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Teaching for the Contextualised Learning of Science: A Checklist-Based Science Curriculum Analysis

Sofia Morgado[1], Laurinda Leite[2] and Luís Dourado[3]

[1] *University of Minho, Portugal, sofiamorgado@ie.uminho.pt, ORCID ID: 0000-0002-3777-5761*
[2] *University of Minho, Portugal, ORCID ID: 0000-0003-4713-3815*
[3] *University of Minho, Portugal, ORCID ID: 0000-0003-3888-5409*

ABSTRACT
Contextualised learning is required for learners to master successfully the 'big ideas' of science and to perceive the relevance of science education. Science curricula can either foster or impair teaching for contextualised learning depending on what science they plan to be taught and the way they recommend this to be done. This paper presents an analysis of the Portuguese science curriculum that aims at ascertaining whether it promotes science teaching for contextualised learning. Data collected through a checklist-based content analysis showed that the curricular documents analysed include instances related to the contextualisation of science. However, the analysis also revealed differences between the various curriculum documents, which can be puzzling for science teachers and limit the impact of the science curriculum recommendations on teachers' teaching practices. Thus, action should be taken to increase consistency among science curriculum documents so that the recommendations relative to teaching for contextualised learning become more effective for the benefit of 21st century pupils. This study made use of an original checklist that other researchers can use and modify to extend its scope and reliability.

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Introduction

School science education is a key educational area that affects the development of what has been addressed as 21st century competences (European Commission/EACEA/Eurydice, 2017; OECD, 2018a; Oldham, Price, 2020). An analysis of the literature (Hodson, 2009, 2010; Leite et al., 2020; Taber, 2017) shows that two main sets of arguments have been put forwards to support this idea. One of them concentrates on the relevance of scientific literacy for citizens living in modern scientific and technologically advanced societies (Chowdhury et al., 2020; Holbrook, Rannikmae, 2017; Sánchez Tapia, 2020; Sharon, Baram-Tsabari, 2020). In this regard, it is stated that they need to understand the key scientific ideas so that they can not only benefit from science without putting (or continue putting) the planet at risk but also engage in informed socio-scientific debates in order to reach thoughtful decisions (Chowdhury et al., 2020; Hobbs, 2020; Sánchez Tapia, 2020; Sharon, Baram-Tsabari, 2020). The other set of arguments focuses on the need to prepare and attract people for scientific and technological careers so that sustainable scientific progress can continue (EC, 2020; European Commission/EACEA/Eurydice, 2022; Holbrook, Rannikmae, 2017; Ma, Spector, 2020).

However, over the last decades, a growing worldwide concern can be perceived among researchers, educators and politicians towards the fact that school science education is not able to attract enough students for science and technology careers (EC, 2020; Kotkas et al., 2021; OECD, 2018). A progressive drop can generally be observed in the proportion of pupils who express positive views about science and technology when moving up from primary school to the upper secondary level (Hasni, Potvin, 2015; Steidtmann et al., 2022).

Awareness of this problem was raised fifteen years ago by a European Commission report stating that Europe needs more scientists to secure its future in both scientific and economic terms (EC, 2007). But the problem remains (OECD, 2019). Several questions arise as to why young people do not engage in or even avoid science careers (Leite, 2017; Oldham, Price, 2020; Taber, 2017). A few possible answers to those questions focus on teachers and teaching. Teachers exert a significant direct influence on pupils through the teaching approach they adopt (Bray et al., 2020; Wegner & Schmiedebach, 2020), the power they have to inspire their pupils (Badri, 2019; Todd, 2020), and the influence they exert on learners' career expectations (EC, 2020; Kotkas et al., 2021, Tian et al., 2020).

Indeed, when moving from primary to secondary school, phenomena-based teaching approaches seem to be often replaced by teaching approaches focused on memorisation and shaped by demanding syllabuses (Leite, 2017; Tufail, Mahmood, 2020) and national terminating assessments at the end of secondary schooling (Leite, 2017). The situation has not changed significantly for the better and too few pupils are currently choosing science subjects in their final years of school (EC, 2015; Kotkas et al., 2021; Palmer et al., 2017) and afterwards (OECD, 2018b). A reason for this failure may have to do with curriculum developers' difficulty in achieving an appropriate balance between avoiding elitist polices and promoting excellent science teaching in order to attract students into science. A consequence is that even though learners recognise the overall usefulness of science, they can hardly perceive the relevance of school science knowledge to their daily lives (EC, 2011, 2015; European Commission/ EACEA/Eurydice, 2022; Sánchez Tapia, 2020; Sánchez Tapia et al., 2018; Sheldrake et al., 2019). In addition, they do not feel confident enough to engage in science courses (EC, 2015; Sheldrake et al., 2019) partly due to a gap between students' learning interests and curriculum contents (Todd, 2020). This impairs a positive correlation between students' interests and life experiences and their attitudes towards science and technology (Chowdhury, 2020).

Thus, a change in the way science education is practised is required in order to give learners the opportunity to appreciate how science relates to their daily lives (Chowdhury, 2020), perceive the characteristics of the scientific enterprise (Todd, 2020) and value scientific careers (EC, 2020). They need to learn the 'big ideas' of science (Harlen, 2010) by engaging in contextualised science, i.e., they need to actively engage in science learning that focuses on the ideas embedded in contexts that they perceive as being significant (Aydin-Ceran, 2021; Gilbert, 2006; Holbrook, Rannikmae, 2017; King, 2012; Picardal, Sanchez, 2022; Wiyarsi et al., 2020).

"Contexts are focal events" embedded in pupils' cultural settings (Gilbert, 2006, p. 960) that bring closer together two worlds - the world of the community of the learner and the science world (King, 2012). Contexts should be chosen in a way as to enable a pertinent selection of the concepts to be taught, so that pupils can learn the key relevant concepts without feeling lost or overloaded with non-relevant facts and ideas of the moment (Gilbert, 2006).

Contexts selected to teach one or more related school subjects should be consistent with learners' interests, foster an interrelationship between the diverse prescribed concepts, promote the transferability of concepts from the context in which they are learned to other contexts, and raise learners' interest and commitment with regard to science learning (Leite et al., 2017). Additionally, an educationally valuable context (whether real or simulated) should foster the pupil-teacher interaction, as this is required to introduce the language and concepts to be learned, and to promote the use of pupils' prior knowledge (Gilbert, 2006). In the latter case, special attention needs to be paid to knowledge that needs to be reconstructed or developed, in order to enable its integration into meaningful conceptual networks (Leite et al., 2017) that are consistent with the scientific accepted version of the moment.

Gilbert (2006) described different models of contextualisation, which have different learning outcomes. As shown in Leite et al. (2017), they can be put into practice through different teaching approaches but socio-scientific problems are at the heart of all of them. However, if the most advanced model (based on the idea of context as social circumstances) is to be implemented, then context-based science education should begin with a problem, associated with a real-world fact or phenomenon, embedded in its multifactorial conditions. This would provide a base for scientific explanations to be built on (King, 2012) and for pupils to understand facts or phenomena in their real-world contexts and in turn to perceive the relevance of science to their daily lives (Broman, 2020; Poerwanti, Istiyati, 2019; Sánchez Tapia et al., 2018; Sánchez Tapia, 2020).

