Contextualized Science Teaching: The Contribution Of Photographs Included In School Science Textbooks

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ABSTRACT
Contextualized science teaching has to do with approaching themes from everyday settings that are relevant to students and making explicit the interrelationship between science and everyday life. Textbooks play an important role in the teaching and learning processes because they are a major source of information in teaching a particular subject. Therefore, textbooks should give a meaningful contribution to contextualized teaching, namely through good quality visual information (including photographs and photograph related visual tools), adapted to the target students' characteristics. Thus, the objective of this paper is to compare photographs included in 8th and 11th grade textbooks, by three different publishers, between them and in terms of their potential to contribute to contextualized science teaching. Results indicate that the use of photographs is hardly guided by context-based science teaching principles and does not differ too much between the two grade levels. Therefore, teachers should carefully analyse textbooks before selecting the ones to be assigned in their school and when using a textbook they should explicitly deal with the possible weaknesses and the benefits of the visual material as well as with the way it is or can be used for the sake of contextualized science teaching.

INTRODUCTION

Contextualized science teaching
Nowadays, it is a matter of general consensus that science is to be taught in schools, to every student, at least for a few years (Holbrook, 2010; European Commission, 2015). This may be seen as a way of democratizing science because it enables students' access to scientific know ledge whatever the students' economics, social and cultural status. However, to acknowledge democracy in schools does not mean to teach the same content to everybody through the same approach. Rather, it requires teaching it differently to match different interests and competences so that every student can perceive the usefulness of the content and grasp it at a good level of understanding.

Besides, it is commonly agreed that science education should train students to be active and responsible citizens, able to take decisions about socio-scientific issues that emerge in their actual (Martins, 2011) or future environments. However, students' interest towards science is not only low (Gilbert, 2006; Fensham, 2009), but it also decreases throughout school levels (Osborne, Simon, & Collins, 2003; Jenkins & Nelson, 2005; Gilbert, 2006; Rannikmäe, Teppo, & Holbrook, 2010). This may be partly explained by the fact that science is shown as a collection of independent and decontextualized facts without any relationship with students' everyday life (Gilbert, 2006). To counteract this, science teachers' actions should be guided by the relevance of science knowledge principles both when they select what to teach and when they choose the best approaches to teach it. Hence, as all students are obliged to learn science for a few years in school, then teachers' biggest challenge is to make students perceive the relevance of science for modern society's daily life as well as for professional science and technology careers (Holbrook, 2010; European Commission, 2015).

It has been argued (Fensham, 2009; Lavonen & Laaksonen, 2009; King, 2012) that teaching contextualized science may promote students' interest towards science as it is a way of making the relevance of scientific

knowledge explicit for the students. Although some research studies seem to lack methodological rigour (Taasoobshirazi & Carr, 2008), there is some evidence that contextualized science teaching may favour students' learning of science (Bennett & Lubben, 2006; Bellocchi, King, & Ritchie, 2016). However, it should be stressed that there are several possible ways of putting contextualized teaching into practice (De Jong, 2006; Gilbert, 2006) and that research studies hardly describe the pedagogical model that was used (Ültay & Ültay, 2014). Nevertheless, theoretical models as well as approaches used to contextualize science teaching acknowledge the establishment of a link between science and daily life environments.

Gilbert (2006) argues for contextualized teaching but he states that it is not easy to define the concept of context. Thus, he acknowledges Duranti and Goodwin's idea of context as a focal event embedded in its cultural setting. De Jong (2006) adds that contexts can be described as practices that help students to give meaning to activities and that they can be classified by looking at the domain of origin. Therefore,

> "a context-based approach is when the 'context' or 'application of the chemistry to a real-world situation' is central to the teaching of the chemistry. In such a way, the chemical concepts are taught on a 'need-to-know' basis; that is, when the students require the concepts to understand further the real-world application." (King, 2012, p.53).

According to De Jong (2006), contexts can be taken from several domains, having diverse educational advantages, as follows: the personal domain: contributes to the personal development of students by connecting science with their personal lives; the social and society domain: contributes to prepare students for their roles as responsible citizens by clarifying science and its role in social issues; the professional practice domain: prepares students for their coming role as professional workers in public or private areas; the scientific and technological: contributes to the development of scientific and technological literacy of students.

Hence, an educational valuable context should fit the following criteria: capture students' interest even though it can be real or simulated; foster the student-teacher interaction as this is required to promote learning; be appropriate to introducing the language and concepts to be learned as this is the goal of science teaching; promote the use of students' previous knowledge (Gilbert, 2006) so that it can be reconstructed if required or developed and integrated into meaningful conceptual networks. As De Jong (2006) points out, concepts are related to contexts in a one to one way and also in multiple ways, as a context relates to many concepts but a concept meaning may vary from one context to the other. Thus, contexts interfere with the language as they determine the meaning of concept labels that is, the meaning of words (Gilbert, 2006; King, 2012).

Besides, the relationship between contexts and concepts has implications on their presentation on teaching (De Jong, 2006) and on the level of activity it require from students. In fact, contexts can be used in a somehow traditional way or within the scope of a modern approach. The former happens if contexts are presented: as illustrations of concepts that already have been taught; to offer the possibility to students of applying their knowledge of a concept. According to the author, "this can lead to the transformation of the existing meaning of a concept or to the addition of a new meaning to the concept." (De Jong, 2006, p.217). The latter (modern approaches) includes cases in which: contexts are presented as the starting point or rationale for teaching concepts; contexts not only have an orienting function, but can also enhance motivation for learning new concepts. Combinations of traditional and modern ways of using contexts are also possible.

