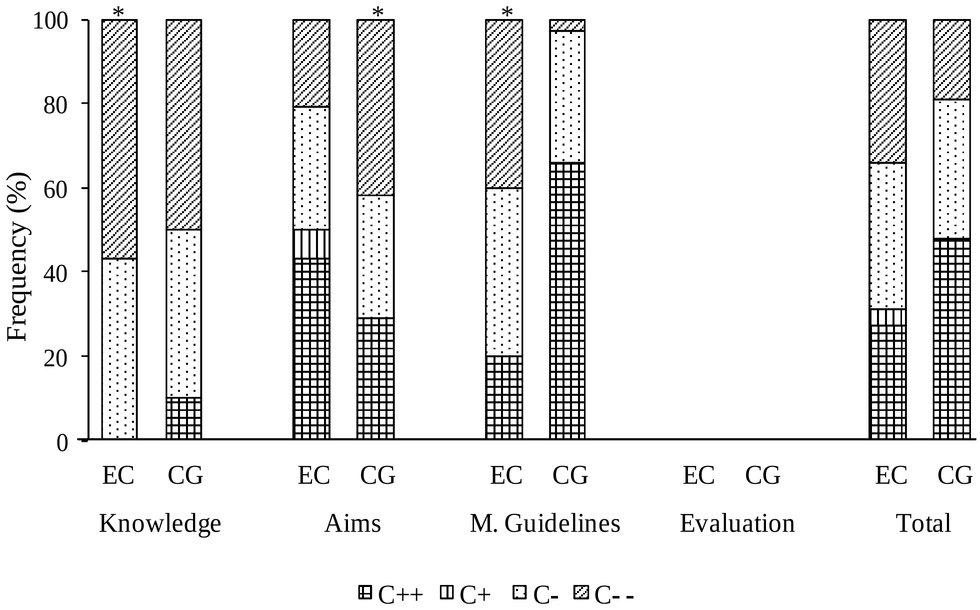
* Units of analysis (UA) < 10

Figure 2 – Degree of complexity of cognitive skills in the curricular documents *Essential Competences* (*EC)* and *Curricular Guidelines* (*CG*).



* Units of analysis (UA) < 10

Figure 3 – Degree of complexity of scientific knowledge in the curricular documents *Essential Competences* (*EC)* and *Curricular Guidelines* (*CG*).



* Units of analysis (UA) < 10

Figure 4 – Intra-disciplinary relations between distinct scientific knowledges in the curricular documents *Essential Competences* (*EC)* and *Curricular Guidelines* (*CG*).

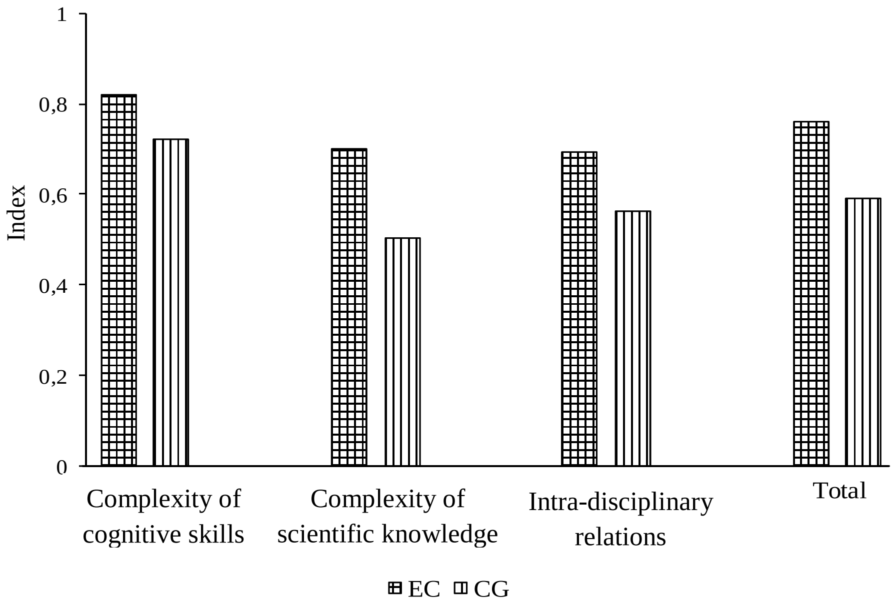


Figure 5 – Level of conceptual demand of curricular documents *Essential Competences* (*EC*) and *Curricular Guidelines* (*CG*) when they are considered as a whole and as given by each one of the three dimensions.

Conceptual demand of science curricula
A study at the middle school level

Abstract

This paper addresses the issue of the level of conceptual demand of science curricula by analyzing the case of the current Portuguese Natural Sciences curriculum for middle school. Conceptual demand is seen in terms of the complexity of cognitive skills, the complexity of scientific knowledge and the intra-disciplinary relations between distinct knowledges within the same discipline. The paper also analyzes recontextualizing processes that may occur within the official recontextualizing field. Theoretically it is based on Vygotsky's ideas and Bernstein's theory of pedagogic discourse and uses a mixed methodology.

The results show that the document with the broad guidelines of the curriculum contains a relatively high level of conceptual demand in terms of the three dimensions of the conceptual demand studied. This message is recontextualized, in the direction of decreasing its conceptual demand, in the document with specific guidelines.

The article explores consequences, in terms of *all* students' scientific literacy, of the low level of conceptual demand recommended by the document with specified pedagogic guidelines, since teachers and textbook's authors rely mostly on this official text to guide their practices and texts. In methodological terms, the study explores assumptions used in the analysis of the level of conceptual demand and presents innovative instruments constructed for developing this analysis.

Key-words: Level of conceptual demand; Curriculum; Recontextualizing processes; Science education.