Moving from traditional teaching to context-based learning requires major changes to the way in which science teaching is carried out (Dolfing et al., 2020; Giamellaro, 2014; Román et al., 2020). It requires a systemic and sustainable reform, achievable only if schools, teachers and learners can cope with the big demands that it puts on them. Thus, this reform should act upon two groups of factors that have an impact on pupils' subject choices: "intrinsic factors relating to the students themselves and their preferences, and extrinsic factors relating to the environment within which subject choice is made." (Palmer et al., 2017, p. 646). Teaching quality and curriculum content are examples of external interrelated factors that need to be seriously considered to increase pupils' likelihood of choosing a science subject or a science programme (European Commission/EACEA/Eurydice, 2022) and to actively engaging in context-based learning (Sadi Yılmaz et al., 2022). Therefore, the success of such a complex and multi-factorial reform would require consistent policy decisions and curriculum reorientations.

The official curriculum of a country is a standard reference document for teachers and curriculum materials developers (Alsubaie, 2016; Kelly, 2004; Ornstein, Hunkins, 2018) such as textbook writers (Syeed, 2019). It is supposed to work as a guide for teachers with regard to what their pupils are expected to learn and consequently to what they are supposed to teach. Curriculum types can range from prescriptive curricula, which does not require teachers to take any major decisions before putting them into practice, to open curricula that offer broad and flexible guidelines to teachers who are supposed to adapt them to the variety of environments and learners they encounter. The more flexible the curriculum is, the more demanding it is for teachers because a flexible curriculum requires them to take decisions on how to reinterpret and to adapt the curriculum to reach the best fit to the diversity of needs of their pupils. However, the more flexible the curriculum is, the more chances it provides of being adapted to the characteristics of the target students for the sake of better learning.

The curriculum can be composed of a single document (including study plan, learning goals, syllabuses, etc.) or a set of interrelated documents, namely the overarching curriculum, including the study plan, curriculum standards, curriculum goals, curriculum guidelines, etc. Whatever its composition, the curriculum for a certain school level should provide information on issues such as school subjects to the taken by the pupils, disciplinary and cross disciplinary learning outcomes, content to be addressed in each school subject, and teaching methodologies to be followed by the teachers (Alsubaie, 2016; Kelly, 2004; Ornstein & Hunkins, 2018).

Most European countries recommend that science should be taught in contexts that relate to contemporary societal issues (EC, 2011; European Commission/EACEA/Eurydice, 2022). If curricula are to promote contextualised learning, they should provide guidelines for teachers to plan their teaching accordingly, which requires planning incorporating elements from the pupils' environment. Thus, broad and flexible curricula would be the most appropriate for teachers to implement teaching for contextualised learning within a heterogeneous country. However, it can be argued that prescriptive curricula can also promote teaching for contextualised learning if they allow teachers to adjust their learning goals, the content they teach, the methodological guidelines they refer to and the support bibliography they recommend. Hence, if a national curriculum is involved, it is important that curriculum guidelines are broad and flexible in order to enable teachers to fit them to their own school surroundings.

To implement a broad and flexible curriculum consistently with a breaking underlying philosophy, teachers would need training (Dolfing et al., 2020; Román et al., 2020; Sadi Yılmaz et al., 2022) and support to face the challenges of breaking the status quo that has characterised science education. To implement teaching for contextualised learning under the scope of a flexible curriculum would be more straightforward, especially if textbooks, a teaching resource that teachers are heavily dependent on (Knight, 2015), are also aligned with the philosophy of the curriculum (Poerwanti, Istiyati, 2019; Syeed, 2019). In any case, consistency within and among curriculum documents would be important to convey teachers a strong message in favour of teaching for contextualised learning.

Research Objectives

Before 2000, the Portuguese curricula for the diverse school levels were essentially restricted to a study plan and the syllabuses of the diverse school subjects consisted of lists of topics to be taught. There was neither an explanation of the underlying philosophy of the curriculum nor recommendations on how to conceptualize and approach teaching and learning of the school subjects. In 2001, new curricula and syllabuses came into effect. With regard to 3rd cycle (7th to 9th grade, 12 to 15 years old), a National Curriculum including two school science subjects (Physical Sciences, that encompasses physics and chemistry issues, and Natural Sciences that include biology and geology issues) was put into force. The philosophy of the National Curriculum as well as the one of the science subjects' curriculum guidelines (which take the place of syllabuses but are more flexible than these are) was consistent with international science education perspectives, acknowledged pupils' previous knowledge, and a Science, Technology and Society (STS) perspective. The idea was that teachers should be cognisant of pupils' alternative conceptions and at the same time should relate science concepts to everyday socio-scientific issues. By following the curriculum guidelines, teachers were expected not only to facilitate pupils' conceptual change but also to lead them to perceive how science relates to everyday life as well as to the natural environment.

During the last decade, the Portuguese government approved few additional curriculum-related documents, including the Compulsory education pupils' profile, which makes it explicit the competences and values to be developed by the students. This states that learning has to be contextualised so that pupils can perceive that science knowledge is relevant for citizens' daily lives, as well as for the sustainable development of the planet.

The objective of this research was to ascertain whether or not the Portuguese 3rd cycle curriculum (taken as a set of related curricular documents, such as the national curriculum and curricular guidelines) promotes teaching for contextualised learning. Before doing so, a checklist to analyse the way curricular documents deal with contextualisation had to be developed. This checklist will be used to get the results needed to attain the research objective and it may be internationally useful as a basis for carrying out similar analyses elsewhere.

It is worth carrying out this sort of analysis to uncover the goals to be achieved at a certain educational stage and the philosophy that underpins them because teachers are supposed to follow them when planning (what to teach and the way it should be taught) and teaching their classes, and pupils' learning should be assessed by reference to them.

Methods

The Selected Portuguese Curriculum Documents

As far as 3rd cycle of basic education (7th to 9th grade, i.e. 12 to 15 years old) in Portugal is concerned, there are five types of curriculum documents, some of them covering one school discipline (natural sciences or physical sciences) and others covering two (natural sciences and physical sciences). This leads to seven documents, which are introduced in Table 1: one national curriculum, one curriculum guidelines (i.e., syllabuses), two school subject standards, one compulsory education pupils' profile and two learning goals. It is worth noting that the first two documents have been revoked (Dispatch n.º 17169/2011) but they were not replaced by other ones with similar scope.

Therefore, those documents continue having impact on curriculum development and were considered for the purpose of this study. Hence, Table 1 describes the curriculum documents, produced since 2001, that are supposed to guide teachers' teaching actions and were used in this study. However, when a document addresses several cycles of study (e.g., Basic Education National Curriculum), the analysis focused on the parts that are relevant for the 3rd cycle only.