There is a point that is worth emphasizing that is that context-based science should begin with a real-world application for which the scientific explanations are provided (King, 2012) so that students can understand real-world contexts that are relevant to their lives and perceive the relevance of science (Roberts, 2007). Thus, as King (2012) argues, context-based science brings close together two worlds - the students' community world and the science world – whose borders may be vanished if a sociocultural approach to classroom science teaching is acknowledged. However, if contexts are to successfully help bridging the gap between meanings of topics in a context setting and meanings in a science setting, an important condition has to be fulfilled that is a careful selection of contexts (De Jong, 2006). A consequence of this is that if science textbooks are to adopt a contextualized approach and to facilitate teachers' challenging task of helping students' to bridge the two worlds referred to above, then they should select, introduce and use contexts with a lot of care.

Textbook Photographs as facilitators of contextualized science learning

School textbooks are primarily targeted to students and they should be designed to support students' learning as prescribed into the official curriculum. This may be the reason why there are no specific guidelines for science textbook authors of any European country (Eurydice, 2011). Thus, school textbook authors should appropriately reinterpret the curriculum so that they can write textbooks that contribute to minimizing the usual expected gap

between the prescribed and the implemented curriculum. However, as textbooks are human enterprises they should not be expected to be perfect (Leite, 2002a) and therefore the existence of an assigned textbook does not release teachers from making their own interpretation of the curriculum and confronting it with the one assumed by textbook authors, in order to find out whether or not a given textbook fully follows the curriculum or to identify which parts of it need special attention.

Research focusing on textbooks has reported several problems that concur towards limited textbook quality. In fact, there is some evidence that textbooks are very conservative (Bungum, 2013) with regard to both the content presented and the teaching approach they adopt to approach it. As a matter of fact, they hardly follow curriculum changes (Moreira, 2003; Valanides, Papageorgiou, & Rigas, 2013), especially when the new curriculum recommendations are innovative. Besides, textbooks may either promote or impair students' learning, depending on their scientific, pedagogical and language quality. Unfortunately, research dealing with several countries textbooks has highlighted some scientific (Leite, 1999; Çobanoglu, Sahin, & Karakaya, 2009; King, 2013; Dourado & Matos, 2014; Marques, 2014) and historical (Leite, 2002b; Antunes, 2012; Tavares, 2012; Niaz & Costu, 2013) inaccuracies, some inappropriate learning activities (Leite, 2006; Morris, Masnick, Baker, & Junglen, 2015; Aldahmash, Mansour, Alshamrani, & Almohi, 2016) and several problems related to language, including readability (Muspratt & Freebody, 2013; Morgado, Otero, Vaz-Rebelo, Sanjosé, & Caldeira, 2014), questioning (Park, 2005; Leite et al., 2013; Skoumios & Diakos, 2015) analogical reasoning (Orgill & Bodner, 2006; Orgill, 2013) and visual aids (Leite & Afonso, 2000; Cook, 2006; Kapıcı & Savascı-Açıkalınb, 2015; Dourado, Morgado, & Leite, 2015) among others.

Although textbooks are targeted to students, research has shown that they also influence teachers' teaching practices (Valanides, Papageorgiou, & Rigas, 2013) and therefore it can be argued that they have a double influence on students' learning. In fact, many teachers tend to ignore the curriculum and to replace it by the textbook. Then, if the textbook is not up to date, teachers' practices will not be consistent with the prescribed curriculum and/or with the state of the art of the subject they teach. This may happen with regard to context-based approaches, which may be fostered or impaired by the way textbooks reinterpret the curriculum. These approaches may be based on verbal and numerical text as well as on visual information (Anagnostopoulou, Hatzinikita, & Christidou, 2012) that facilitate the presentation of abstract concepts with concrete depictions and help to link science and everyday life.

It seems that teachers prefer high visual-content books to traditionally formatted textbooks (Slough & McTigue, 2013). This preference may have to do with the fact that visual information may inspire students' curiosity (Tufekcic, 2012) and promote science learning (Cook, 2008) especially when abstract concepts are at stake (De Jong, 2006) and students are young. Besides, in the modern pedagogical educational reality, textbooks have to compete with strong rivals, with high levels of visual, dynamics and interactive information, like the internet and e-books. Even though students seem to prefer printed textbooks (Woody, Daniel, & Baker, 2010), in an attempt to capture their attention to textbooks, textbooks authors and publishers launch on the market colourful and beautiful visual aids often at the expense of an accurate explanation of the central ideas of the content under question (Koppal & Caldwell, 2004; Lee, 2010). However, "The illustrations should additionally enrich the textual parts of a textbook, which is only possible when they are designed to emphasise something and not inserted just for the sake of being there [because] proper illustration is one of the key factors having the students accept/reject a textbook." (Tufekcic, 2012, p.121). Unfortunately, this is not always the case (Lee, 2010).