Table 1

Curricular Documents Used in the Study

Code	Documents	Description
A	Basic Education National Curriculum (1st to 9th grade)	Provides a set of key competences to be developed up to the 9th grade all over the country. It includes cross curriculum competences, to be developed through all the curriculum subjects, and discipline-based competences to be developed through each curriculum area or school subject, in each of the three basic school levels.
B	Physical and Natural Sciences Curriculum Guidelines - 3rd cycle	This is a sort of syllabus that provides information about content knowledge to be addressed and general methodological ideas to be followed when teaching the national Physical and natural sciences curriculum themes. As Natural Sciences and Physical Sciences must cover the same themes, they are presented side by side so that similarities and differences are highlighted. They are named Curriculum Guidelines instead of syllabuses, as they are intended to permit a flexible implementation, namely with regard to the sequence of topics to be followed.
C	Physical Sciences Curriculum standards - 3rd cycle (Dispatch n.º 5122/2013)	Set of content knowledge learning outcomes to be reached and abilities to be developed by Physical Sciences pupils in each 3rd cycle grade. They emphasise the Physical Sciences key curriculum priorities.
D	Natural Sciences Curriculum standards- 3rd cycle (Dispatch n.º 5122/2013 and Dispatch n.º 110-A/2014)	Set of content knowledge learning outcomes to be reached and abilities to be developed by Natural Sciences pupils in each 3rd cycle grade. They emphasise the Natural Sciences key curriculum priorities.
E	Compulsory education pupils' profile (1st to 12th grade) (Decree-law n.º 55/2018)	A matrix of principles, vision, values and areas of competences that compulsory school curriculum development should promote in order to enable the intended compulsory education pupils' profile.
F	Physical Sciences basic learning goals - 3rd cycle (Dispatch n.º 6944-A/2018)	Set of main content knowledge issues to be mastered and attitudes to be developed by Physical Sciences pupils in each 3rd cycle grade. They emphasise the Physical Sciences key curriculum priorities according to the pupils' intended profile. In addition, they provide a rational for the school subject as well as a set of strategic actions targeted to the development of the areas of competency encompassed by the pupils' profile.
G	Natural Sciences basic learning goals - 3rd cycle (Dispatch n.º 6944-A/2018)	Set of main content knowledge issues to be mastered and attitudes to be developed by Natural Sciences pupils in each 3rd cycle grade. They emphasise the Natural Sciences key curriculum priorities according to the pupils' intended profile. In addition, they provide a rational for the discipline as well as a set of strategic actions targeted to the development of the areas of competency encompassed by the pupils' profile.

Development of a Checklist to Analyse the Content Relative to Contextualisation in Science Curriculum Documents

The objective of this section is to describe the process of construction and validation of a checklist that will be used for data collection purposes afterwards. A checklist was developed through a methodology that compares to the ones used by Chin et al. (2007), Leite (2002), Leite et al. (2012) and Ozmantar (2017). This includes getting support from the literature and performing a sequence of tentative analyses of the set of curricular documents to get useful information to improve the accuracy of the checklist (e.g., by replacing, redefining or splitting the initial dimensions) and get the best fit to the set of curricular documents to be analysed. Only after this process of checklist development and validation is concluded, can the analysis for data and results purposes be performed.

Thus, acknowledging McMillan and Schumacher (2014) recommendations, after having identified the documents to be analysed, the first step consisted of a 'floating reading' to become aware of their structure and content. When doing this sort of reading on should bear in mind relevant literature on the topic in order to find out which topics emerge. Each topic indicates an issue to be analysed, that is a dimension to be included in the checklist and considered in the overall analysis. Nine dimensions were identified (see Table 2): dimensions D1 to D4 focus on two types of knowledge to be developed through science teaching for contextualised learning, that is science knowledge and knowledge about science; dimensions D5 to D7 focus on methodological approaches used within the scope of contextualised learning, that is on procedures related to doing science; dimensions D8 and D9 focus on the development of lifelong learning competences by engaging in the contextualised learning of science. This first version of the checklist was used to perform an exploratory analysis of the curriculum documents given in Table 1, in order to find out whether dimensions would need to be split into a few sub-dimensions and their definitions would need to be improved.

The exploratory analysis indicated that sub-dimensions were needed in order to improve the objectivity and the accuracy of the information that emerges from the analysis. Based on the results of the exploratory analysis and the literature reviewed on contextualised science teaching, sub-dimensions were settled for each dimension (see Table 2). The meaning of each dimension was improved with support in the exploratory analysis and the relevant literature as shown below and the questions underlying each dimension where made explicit. These questions increase the focus of the information collected and provide guidance for data presentation and discussion. The meaning of the dimensions and the questions associated to them are summarised as follows:

D1. Use of real settings: this dimension has to do with the basics of contextualised science learning. Gilbert (2006) points out everyday real settings are at the heart of science teaching for contextualised learning. Thus, curriculum documents should be expected to advocate the use of out of school science teaching so that pupils could learn science directly on and from real settings (Holbrook & Rannikmae, 2017; King, 2012), including social and cultural settings and oral tradition such as the one related to proverbs (Leite et al., 2019). Data will provide an answer to the following question: do Portuguese curriculum documents advocate the use of out of school science teaching so that pupils could learn science directly on and from real settings?

D2. Use of representations of real settings: this dimension focuses on the indirect contact with real settings. It is an alternative to the former dimension and it may be useful when direct contact with reality is not possible for the geographic or temporal distance of the phenomena or even for its magnitude (King, 2012; Leite et al., 2016; Liono et al., 2021). Data will provide an answer to the following question: do Portuguese curriculum documents advocate the use of representations of real settings? If yes, under what conditions do they advocate its use?

D3. Use of socio-scientific problems: this dimension has to do with the use of problems that emerge from controversial science, technology and society interactions (Chowdhury et al., 2020; Hodson, 2010; Holbrook, Rannikmae, 2017; Karakaş, 2022, Reis, 2013) or from scientific research results which may or may not be controversial (Holbrook, Rannikmae, 2017). The kinds of problems that the mass media usually brings to citizens' daily life have scientific groundings and strong social implications, which often provoke people's strong emotional engagement. King (2012) argues that contextualised teaching of science based on socio-scientific issues leads learners to learn scientific contents meaningfully from and through their own local contexts. Besides, it may lead them to understand and form an opinion on current controversial issues such as climate change, energy crisis (Martin et al., 2017), food provision or water supply. Data will provide an answer to the following question: do Portuguese curriculum documents advocate the use of socio-scientific problems?

D4. Use of historical settings: some science concepts and ideas are understood better in the historical setting they were created and developed (Harlen, 2010). This is especially true for attaining two objectives: learning about the nature of science and scientists, which Hodson (1988, 2010) addresses as learning about science; and learning about how and why new science ideas were accepted or rejected by the society of the time. Actually, a few authors (Kato, Kawasaki, 2011; Clough, 2017; Martins, Mendes, 2017) have argued that the history of science provides appropriate settings to developing contextualised epistemological learning of science, as it enables pupils to be acquainted with the context of the times. Data will provide an answer to the following question: do Portuguese curriculum documents advocate the use of historical settings? If yes, what do they advocate?

D5. Engagement with context-based science knowledge construction processes: one of the goals of science education is what Hodson (1988) addresses as learning how to do science, which includes learning about the methods and processes used by scientists to produce and validate new knowledge. These methods may be rather different from those used by laymen in day-to-day situations. Therefore, they may be hard to understand and accept if pupils cannot both, get acquainted with them in the research environments where they are practised, and have the chance to confront them with their own day to day ways of building knowledge. This means that science knowledge construction processes should be learned in or from real settings (Gilbert, 2006; King, 2012). Data will provide an answer to the following question: do Portuguese curriculum documents advocate the learning of science knowledge construction processes in or from real contexts?

D6. Use of cross-curricular approaches to real issues: in real (including professional) settings, all sciences act together and interact with other areas of knowledge to make things happen or be the way they are (Barnes, Cremin, 2018). Thus, real issues cannot be appropriately approached from the lens of a single discipline. An appropriate approach to deal with real issues requires a holistic cross-curricular multidisciplinary analysis of the issue embedded in the real setting in which it emerges. Data will provide an answer to the following question: do Portuguese curriculum documents advocate the use of cross-curricular approaches to deal with real issues? If yes, what do they advocate?

D7. Use real-world settings to promote the ability to reconstruct beliefs and conceptions: individuals develop ideas about natural phenomena, which depend on what they can observe (Piaget, 1979), and on the culture of the community they belong to (Pozo et al., 1991). The construction of these ideas is based on what Carrascosa Alís & Gil Pérez (1985) and Gil Pérez & Carrascosa Alís (1985) have addressed as the methodology of superficiality, which is characterised by acritical generalisation based on limited observations of the natural environment. To make pupils aware of the shortcomings of this methodology as well as of the ideas it engenders, they should be given the opportunity to explore familiar environments through a new and scientifically accepted methodology, to face settings that do not match their previous beliefs and conceptions or both. Any of these approaches would make them feel a cognitive conflict and the need to build knowledge in or from real settings and to improve their previous knowledge (Holbrook, Rannikmae, 2017). Data will provide an answer to the following question: do Portuguese curriculum documents advocate the use of real-world settings to promote pupils' reconstruction of their own beliefs and conceptions about the world?

D8. Use of social interaction as a scaffolder for socially relevant learning as Vygotsky (1930) showed many years ago, interaction with other people (either peers or experts) can work as a scaffolder to help the learner to go beyond the zone of proximal development. Thus, by interacting with other people, pupils should learn more and better than if they were on their own. Assuming that "a context is situated as a cultural entity in society" (Gilbert, 2006, p. 969) and that science teaching should lead learners to grasp the basics of science culture, it should promote bridge building between these two cultures (King, 2012). This bridge-building process requires fruitful communication between learners and members of the community, including laymen, professionals, local authorities, politicians, etc. This may enable pupils to perceive not only the relevance of science in and for society but also how societal needs and environmental issues foster the development of science and technology (Hodson, 2010). Besides, it will promote the development of competences that are relevant for pupils in the future as professionals and as active and responsible citizens (Holbrook, Rannikmae, 2017). Data will provide an answer to the following question: do Portuguese curriculum documents advocate the use of social interaction to promote learning?

D9. Promote an awareness of the features of contextualised learning: pupils should be asked to engage in self-evaluation processes so that they can monitor and take responsibility of their ongoing learning (Black, 2017). In doing so, they may acquire an awareness of the path they are following to learn which is beneficial for their contextualised learning (Vogelzang, Admiraal, 2017). This requires them to identify and compare the potential gains and the limitations of the various specific strategies used to learn in and from real contexts. This a valuable strategy not only to learn how to learn, but also to develop critical analysis and metacognitive competences which are necessary for decision making processes taking place in school and in the community. Data will provide an answer to the following question: do Portuguese curriculum documents advocate the analysis and monitoring of contextualised learning processes by science teachers?

Table 2 shows the checklist with its final dimensions aforementioned and their sub-dimensions, inspired by the exploratory analysis and the literature reviewed. Whenever necessary, a brief description accompanies the sub-dimensions in order to make their intended meaning more explicit.

Table 2

Checklist to Analysing Curriculum Documents with Regard to Contextualization

Dimensions and sub-dimensions (brief explanation)
D1. Use of real settings (Includes instances that require pupils to learn in and from a real and as familiar as possible context. Excludes instances that simply ask pupils to use previously acquired knowledge).
- *Natural environment* (landscape, dune, river, mountain, etc.)
- *Productive environment* (bakery, factory, farm, etc.)
- *Home environment* (food, detergents, clothes, decorative objects, etc.)
- *Professional laboratory* (clinical analysis laboratory room, laboratory equipment, people handling laboratory equipment, etc.)
- *Cultural items* (poetry, folk music, paintings, proverbs etc.)
- *Leisure places* (painting club, gymnasium, movie room, beach, etc.)
- *Historical places* (castle, medieval bridge, mythical fountain, etc.)
- *Informal science settings* (science museums, interactive science centres, zoos, botanic gardens, etc.)
- *Community services* (water supply station, waste collecting central, hospital, etc.)
- *Non-specified daily life situations* (general reference to daily life or everyday life)

Table 2 *(Continued)*

Dimensions and sub-dimensions (brief explanation)
D2. Use of representations of real settings (Includes instances that require pupils to learn from representations of real settings which cannot be directly accessed by themselves or that are no longer available). - *Media news* (newspapers, radio spots, TV clips, etc.) - *Reports on natural phenomena/events* (past or present reports) - *Photographs* (pictures, images, slides, etc.) - *Simulations* (computer simulations or roleplaying on real events) - *Video-clips* (videos, movies, etc.) - *Recorded music* (ethnographic or local music, etc.) - *Other*
D3. Use of socio-scientific problems (Includes instances that require pupils to learn by working on local socio-scientific problems. Excludes instances that require pupils to solve exercises by using previously acquired knowledge). - *Climate change* - *Disease control* - *Transport provision* - *Water supply* - *Waste management* - *Energy supply* - *Recycling* - *Hunger and food provision* - *Pollution* - *Natural disasters* - *Other*
D4. Use of historical settings (Instances that require pupils to analyse history of science documents and other materials and to learn from the context of the times). - *Scientists' biographies* - *Discovery reports* - *Historical science models* - *Historical experiments* - *Historical objects* - *Other*
D5. Engagement with context-based science knowledge construction processes (Instances that require pupils to learn how to do science in and from real research contexts). - *Problem posing* (questioning, problem formulation, etc.) - *Problem-solving* - *Project-development* - *Data collection* (observe, measure, control, etc.) - *Data analysis* (data handling, data computation, data interpretation, relating data, etc.) - *Knowledge application* (explaining, constructing, arguing, modelling, etc.) - *Drawing conclusions* (extrapolating, taking decision, systematizing, etc.) - *Other*
D6. Use of cross-curricular approaches to real issues (Instances that require pupils to use methodological approaches characteristics from two or more different school subjects and to use them in an integrated way). - *Physics and Chemistry* - *Physical and Natural Sciences* - *Geography and Geology* - *Natural Science and other knowledge areas* - *Other*
D7. Use real world settings to promote the ability to reconstruct beliefs and conceptions (Instances that do not fit pupils' previous beliefs and conceptions about the world and that require them to be modified). - *Cognitive conflict-based strategies* (testing beliefs and conceptions, comparing different conceptions, etc.) - *Developmental strategies* (pupil-cantered 'need to know' learning strategies, etc.) - *Other*