In most educational systems (including the Portuguese one) teachers can choose the textbook to be assigned from an approved list drawn up by the ministry of education (Eurydice, 2011) and they may tend to overvalue the visual content over the other textbook selection criteria. The result of this action may be an undesirable one, unless teachers have visual training in the subject area they teach and textbook authors use good quality visual material with parsimony and accuracy.

Textbooks may include several types of visual aids including photographs, drawings, textboxes, flow charts, tables, and other (Slough & McTigue, 2013) even though photographs seem to be the most frequent (Pozzer & Roth, 2003; Lee, 2010; Kim, Kong, & Lim, 2011). Photographs or drawings like photographs offer realistic representations (Lee, 2010; Devetak & Vogrinc, 2013) that may facilitate the connection between King's (2012) two worlds: the science world and the students' community everyday world, which includes other components (e.g.: social) behind the physical and natural ones. They may invite the learner into sciences by exhibiting how modern scientists work and by referring to the relevance of science (Bungum, 2013). However, the students' ability to interpret visual material depends on their prior experiences (Kearsey & Turner, 1999; Lee, 2010; Pozzer & Roth, 2005) with the content under question.

In some contexts a real photograph may be better than a thousand words; in other context they may be less useful or even confusing as they simultaneously "lack determinacy and exhibit an excess of meaning." (Pozzer & Roth, 2005, p.219). Thus, students may interpret the photograph based on what they think is there rather than on what is really there. "Photographs are culturally situated and consequently convey different meanings to different viewers based on personal life experiences, knowledge, and perspectives. Photographs, like words, are both encoded and decoded with meaning." (Moran & Tegano, 2005, p.3). Hence, it should be noted that the photograph background may allow the reader to distinguish the relevant details in the photographs (Pozzer & Roth, 2005). The point is that some textbooks include photographs with decontextualized entities (Dourado, Morgado, & Leite, 2015) which may hardly be interpreted according to textbook authors' intention. The printing quality of the photograph, its (in)compatibility with the text elements, and the captions that accompany it may also diminish photographs educational value (Çobanoglua, Sahinb, & Karakaya, 2009).

Also, photographs are instantaneous and therefore they can hardly show dynamic processes. However, there is some empirical evidence that readers make inferences based on their previous experience and knowledge and therefore do not differentiate between what they can see and what they may think, have heard, or believe (Pozzer, & Roth, 2005), they can see the "right" process in a photograph if they are used to it. Otherwise, they can activate inappropriate ideas and interpret photographs in unanticipated ways. Given that students react to different pictures in different ways, it is important that textbook writers and science teachers are aware of how different kinds of images can invite students into science by addressing their various roles (Bungum, 2013) and possible interpretations.

OBJECTIVE

Textbooks play an important role in the teaching and learning processes because they are still being used as a major source of information in teaching a particular subject (Khine, 2013). Therefore, the quality and accuracy of their content is crucial for their educational effectiveness. Thus, they should give a meaningful contribution to contextualized teaching, namely through visual information (including photographs and photograph related visual tools), adapted to the target students' characteristics. Thus, the objective of this paper is to compare photographs included in 8th and 11th grade textbooks between them and in terms of their potential to contribute to contextualized science teaching. The findings will give insights on whether "photographs are planned to enrich the textual parts of a textbook or whether they were inserted just for the sake of being there." (Tufekcic, 2012, p.121) for decorative purposes.

THE STUDY

To attain the objectives of this study, three 8th grade Physical Sciences textbooks (TB1 to TB3) and three 11th grade Physics and Chemistry textbooks (TB4 to TB6) were content analysed. These textbooks form three pairs, based on the publisher, as there is a book by each publisher in each grade level. It should be noted that these grade levels belong to different school levels as follows: 8th grade belongs to the third cycle which is the final cycle of basic education where science is taught to all students; 11th grade belongs to secondary school level, which is compulsory even though students can choose to take science or not. Thus, TB1 and TB4 are by the one publisher (P1), TB2 and TB5 are by another publisher (P2) and TB3 and TB6 are by a third publisher (P3). A sample with these characteristics enables comparisons to be made between editors and between the two school levels in order to find out whether or not publishers deal with photographs differently in the two school levels. The textbooks analysed were assigned in Portuguese schools in the academic year of 2015/16.

The analysis concentrated on the teaching units that are related to Chemical Reactions, as this is an issue that has a strong relationship with the daily life settings which may facilitate the job to those that want to use a contextualization approach. Thus the teaching units are: Chemical reactions – 8th grade; Chemistry and industry and From Atmosphere to Ocean – 11th grade. They include not only the concept and ways of representing of Chemical Reactions but also themes like acid-base reactions, precipitation reactions, redox reactions and chemical kinetics.

Photographs, realistic schemes (drawings that look like photographs) and photographs combined with other elements (e.g.: graphs) that are included in the teaching units referred to above were selected and analysed. Despite their differences, all of these graphical elements will be addressed from now on as photographs, as it was done in a previous study (Dourado, Morgado, & Leite, 2015),

The analysis concentrated on several dimensions previously identified by Devetak and Vogrinc (2013) and partly used in Dourado, Morgado, and Leite (2015). These dimensions are the following: number of photographs; types of photographs; location of the photographs; role of the photographs; caption of the photographs; relationship of the photographs integrated along the text with the text itself, contextualization of the entities photographed.