Table 2 *(Continued)*

Dimensions and sub-dimensions (brief explanation)
D8. Use of social interaction as a scaffolder for socially relevant learning (Instances that require pupils to interact with their peers as well as with other people, to make (better) sense of the world). - *Pupil- teacher(s)* - *Pupils - pupil* (work in pairs, teamwork, etc.) - *Pupils - community members* (focus groups, debates, etc.) - *Pupils - experts/professionals (*focus groups, discussions, etc.) - *Other*
D9. Promote the awareness of the features of contextualised learning (Instances that require pupils to analyse their ways of knowing to improve them in order to learn how to learn). - *Perform self-evaluation* - *Monitor the learning process* (learning weaknesses and strengths, feedback, etc.) - *Use remediation strategies* (ask for feedback, re-read, reanalyse, etc.) - *Other*

Data Collection

When the checklist was completed, categories were defined for each dimension/sub dimension, consistently with the nature of the latter. Afterwards, documents mentioned in Table 1 were content-analysed by two of the authors, separately, for the purpose of data production. Explicit and emerging meanings were considered. Tables per dimension of analysis (Table 2) were organised to register data collected. To perform data collection, authors read the documents and highlighted the parts that they felt have to do with contextualisation as expressed in the checklist. Afterwards, they compared both registers in order to find out whether there were some discrepancies between data obtained by each of them. Minor discrepancies were noted in the dimensions involving the use of real settings to teach science, and the use of knowledge construction processes. Then, discrepancies were discussed by the three authors, to reach a consensus on where and how to interpret and classify the excerpt under question.

Data Analysis

As mentioned in the previous section, data registered in the tables, organised per dimension of analysis, consist of presence/absence of the sub-dimensions of the dimension that is at stake. Based on the agreed data, the documents under question were qualitatively compared for relative predominance of the sub-dimensions of each dimension.

Instances that illustrate how curriculum-related documents may foster the issue of each dimension were selected and will be provided in the next section to enable the reader to verify the reliability of the analysis. They illustrate the categorisation carried out and support differences among documents. The origin of the quotations will be identified by the code given to the document, as in Table 1, followed by the original page number. Italics will be used to highlight the parts of the quotations that constitute evidence of each sub-dimensions.

Findings and Discussion

Data given in Table 3 show that all the official curriculum documents listed in Table 1 and that have been guiding science teaching in Portugal since the beginning of the 21st century seem to suggest the 'Use of real settings' for teaching science. However, they differ with regard to the sub-dimensions they emphasise. Document B (Physical and Natural Sciences Curriculum Guidelines) seems to consider more sub-dimensions especially compared with documents E (Compulsory education pupils' profile) and G (Natural Sciences basic learning goals - 3rd cycle). Besides, while evidence of the Natural environment sub-dimension was found in all the documents, three sub-dimensions (Cultural elements, Leisure places, Historical places) were not found in any of the documents. However, it should be noted that leisure places would be a good context in which to teach about motion and forces, and cultural and historical places could probably be used to teach about sustainability on earth, which are 3rd cycle Portuguese science curriculum themes. These results suggest that curriculum recommendations with regard to real settings may be more ad hoc suggestions than well-planned theory-based suggestions. Quite similar results were found by Ozmantar (2017), who concluded that only two of the nine mathematics curricula analysed asked teachers to create real-life learning contexts.

Table 3

Presence of the Use of Real Settings Sub-dimensions

Sub-dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Natural environment	X	X	X	X	X	X	X	*Characterise the school environmental surroundings* (dominant rocks, relief), based on data collected in the field. (G, nd)
Productive environment	X	X	X	-	-	-	-	Pupils may *visit paint and varnish factories* […]. (B, p.25)
Home environment	X	X	X	X	-	X	-	To design an action plan aiming at *reducing water consumption* at school *and at home* based on the European Water Charter. (D, p.22)
Professional laboratory	-	X	X	X	-	X	-	*Identify energy transfer processes taking place* in daily life *or in laboratory settings.* (C, p.12)'
Cultural environment	-	-	-	-	-	-	-	----
Leisure places	-	-	-	-	-	-	-	----
Historical places	-	-	-	-	-	-	-	----
Informal science settings	-	X	-	-	-	-	-	[…] organisation of a *visit to a Planetarium* […] (B, p.13)
Community services	X	X	-	-	-	X	-	To search about the use of separation techniques *to treat water for domestic consumption and to treat effluents* as well as about their importance for the balance of ecosystems and quality of life, and to share the conclusions. (F, nd)
Non-specified daily life	X	X	X	X	X	X	X	[..] to approach the diverse disciplinary contents by relating them to situations and *problems that belong to the pupil's daily life*. […] (E, p.31)

Finally, it should be emphasised that all the documents analysed require teachers to use pupils' daily life issues and problems to teach science content but they do it without providing concrete examples of what should be used for this purpose. Therefore, they leave at the teacher's discretion the decision of what daily life stances to choose and how to use the examples chosen. This may be a good option if teachers are trained to teach for contextualised learning which seems not to be the case in many countries (Davidsson, Granklint-Enochson, 2021; Dolfing et al., 2022; George, Lubben, 2002), including Portugal. If not, training would be required for them to do an appropriate and authentic selection of pupils' daily life issues.

According to data given in Table 4, the 'Use of representations of real settings' is present in five (A, B, E, F e G) of the seven curriculum documents analysed. Probably, the other two documents

(C - Physical Sciences Curriculum standards - 3rd cycle; D- Natural Sciences Curriculum standards - 3rd cycle) do not suggest the use of this type of representation because they deal with learning goals that pupils are supposed to achieve by the end of each science theme and or when they complete a given school level, and are not concerned with what to do to help pupils to achieve such goals.

As 3rd cycle pupils are supposed to learn about sound and acoustic phenomena, which young people usually enjoy outside school, it seems strange that there is not even a single mention of recorded music. As in other countries (Lee, 2010; Pozzer, Roth, 2003), most representations of the real world are there just for decorative purposes and present key entities in a decontextualized way. Audio-visual or digital material including representations of the natural world are seldom present in the documents analysed even though they may significantly improve pupils' achievement and interest (Ibe, Abamuche, 2019; Liono et al., 2021) especially when it is not possible to access reality or to reproduce it in the school laboratory.

Table 4

Presence of the Use of Representations of Real Settings Sub-dimensions

Sub-dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Media news	X	X	-	-	X	X	-	To analyse critically *newspapers and television news*, using science knowledge to approach daily life issues. (A, p.132)
Report on natural phenomena/events	-	X	-	-	-	-	-	To study volcanism and associated phenomena, the use of […] historical *reports on great volcanic eruptions* […] is suggested. (B, p.18)
Photographs	-	X	-	-	-	-	-	The *visualisation of photographs* or slides on minerals that are characteristic of a given environment and or certain rocks […]. (B, p.20)
Simulations	-	X	-	-	-	X	X	Pupils should […] *explore computer simulations* […], in which physics and chemistry are contextualised appropriately […]. (F, nd)
Video-clips	-	X	-	-	-	-	-	*Watching videos*, […] are examples of situations in which pupils are confronted with the dimensions of the Universe as well as with the different orders of magnitude of the distances within the Universe. (B, p.13)
Recorded music	-	-	-	-	-	-	-	----
Other	-	-	-	-	-	-	-	-----

As far as the 'Socio-scientific problems' dimension is concerned, instances of it were found in all the documents analysed (Table 5). However, no sub-dimension is present in all the documents and no instance of two of the sub-dimensions included in the checklist (Recycling and hunger and Food provision) was found in any of the documents. These sub-dimensions have to do with most contemporary world problems that could be used as contexts (or starting points) to teach some science curriculum content, and to develop pupils' competences in issues that are regarded as pressing for 21st century citizens (see European Commission/EACEA/Eurydice, 2017; OECD, 2018b).

Although these results are consistent with those obtained from the analysis of other curricula (Chowdhury et al., 2020, Reis, 2013; Zeidler et al., 2019), they are in contradiction with the European Commission's recommendations (EC, 2011) and with the guidelines for science teaching that emerge from recent research results (European Commission /EACEA/Eurydice (2022); Reis, 2013) that strongly argue for a socio-scientific dimension to be included in science education.

Table 5

Presence of the Use of Socio-Scientific Problems Sub-dimensions

Sub-dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Climate change	-	-	-	-	-	X	-	To recognise, in an interdisciplinary way, *climate changes* as one of the big environmental problems of the moment and to relate them with air pollution due to the increase of the amount of greenhouse gases. (F, nd)
Disease control	-	X	X	-	-	-	-	Pupils can do teamwork research […] on community and individual health issues, such as *medical assistance, vaccination, screenings, stress* […]. (B, p.32)
Transport provision	-	X	-	-	-	-	-	Development of projects focused on themes like […], (iv) *chemical products transport* and (v) increase of *road and rail networks* are suggested. (B, p.38)
Water supply	X	-	X	-	-	X	-	Pupils may engage in the project '*Water in my municipality*', approaching it from diverse perspectives: the origin of water; water as a life support; water consumption per capita and its evolution over time; local needs related to water including water use and treatment […]. (A, p.130)
Waste management	X	-	-	X	-	X	-	[…] create situations that lead to decision-making processes for individual and collective intervention leading to *material* and energetic *resources sustainable management*. (F, nd)
Energy supply	-	-	X	-	-	-	-	To identify *renewable and non-renewable energy resources*, to assess advantages and disadvantages of their use in nowadays society as well as their consequences for the sustainability of Earth. (C, p.11)
Recycling	-	-	-	-	-	-	-	----
Hunger and food provision	-	-	-	-	-	-	-	----
Pollution	-	-	-	-	-	X	-	[…] through inquiry, critically *assess the consequences of acoustic pollution for the human being*, suggesting measures to prevent and protect from it. (F, nd)
Natural disasters	-	-	-	-	-	-	X	*To discuss measures that may reduce the impact of natural disasters* as well as of disasters of anthropic origin on ecosystems, in general, and on ecosystem of the school surroundings, in particular. (G, nd)
Other	X	X	X	-	X	X	X	To do so, they mobilise values and competences that may enable them to intervene in the life and the history of the individuals and the societies, *take well-grounded and free decisions* on natural, social, and ethical issues and be able of active and conscious as well as responsibly civic participation. (E, p.10)

Table 6 shows that the dimension 'Use of historical settings' is present in all the documents analysed even though the same does not apply to a few of its sub-dimensions. In fact, suggestions dealing with scientists' biographies and historical experiments were not found in any of the documents analysed. Scientists' biographies could help pupils to understand a little bit better how scientific discoveries take place and help them to learn about science, which is one of the key dimensions of a well-balanced science education (Hodson, 1988) curriculum. Moreover, they would enable learners to perceive that science is a human enterprise that is influenced not only by the science practitioners themselves but also by their families, as well as by the technological and the historical and political context of the times (Leite, 2002). Similarly, historical scientific experiments could help pupils to understand better how science models are developed and why science is provisional, which McComas (2002) would consider important for pupils to get a more accurate and demystified image of science.

Table 6

Presence of the Use of Historical Settings Sub-dimensions

Sub-dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Scientists' biographies	-	-	-	-	-	-	-	----
Discovery reports	X	X	-	-	-	X	X	[…] the analysis of and discussion on *reports of scientific discoveries* is suggested. They should show successes and failures, persistence and ways of working of different scientists, influence of society on science […]. (B, p.6)
Historical science models	X	X	X	-	-	X	-	To characterise the *geocentric and the heliocentric models*, *framing them historically* (contribution of Ptolemy, Copernicus and Galileo). (C, p.4)
Historical experiments	-	-	-	-	-	-	-	----
Historical objects	-	-	-	-	-	X	-	To explain *the role of* observation and *instrumentation* in the historical evolution of knowledge about the Universe, through information search and selection. (F, nd)
Other	X	X	-	-	-	-	X	[…] creating the opportunity to carry out small pieces of research, individually or collaboratively, *dealing with the history of science*, which is plenty of those issues. (A, p.137)

Table 7 shows the results of the analysis relative to the dimension 'Engagement with context-based science knowledge construction processes'. It is present in all the documents analysed but the same does not apply to a few of its sub-dimensions.

Only the data analysis and the knowledge application sub-dimensions, that have to do with processes traditionally dealt with in science, are present in all documents. It is worth stressing that the first three dimensions in this table are the most innovative as they have to do with learner-centred sub-dimensions. Due to novelty, they are more demanding for pupils and more challenging for teachers. Teachers are not accustomed to asking pupils to solve real problems or to develop research projects (Dewitt et al., 2018). These arguments make the inconsistency of the mentions of these sub-dimensions in the documents analysed very problematic. In fact, this may lead teachers to avoid focusing on these processes even though (if properly and safely approached) these are a key component of science education (Hodson, 1988) and can give a valuable contribution for citizens' development of 'learning how to learn' competences (European Commission/EACEA/Eurydice, 2017). Based on Ozmantar's (2017) results of a study carried out with eight mathematics curricula which were found to used real life problems, our results were unexpected as science has a much more explicit relationship with the real world than mathematics does and solving real life problems would be an expected tool for contextualised learning of science.