For each dimension of analysis, a set of categories based on the one used by Dourado, Morgado, and Leite (2015) was adopted. The categories will be introduced in the next section. To improve reliability of the analysis, photographs were classified on this set of dimensions and respective categories by two of the authors separately. The provisional results obtained were compared and discrepant results were discussed by the three authors so that a consensual classification was reached.

FINDINGS

Number and type of photographs

Results indicate that the absolute number of photographs diminishes from 8th to 11th grade in all textbooks but those by P2 (that is TB2 and TB5) and that the number of photographs per page diminishes from 8th to 11th grade whatever the publisher and textbook. Textbooks by P2 are those that have fewer photographs per page in the 8th grade and more photographs per page in the 11th grade (table 1). Even though this result may seem a bit surprising, there is also a reduction in the number of photographs per page from 8th to 11th grade. Thus, even though all publishers reduce the number of photographs per page, from 8th to 11th grade, the publishers whose textbooks have larger absolute numbers of photographs are the ones that reduce most the number of photographs per page, from 8th to 11th grade. Anyway, these results suggest that all the textbook publishers follow a similar pattern that may be due to a conscious and planed editorial option that is: as the grade level increases, the number of photographs per page should decrease because students get older and do not need too much extrinsic motivation or too many facilitating elements.

Table 1: Number of photographs per textbook and page

Grade Level	Textbook	Number of Photographs	Number of Pages	Photos/Page
8th	TB1	292	106	2,75
	TB2	194	88	2,2
	TB3	254	86	2,95
11th	TB4	195	239	0,81
	TB5	265	184	1,44
	TB6	121	202	0,60

The large number of photographs per page included in 8th grade textbooks is consistent with the results obtained in other studies (Dimopaulos, Koulaidis, & Sklaveniti, 2003; Pozzer & Roth, 2003; Kim, Kong, & Lim, 2011; Kapıcı & Savascı-Açıkalınb, 2015) dealing with textbooks from diverse countries and school levels. However, López-Manjón and Postigo (2014) found that Spanish primary school Biology textbooks include fewer photographs per page (around 1,4) which is a result that compares better to the number of photographs per page obtained with 11th grade textbooks. Besides, the number of photographs per page in lower than the one obtained for Portuguese 8th grade textbooks on the theme 'Resources Sustainable Management' (Dourado, Morgado, & Leite, 2015) probably because the latter theme focuses more on nature and daily and professional life. Nevertheless, it should be noted that using many photographs is not necessarily a good thing. In fact too many photographs per page may not only conflict with scientific accuracy (Lee, 2010), make the page too colourful and confusing for the students, and increase the price and/or the length of the textbook, and make the non-interesting photographs to override the educationally valuable ones.

Excluding textbooks TB4 and TB6, all textbooks include the three types of photographs (table 2) considered for the purpose of this study and included them in the textbook sections selected to be analysed, as it was found in previous study (Dourado, Morgado, & Leite, 2015) focusing in 8th grade textbooks. However, drawing-like photographs (that is drawings that look like photographs) are the less frequent type of photographs in the 8th grade (excluding TB1) as well as in the 11th grade textbooks. Besides, the percentage of real photographs increases from 8th to 11th grade in textbooks by publishers P2 and P3 and it decreases a bit in textbooks by P1. An explanation for the result regarding P2 and P3 may be based on the idea that real photographs contain educationally relevant elements mixed with irrelevant ones and that the latter may make learning harder for young students. In fact, young students may find it difficult to separate the relevant from the irrelevant elements of a photograph (Pozzer & Roth, 2003) and if it is so, they consequently would hardly be able to take profit form the photograph.

Table 2: Types of photographs used by the textbooks when dealing with the theme (%)

Type of photographs	8th grade			11th grade		
	TB1 (n=292)	TB2 (n=194)	TB3 (n=254)	TB4 (n=195)	TB5 (n=265)	TB6 (n=121)
Real photographs	67,8	39,2	37,0	55,4	57,7	80,2
Drawing-like photographs	23,3	5,7	8,3	0,0	0,8	0,0
Photographs combined with other graphic and/or verbal elements	8,9	55,1	54,7	44,6	41,5	19,8

In addition, two publishers (P2 and P3) tend to use photographs combined with other graphical elements (e.g., graphs) in the lower school level more than they do in the higher one. One explanation for this result may be anchored on textbook authors' belief that by doing so they can foster the relationship between science knowledge, (represented, for example, by graphs), and everyday life (represented, for example, by photographs). Other authors (López-Manjón & Postigo, 2014) found photographs combined with other verbal and pictorial elements in percentages similar to those obtained in the present study. However, Dourado, Morgado, and Leite (2015) found percentages a bit lower with 8th grade textbooks even though in a different theme. The point that deserves attention is that some visual elements like graphic are very demanding for students and they may become even more demanding when combined with photographs.

Location of the photographs

Textbooks analysed include photographs in different places (table 3) but some of them do not include photographs in the all the places considered for the purpose of this analysis. Besides, excluding TB1 and TB5, more than half of the photographs are integrated into the text throughout the presentation of the content. Anyway, in those two textbooks, the percentages of photographs integrated into the text are about 45% of all the photographs they include in the units analysed. Hence, these results indicate that textbook authors worry about integrating illustrations of the content into the text, to make it either more understandable/easy to grasp for the students or more appealing to them.