Table 7

Presence of the Engagement with Context-Based Science Knowledge Construction Processes Sub-dimensions

Sub-dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Problem-posing	X	X	-	-	X	X	X	It is expected that youngsters leaving compulsory education are citizens: equipped with multiple literacies that enable them to analyse and *critically question reality* […]. (E, p.16)
Problem-solving	X	X	-	-	X	X	X	*Problem solving and decision-making for individual and communitarian interventions, leading to sustainable water management* […]. (A, p.131)
Project-development	X	-	-	X	X	-	-	To characterise the community food habits, *through project work*. (D, p.4)
Data collection	X	X	X	X	-	X	X	Pupils may measure the levels of sound intensity in diverse areas of the school, using a sound level meter. (B, p.18)
Data analysis	X	X	X	X	X	X	X	*To analyse natural phenomena and everyday situations* based on laws and models […]. (F, ND)
Knowledge application	X	X	X	X	X	X	X	To verify Archimedes' law within the scope of a laboratory activity and *to apply that law in daily life situations*. (C, p.18)
Drawing conclusions	-	-	X	X	X	X	X	*To systematise* trophic chains typical of water and earth environments, which are the predominant ones in the school surroundings, showing energy transfer. (G, nd).
Other	-	-	-	-	-	-	-	-----

Data given in Table 8 show that the dimension 'Use of cross curricular approaches to real issues' is present in five (A, B, E, F and G) of the seven documents analysed.

Table 8

Presence of the Use of Cross-Curricular Approaches to Real Issues Sub-dimensions

Sub-dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Physics and Chemistry	-	X	-	-	-	-	-	The exploration of this content may help to answer to the following specific question 'What makes Earth a planet with life?' whose answer would be complete when the comparative study of the planets, to be carried out in *physical sciences*, is done. (B, p.13)
Physical and Natural Sciences	-	X	-	-	-	-	-	To study, for example, the action of electric current, the action of light, the action of heat and the mechanics action. To relate it with the study of the rocks done in *natural sciences*, where the effects of pressure and temperature can be perceived. (B, p.18)
Geography and Geography	-	X	-	-	-	-	-	The influence of human activities on atmosphere and climate. The study of this topic, given its interdisciplinary nature, should be done in coordination with natural sciences and geography. (B, p.27)
Natural science and other knowledge areas	X	X	-	-	X	X	X	To characterise the variation of the heart rate and the blood pressure in some daily life activities, by relating it to *knowledge from other subject* (e.g., Physical Education). (G, nd)
Other	-	-	-	-	-	-	-	-----

This dimensions is not present in the Curriculum standards which are specific of each of the science subjects (Physical Sciences and Natural Sciences) and may not have given enough importance to cross disciplinary relationships and or may have forgotten the fact that a few content themes like the Universe are approached in both the physical sciences and the natural sciences school subjects (as defined above). Themes as this one should be approached in an integrated way so that pupils could look at the universe from the multiple perspectives it can be looked at and could make deeper sense of what they observe. This is especially important if we do not want pupils' explanations of a given natural phenomena to be dependent on the task used to elicit those explanations, as research (Leite, Afonso, 2004) suggests that they can be. Consistent curriculum recommendations on the use of cross curricular approaches would be very welcome not only for their educational value but also because it is known that many teachers resist to changing their usual teaching practices (Leite et al., 2013) that tend to attend solely to the subject they teach. This happens for many reasons, some of them unconscious, but probably related to both accountability measures imposed by school administration (Pecore, 2012) and insecurity or fear from lowering the status of their own subject if they allow themes that also appear in the syllabuses of other subjects to be approached in an integrated way (George, Lubben, 2002; Braskén et al., 2020).

The dimension 'Use real world settings to promote the ability to reconstruct beliefs and conceptions' is present in all documents except on the Curriculum standards ones (C and D), as shown in Table 9. However, neither of the two main sub-dimensions is present in all documents. This absence may reduce the probability of teachers to use real contexts or of representations of real contexts to lead pupils to test the validity or the limits of validity of the ideas about the world that they build up from an early age, and that often contradict scientific ideas (Osborne, Freyberg, 1985; Allen, 2020). A strong recommendation for teachers to consistently use challenging strategies of students' ideas seems to continue being needed as its use may continue being very limited as it was (Sequeira et al., 1993) by the time alternative conceptions and teaching for conceptual change were major research topics.

Table 9

Presence of the Use Real World Settings to Promote the Reconstruction of Beliefs and Conceptions Sub-dimensions

Sub-dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Cognitive conflict-based strategies	-	-	-	-	X	-	X	Pupils formulate questions and analyse questions to be investigated, *differentiating what they know from what they want to uncover.* (E, p.16)
Development strategies	X	X	-	-	X	X	X	[…] the teacher should consider: […] b) *learner-centred teaching processes so that pupils can assume the role of active agents in the construction of their own knowledge, looking for and organising information, and analysing and interpreting data, planning and carrying out practical activities.* (G, nd)
Other	-	-	-	-	-	-	-	-----

Table 10 shows that the dimension 'Use of social interaction as a scaffolder for socially relevant learning' is present in five of the seven documents analysed.

The absence of the pupils-experts/professionals sub-dimension is obviously critical from a contextualised learning perspective. Unexpectedly, instances of the pupil-teacher interaction sub-dimensions were not found. This may suggest that curriculum designers consider the interaction in the classroom as a taken for granted interaction that does not deserve calling attention to. In reality, the pupil-teacher interaction is lop-sided and strongly favours the teacher (Dewitt et al., 2018), which is not appropriate if teaching for contextualised learning is supposed to be going on. However, it should be emphasised that arguing that teaching for contextualised learning is learner-centred does not mean that the teacher has no role to play in that process and that he/she does not need to communicate with the pupil. On the contrary, it means that teacher-pupil communication can no longer be top-down (from the one to knows to the one that has a lot to learn). It rather means that instead of being there to teach what the curriculum requires pupils to learn, the teacher is there to ascertain that pupils learn on their own. Thus, the teacher has to play the role of a facilitator (Anggraeni, Yusnita, 2017) or a questioner (Joglar, Rojas, 2019) who is there to facilitate the pupils' demanding task of learning by building bridges between science and the real world.

Table 10

Presence of the Use of Social Interaction as a Scaffolder for Socially Relevant Learning Sub-dimensions

Dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Pupil- teacher	-	-	-	-	-	-	-	-----
Pupil - pupil	X	X	-	-	X	X	X	To participate in *interpersonal and team* activities, being respectful for norms, rules, action and coexistence criteria, relative to working in diverse settings. (A, p.25)
Pupil - community members	-	-	-	-	X	-	-	To develop and maintain positive and diversified relationships with them and with the others (community, school, family), in settings that require collaboration, cooperation and mutual help […]. (E, p.18)
Pupil -experts/ professionals	-	-	-	-	-	-	-	-----
Other	X	-	-	-	X	X	X	The competences associated with interpersonal relationship require pupils to be able to: adequate their behaviour in settings that require cooperation, sharing, and collaboration and competition; teamwork and use of face to face and distance communication tools. (E, p.18).