Table 3: Location of the photographs used by the textbooks when dealing with the theme (%)

Location of the photographs	8th grade			11th grade		
	TB1 (n=292)	TB2 (n=194)	TB3 (n=254)	TB4 (n=195)	TB 5 (n=265)	TB6 (n=121)
Presented at the beginning of the chapter and sub-chapter	1,3	3,6	1,2	9,8	0,0	8,3
Integrated into the text that introduces the content	44,2	62,9	53,1	62,1	45,7	79,3
Integrated into the activities	15,1	20,6	45,7	19,0	44,9	0,0
Apart from the text, into Curiosity boxes	2,4	12,9	0,0	5,1	9,4	0,0
Presented at the end of the chapter	0,7	0,0	0,0	0,0	0,0	12,4
Used as a page background	36,3	0,0	0,0	4,0	0,0	0,0

In all but TB6 some photographs are associated to learning activities. Textbooks 3 and 5 are the ones that use larger percentages of photographs in this way. This way of using photographs suggests that textbook authors worry about making the activities easier to understand by the students.

Excluding TB5, all the textbooks analysed show photographs at the entrance page of the chapters or subchapters. However, the percentages of photographs are small when compared with the total number of photographs included in the teaching units analysed. Nevertheless, this result is not surprising because the number of sub-units dealing with issues considered in this paper is small and so is the number of entrance pages. Also, textbooks by all publishers but P3 show photographs in a small box placed at the margin of the page. This location of photographs seems to intend to call students' attention and raise their interest for additional information on the content developed in the main text of the page. As TB3 and TB6 do not use photographs in this way, it can be hypothesised that it is not due to a planned choice of the authors but rather to an editorial decision of the publisher. The use of photographs as a background of the page may also be an editorial decision of P1. Photographs used in this way are more frequent in the 8th (TB1) than in the 11th grade (TB4) probably because of a belief in that it is more important to try to catch more 8th graders' than 11th graders'' attention. Only two textbooks (TB1 and TB6) use photographs at the end of the chapter and the percentages of photographs used in this way is very low, especially in TB1.

In what concerns the two most frequent ways of using photographs, these results compare to those of a previous study (Dourado, Morgado, & Leite, 2015) even though photographs at the end of the chapter and as a page background had not been found in the former study. However, Pozzer and Roth (2003) also found that a small number of photographs that appeared at the beginning of a unit, chapter, or section of text without being explicitly related to it.

Role of the photographs

The analysis of the integration of the photographs in the textbooks suggests that they are intended to play diverse roles (table 4), ranging from students' motivation to learn, content illustration, and activities content complement/illustration to providing a background image to beautifying the textbook page. All the textbooks include photographs aiming at motivating students to learn. Those photographs are presented at the unit or sub-unit opening page (excluding TB5) or closing pages (only in TB1 and TB6).

The photographs that aim at complement and/or illustrate the text are included along it. From 8th to 11th grade, two publishers (P1 and P3) increase the number of photographs that seem to play this role. All textbooks but those by P3 include photos in small boxes aside the main text. These photographs aim at adding information to the main text usually with a non-compulsory or curiosity character. Some of them have to do with historical pictorial information (e.g.: scientists' photographs).

All but one textbook (TB6) integrate photographs in both laboratory activities and knowledge use (mainly paper and pencil exercises or problems) activities as a way of illustrating what is mentioned in the text of the activity (e.g., mentioning a burette, showing a burette) or of complementing it, either in the laboratory activities (e.g.: showing an *apparatus* necessary to carry out some laboratory procedure) or in the paper and pencil (e.g.: showing a photographs of what is mentioned in the exercise/problem to ask questions about it) context. However, the percentages of photographs used with these purposes are quite low except for textbooks by P3 that integrates over one third of their photographs in knowledge use activities. One of the publishers includes photographs as textbook page background even though the percentage of photographs in these conditions reduces from 8th to 11th grade.

Table 4: Role of the photographs used by the textbooks when dealing with the theme (%)

Role of the photographs		8th grade			11th grade		
		TB1 (n=292)	TB2 (n=194)	TB3 (n=254)	TB4 (n=195)	TB5 (n=265)	TB6 (n=121)
Motivation to learn		2,0	3,6	1,2	9,8	0,0	20,7
Curiosity towards content		2,4	12,9	0,0	5,1	9,4	0,0
Text content illustration		44,2	62,9	53,1	62,1	45,7	79,3
Activities content complement/illustration	laboratory activities	3,4	13,4	11,1	11,8	10,9	0,0
	knowledge use activities	11,7	7,2	34,6	7,2	34,0	0,0
Page background		36,3	0,0	0,0	4,0	0,0	0,0

These roles of photographs were found in previous studies carried ou with natural sciences (Dourado, Morgado, & Leite, 2015) as well as with Biology (Pozzer & Roth, 2003) textbooks even though in the latter case they were named differently.

Captions of the photographs

Data given in table 5 show that most of the photographs include in two (TB1 and TB3) of the three 8th grade textbooks do not have a caption. Also, more than 40% of the photographs included in two (TB4 and TB5) of the three 11th grade textbooks do not include captions either. The absence of a caption in photographs included in textbooks was found in previous studies (Dourado, Morgado, & Leite, 2015; Kapıcı & Savascı-Açıkalınb, 2015) and it could be argued that it may give students freedom to interpret the meaning of the photograph. However, it can also be argued that it may cause trouble to students (Kapıcı & Savascı-Açıkalınb, 2015), leading them to do unintended or unanticipated interpretations, especially in the lower school levels.

Table 5: Caption of the photographs used by the textbooks when dealing with the theme (%)

Caption of the photographs		8th grade			11th grade		
		TB1 (n=292)	TB2 (n=194)	TB3 (n=254)	TB4 (n=195)	TB5 (n=265)	TB6 (n=121)
Caption	Appropriately matches the content of the photo	2,1	38,1	5,9	7,7	25,7	52,1
	Makes some explanatory comments on what is shown in the photo	32,2	4,6	9,8	30,3	12,1	30,6
	Does not match the content of the photo	1,0	36,7	5,5	5,1	17,3	5,8
Replaced by an explanation focusing on page content and ignoring the photo content		2,4	1,0	2,8	14,3	0,4	2,4
No caption		62,3	19,6	76,0	42,6	44,5	9,1

Besides, when captions are provided, some of them do not give a contribution to make it explicit the content of the photograph. In fact, there are cases in which the caption presents comments related with elements that are shown in the photograph instead of comments to the photograph itself. This happens with about one third of the photographs included in TB1, TB4 and TB6. There are also cases in which the caption does not match the content of the photograph. This happens with about one third of the photographs included in TB2. These mismatches may make students feel confused and/or develop alternative conceptions (Devetak & Vogrinc, 2013). Finally, all the textbooks analysed included photographs in which the caption is replaced by an explanation. The number of photographs in this circumstances increases from 8th to 11th grade in textbooks by P1 and is kept approximately constant in the other textbooks. In the overall, the findings relative to captions compare to those obtained by Dourado, Morgado, and Leite (2015), with 8th grade Portuguese textbooks, and by Pozzer and Roth (2003), with Brazilian textbooks.

Exploration of the photographs integrated into the text

Photographs that are integrated along the text were analysed in order to find out whether or not they are explored with the aim of illustrating and complementing the content that is being presented. Table 6 shows that the majority of the photographs are related with the content being presented. However, textbooks by P3 are the only ones that make an explicit relationship between the text and the photographs, either in a considerable amount of (TB3) or in all the photographs (TB6) that they integrate into the text. The result obtained with TB3 compares to the one obtained by Kapıcı and Savascı-Açıkalınb (2015) with Turkish 8th grade chemistry textbooks. Pozzer and Roth (2005) stated that the main text is an important resource in helping readers to interpret photographs. Thus, a good relatedness of photograph's and text would make the task of interpreting photographs much easier and accurate for the reader, namely for the students.

Photographs that are not related to the content being presented seem to intend to add new (different) information or to provide a background of the page to beautify it. This way of using photographs, that was also found by Dourado, Morgado, and Leite (2015) and by Kapıcı and Savascı-Açıkalınb (2015), may have selling purposes (Cook, 2008) and are dispensable (Perales, 2008) from an educational point of view. In fact, they may hardly facilitate or enhance students' learning because, as Pozzer and Roth (2004) argue, it is difficult for students to correctly interpret them.

Table 6: Relationship of the photographs integrated along the text with the text itself (%)

Relationship of the photographs with the content		8th grade			11th grade		
		TB1 (n=129)	TB2 (n=122)	TB3 (n=135)	TB4 (n=121)	TB5 (n=121)	TB6 (n=96)
Related to the content presented	Explicitly mentioned	0,0	0,0	43,0	0,0	0,0	100,0
	Not explicitly mentioned	98,4	100,0	56,3	74,4	95,0	0,0
Not related to the content presented nor explicitly mentioned	Simply add new information	1,6	0,0	0,7	23,1	5,0	0,0
	Work as a background to beautify the page	0,0	0,0	0,0	2,5	0,0	0,0

Contextualization of the entities shown in the photographs

Table 7 shows that, whatever the textbook, very few photographs show entities in a context or background. In addition, when a background is provides, in a few photographs there are not enough data to identify the type of context even though some of those photographs contain elements that may be meaningful for people holding a certain kind of previous knowledge and experience. However, if photographs are to complete the text, then they should be self-meaningful so that they could be interpreted by the students in the way textbook authors want them to be, that is according to the intention underlying the choice of a given photograph and the decision on where to locate it in the page.

Table 7: Contextualization of the entities shown in the photographs used by textbooks when dealing with the theme (%)

Contextualization	8th grade			11th grade		
	TB1	TB2	TB3	TB4	TB5	TB6
	(n=292)	(n=194)	(n=254)	(n=195)	(n=265)	(n=121)
Yes	12,7	8,8	11,0	14,8	9,4	23,1
No	79,8	75,2	84,6	74,4	79,2	58,7
Not enough data	7,5	16,0	4,4	10,8	12,2	18,2

The large percentages of photographs with non-contextualized entities (between about 59% and 85%) identified in the textbooks analysed raise the question of how those photographs are interpreted and whether such kind of photographs may play their intended roles or not and if not, whether or not they interfere negatively with students learning. In a previous study (Dourado, Morgado, & Leite, 2015), larger percentages of photographs were assumed as being contextualized at least in part because the category "not enough data" was not considered and some photographs that the authors, as experts in the area, could anticipate to they were related to were classified as contextualized. The inclusion of this category was supported by Pozzer and Roth (2005) argument on that the background of the photograph is needed if the reader is expected to make appropriate sense of the picture relevant elements. Thus, for instance, photographs showing fireworks that occupy the whole photograph space or showing lab glass material supported by fingers wearing gloves were classified in the category "not enough data". In the former case, the image shown could represent something else than a firework, for instance an anemone; in the latter case, the fingers with gloves can make people think about a laboratory context but in fact only people with a science background (not beginning science students) know it. Bearing in mind Lee's (2010) and Pozzer and Roth's (2005) results, they each student could interpret these photographs in its own way and then the photograph would not fulfil the textbook's authors aims.