As shown in Table 11, the dimension 'Promote awareness of the features of contextualised learning' is present in all the selected curriculum documents except in the Curriculum standards of the two science subjects (C and D). Of course, it can be argued that standards focus on the product (the learning outcomes) and are not about the means to reach it (that is, on the strategies). Besides, none of the sub-dimensions is present in all the other five documents. Again, a lack of coherence among the documents should be pointed out as potentially problematic, as it may make teachers and other curriculum developers devaluate the importance of contextualised learning. Teachers' awareness of the importance of contextualised learning is a necessary condition for promoting students' lifelong learning (Black, 2017) which in turn is a relevant learning for 21st century citizens (European Commission/EACEA/Eurydice, 2017).

Table 11

Presence of the Promote Awareness of the Features of Contextualised Learning' Sub-dimensions

Dimensions	Documents							Examples of instances (quotations)
	A	B	C	D	E	F	G	
Perform self-evaluation	X	-	-	-	X	-	X	*Perform self-evaluation* and adjust the work methods to his/her way of learning and to the objectives to be attained. (A, p.21)
Monitor the learning process	X	-	-	-	X	X	X	To promote strategies centred on tasks and criteria that guide the pupils to: - *ask question to himself about his own learning*, identifying weakness and strengths; consider the peers' feedback to improve or deepen knowledge […]. (F, nd)
Use remediation strategies	-	X	-	-	X	X	X	[…] – based on the teacher's feedback, reorient the work either individually or in small groups. (F, nd)
Other	-	-	-	-	-	-	-	----

Conclusion and Implications

Teaching science for 21st century citizenship is a challenging and demanding task. It requires the adoption of multidisciplinary approaches and diversified tools (Leite et al., 2020) able to help pupils to build bridges between school and daily life contexts and to lead them to perceive the relevance of school science for their personal and professional lives, as well as for the sustainability of the social and natural world. Some specialists in science education acknowledge context-based learning approaches as being able to fulfil these goals (Broman, 2020; King 2012; Leite et al., 2017) but the acceptance of these approaches in schools varies worldwide. "In some countries, for example the US and the UK, the CBL [context-based-learning] approaches have been a part of the curriculum for several years, whereas other countries have introduced this approach more recently" (Broman, 2020, p. 52). Still, in other countries (e.g., Sweden) context-based learning approaches are not a formal part of the curriculum, but teachers are encouraged to apply relevant aspects of them to improve teaching (Broman, 2020) for chemistry.

The Portuguese curricular documents that have been guiding science education in Portugal were content-analysed in order to ascertain whether or not they promote teaching for contextualised learning. A checklist was developed for the purpose of that analysis. The results of the study indicate that all the seven curriculum documents analysed include references to contextualisation but there are differences between them. Analysing tables 3 to 11, it can be noted that the two documents relative to standards (C and D) do not include instances of the following four (out of nine) dimensions: 'Representations of real settings', 'Cross-curricular approaches', 'Beliefs and conceptions challenging settings', 'Social interaction as a scaffolder for new learning', and 'Awareness of ongoing learning'. In addition, the Compulsory education pupils' profile (E) does not include any instance relative to the 'Historical settings' dimension. The remaining four documents include instances of all the dimensions. Nevertheless, when focusing on the sub-dimensions, differences between the documents can be noted with the national curriculum (A) and the curriculum guidelines (B) tending to include instances of more sub-dimensions than the other documents. Hence, on the whole, one can conclude that Portuguese curriculum promotes teaching for contextualised learning and suggests it be done in a variety of ways. This result is similar to the one achieved by Kato & Kawasaki (2011) in Brazil and by Martin et al. (2017) for three European countries. However, acknowledging Yeh et al. (2019) arguments on the importance of coherence between curricular documents, one can state that the inconsistencies found among the documents analysed may be confusing for teachers and lead them to not take contextualisation as seriously as it deserves to be taken. Therefore, we would like to argue for the coherence among different curriculum documents with regard to contextualisation in order to make the cause stronger.

It should be stressed that documents A and B are those that address contextualisation in a more comprehensive way, even though they are the oldest ones. As these documents were revoked (without being replaced by equivalent ones), and the other documents published more recently give less importance to contextualisation, the Portuguese curriculum may be in danger of conflicting with European Commission recommendations relative to science teaching in schools (EC, 2011). Besides, they are a cause for concern, as they seem to indicate that there has been a decrease in the importance given by the formal curriculum to contextualised learning since the beginning of the second decade of the 21st century.

Of course, the formal curriculum may be rather different from the implemented curriculum (Alsubaie, 2016; Kelly, 2004), being the latter at least in part dependent on teachers' pedagogical content knowledge and conceptions about what the aims of science education should be. The decrease referred to above can nonetheless convey a misleading message to teachers (Dolfing et al., 2020) and, if they limit their actions to follow the curricular documents in force, they will be acknowledging inconsistent and outdated teaching guidelines that can be harmful with regard to attracting pupils for science and science careers.

It is widely accepted that there can be no perfect learning environment or curriculum for all learners. However, efforts to move towards optimal learning environments should be made. The effects of such efforts may be hindered by limited understandings of how contextualisation impacts science learning (Giamellaro, 2014). This means that teachers need to perceive the real impact that teaching for contextualised learning may have not only on pupils' science learning but also on their motivation and cognitive engagement (Sánchez Tapia, 2020), so that they develop a willingness to change their practices from content-centred to pupils' context-centred ones.

Even though all the checklist dimensions are relevant for contextualised teaching and learning, it is worth pointing out that they are not all equally viable whatever the topic or issue. In fact, real-world setting and socio-scientific problems would be the most promising for contextualised learning but they are not always viable due to the scale or the accessibility of the issue under study. For instance, the use of representations of real settings may be the only form to contextualise the internal dynamics of the earth or atomic structure due to the inaccessibility of the former and the small scale of the latter. This means that, when preparing teaching, curriculum developers (teachers included) need to select the most appropriate dimensions and sub-dimensions by considering the content that is involved, the characteristics of the learners and the features of the school environment.

This study has implications for science curriculum changes, as these should be informed by relevant research in the area. The checklist can act as a scaffold tool to guarantee that the new curriculum documents are consistent with research guidelines relative to teaching science for contextualised learning.

The paper has limitations that emerge from the scope of the set of documents analysed. However, it has an added value that comes from the fact that the checklist developed was able to compare diverse documents, this checklist can be a useful research tool to analyse other curriculum materials in Portugal or in other countries. For instance, it can be used with curriculum documents of other school levels (e.g., primary or secondary school) and or school subjects (e.g., Mathematics and or Geography), in Portugal or abroad, in order to find out whether it encompasses all the relevant characteristics of contextualisation present in those documents or whether it needs to be adapted or developed. It is expected that further studies will provide occasions to improving the checklist and to extend its field of applicability to other subjects.

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