The contextualized entities focused on the photographs are concrete entities or processes (table 8). It should be noted that the photographs focusing on processes show only one take of the phenomena, that is they offer a static picture of it and therefore they are not elucidative about the dynamism of phenomenon which would be an important information for students that are not familiar with it. As it was mentioned above, people can see in the photographs what they want to see (Pozzer & Roth, 2005) but they will not probably be creative enough to correctly imagine how a new (to them) science phenomenon evolves unless they are already familiar with it. Then, this type of photographs has a limited illustrative value. From 8th to 11th grade, the percentage of photographs focusing on concrete objects decreases in textbooks by P1 and P3 but somehow surprisingly it increases in textbooks by P2. As it is widely accepted, as students get older they need less contact with concrete objects. Thus, P2 option seems to be consistent with Tufekcic's (2012) idea that photographs are included in the textbooks just to be there.

These results compare to those previously obtained with Portuguese 8th grade textbooks (Dourado, Morgado, & Leite, 2015) in which photographs showing contextualized concrete entities and processes were found. However, simply including photographs of entities or processes does not add to students' understanding of the science content that is being approached and does not play a meaningful role in students' interpretation of photographs. Therefore, most of them would be dispensable (Perales, 2008) even though they may be worked out in the classroom in a more interesting way.

Table 8: Nature of the entities that are contextualized (%)

Nature of the entities	8th grade			11th grade		
	TB1 (n=37)	TB2 (n=17)	TB3 (n=88)	TB4 (n=29)	TB5 (n=25)	TB6 (n=28)
Concrete entities	56,8	29,4	64,3	31,0	56,0	21,4
Processes	43,2	70,6	35,7	69,0	44,0	78,6

Photographs that show contextualized entities concentrate on people, objects, places and animals (table 9), being places and objects usually the most frequent, as expected based on Dourado, Morgado, and Leite (2015). From 8th to 11th grade, the percentages of photographs showing places (e.g., beach, mountain, etc.) increase in the textbooks by publishers P1 and P3. The opposite happen with P2 but this variation has to be interpreted with caution because the number of photographs showing contextualized entities is very low, especially in the 8th grade textbooks. text.

Table 9: Types of concrete entities that are contextualized (%)

Types of concrete entities	8th grade			11th grade		
	TB1 (n=21)	TB2 (n=5)	TB3 (n=18)	TB4 (n=9)	TB5 (n=14)	TB6 (n=6)
People	23,8	20,0	16,6	11,1	21,4	33,3
Objects	52,4	0,0	27,8	33,3	21,4	0,0
Places	23,8	60,0	55,6	55,6	50,0	66,7
Animals	0,0	20,0	0,0	0,0	7,1	0,0

Percentages of photographs showing animals in a background are very low probably due to the nature of the science content. Photographs that concentrate on people in a setting are more frequent then those with animals. This result may be to the fact that the theme under analysis has a rich history and that textbooks include pictures from several scientists when developing it. However, as it was discussed elsewhere (Leite, 2002), the content of such pictures may fulfil some students curiosity about how the scientists of the past were used to look like but it adds very little to the content presented in the

Even though the number of photographs showing contextualized processes relative to matter transformation is very low (table 8), table 10 indicates that in the 8th grade textbooks, most of these photographs show the transformation of substances in daily life settings (e.g., dynamite explosions, rockets launch, rust in gates, boats, etc.), statues corrosion, acid rain forest destruction, etc. These percentages decrease from 8th to 11th grade and, as a consequence of this, the percentages of photographs showing industry processes increase. This may be due to the nature of the content that textbooks are dealing with, as in 11th grade they have to approach, for instance, the industry process of ammoniac production. A few textbooks also include photographs that try to show processes associated with human basic needs fulfilment, like eating and drinking. However, showing a person drinking water or juice is not showing a transformation of matter process. In fact these will start after drinks or food are ingested, include a variety of transformations and cannot be seen at naked eye. Maybe authors just want them to serve as a basis for students to think about chemical reactions.

Table 10: Settings in which the processes that are contextualized take place (%)

Settings	8th grade			11 th grade		
	TB1	TB2	TB3	TB4	TB5	TB6
	(n=16)	(n=12)	(n=10)	(n=20)	(n=11)	(n=22)
Industry	18,8	25,0	20,0	50,0	45,5	45,5
Daily life	62,4	58,3	80,0	40,0	54,5	40,9
Personal needs	18,8	16,7	0,0	10,0	0,0	13,6

However, it should be noted that photographs that try to show a process are not dynamic and do not represent several phases/moments of the phenomenon; rather, they just show a take of it. Therefore, it may happen that photographs are more helpful for students to learn about labelling structures and describing the phases of a process, than to learn about the overall process as a whole (Cook, 2008).

As shown in table 11, few photographs show entities contextualized in indoor surroundings. These surroundings are home or (school, research or industry) laboratory environments. However, the content of the photographs and the background of the entities photographed do not contribute too much to help students to perceive, for instance, the domestic and the industrial applications of chemical reactions.

Table 11: Types of spaces surrounding the contextualized entities (%)

Types of spaces	8th grade			11th grade		
	TB1 (n=37)	TB2 (n=17)	TB3 (n=28)	TB4 (n=29)	TB5 (n=25)	TB6 (n=28)
Indoors	16,2	0,0	10,7	3,4	8,0	14,3
Outdoors	83,8	100,0	89,3	96,6	92,0	85,7

The outdoor surroundings used in the textbook photographs are quite diverse but in some cases they show open spaces that can hardly be characterized (table 12) because they either are quite narrow or are too homogeneous (e.g., a grass field) for the (geographic, geological, urbanistic, etc.) characteristics of the space that surrounds the entity to be identified. Textbooks by P2 are the ones that include more photographs in this category that adopt a way of contextualization which is poor.

There are many chemical reactions that take places in open spaces and many types of open spaces are considered by the textbooks. However, chemical reactions cannot be seen at naked eye. Only indirect evidences of a chemical reaction can be observed. Thus, the nature of the open spaces depends on the chemical reaction specific topic to be addressed, that is on the place a given chemical reaction occurs and the entities that are associated with it. For instance, a photograph of a beach relates to an open space where it is known that the sun fosters chemical reactions on people's bodies despite the fact that those reactions cannot be directly observed. Therefore, a question should be raised: what are the educational added value and the motivating power of such photograph? Does it really facilitate students' learning task or does it distract them? Does it show something that they do not know and that they are expected to know?

Table 12: Nature of the open spaces in which contextualized entities are shown (%)

Nature of the open spaces	8th grade			11th grade		
	TB1 (n=31)	TB2 (n=17)	TB3 (n=25)	TB4 (n=28)	TB5 (n=23)	TB6 (n=24)
Mountain	12,9	17,5	12,0	25,0	21,7	29,2
Field	3,2	11,8	8,0	3,6	8,7	16,6
Beach	16,1	5,9	0,0	3,6	8,7	8,3
River and Ocean	12,9	5,9	24,0	14,3	26,2	4,2
Sky	12,9	11,8	12,0	0,0	0,0	0,0
Caves	3,2	11,8	8,0	3,6	4,3	4,2
Roads	12,9	0,0	8,0	7,1	0,0	0,0
Urban areas	6,5	5,9	4,0	7,1	4,3	8,3
Ill-defined	19,4	29,4	24,0	35,7	26,1	29,2

CONCLUSIONS

The objective of this paper is to compare photographs included in 8th and 11th grade textbooks, by three different

publishers, between them and in terms of their potential to contribute to contextualized science teaching. Three textbooks for each grade level and by three different publishers were analysed with regard to the way they deal with photographs (or photograph related visual material). Research findings seem to indicate that, in the overall, the use of photographs does not differ too much among textbooks and between grade levels and is hardly guided by context-based science teaching principles and that it does not differ too much between the two grade levels textbooks. In the overall, the results compare to those reported by other authors with regard to the use and inferred purpose of the photographs, as well as with the approach to contextualizing the entities that are photographed.

Some small differences were noted between publishers with P2 seeming to have less planned criteria to using photographs in the two school levels. However, this paper focuses on a part of the textbooks from which cannot be inferred the way photographs are used in the rest of the textbook. Therefore more research in needed in order to identify the features of photographs use in the different textbooks and by the diverse authors and publishers. This research that would require a interviews to be conducted with people in charge of publications as well with textbook author, would give some insight on the way photographs and other visual material are planned and used in science textbooks.

Even though further study is needed to address important issues related to the pedagogical potential of the photographs included in textbooks (Pozzer & Roth, 2003), the findings of the research reported in this paper have several educational implications, being the first of them for textbook authors and publishers: they should appropriately select and integrate the different visual tools in their textbooks so that those tools may in fact assist students in making sense of what they are expected to learn.

Besides, these findings put some pressure on teachers as they should be able to pay attention to the possible weaknesses and strengths of photographs (Kapıcı & Savascı-Açıkalınb, 2015) included in students' textbooks and to be sure that their students understand the 'codes of representation' (Gilbert & Afonso, 2014) that might be used in those photographs, in order to find the best ways to succeed in leading photographs to effectively become bridging tools between science content and everyday life. This bridge building process is at the heart of student-centred contextualized science education approaches.

However, the acknowledgment of this idea may raise another concern that has to do with teachers' training for contextualized science teaching approaches. As Ültay and Ültay (2014) pointed out, "because the teachers are the implementers of the approach, their views, perceptions and involvement should be regarded as important and their professional development should be examined. If needed, in-service education should be given." (p.215), especially if the more modern contextualizing approaches are to be adopted. These are more demanding for teachers as they may require many of them to move away from teacher- and canonical science- centred to student-centred and daily life-based approaches.

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