PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019
636

TEACHERS' VIEW OF LANGUAGE(S) IN (CLIL) SCIENCE EDUCATION: A CASE STUDY IN PORTUGAL

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Abstract

The development of meaningful environments at school for the learning of Science as well as of foreign languages is an educational concern. CLIL (Content and Language Integrated Learning), aimed at the students' acquisition of both the foreign Language and specific subject Content, is an approach that may promote the learning of English in use during subject classes and could result in the improvement of conditions and practices of Science education. Research, actually, reveals that teaching methodologies aware of language – such as CLIL – and other semiotic modes implied in Science are beneficial for the learning of Science. Studying a CLIL programme ("English Plus" project, EP), in which Science is taught/learnt with/in English, is thus relevant. A case study on the EP project and its participants (English and Science teachers, students involved in different school years) in one lower secondary state school in Portugal was carried out. In the present research, qualitative data collected through teacher interviews are presented and discussed, with the goal of understanding the role of Language(s) (verbal language in the mother tongue or English and other representation modalities) in the teaching of Science for EP teachers, both in conventional and project classes. A greater teacher awareness and use of Language(s), when an additional language (English, here) is also present for Science education, results from this work. This contributes to research on CLIL Science studies and teacher reflections on adopting a language-focused approach for Science education, also when the mother tongue is spoken.
Keywords: *CLIL (Content and Language Integrated Learning), EFL (English as a foreign language), language-focused science education, qualitative design, reflections on teaching.*

Introduction

Science education has a pivotal role in the information society and for lifelong learning. It is a "public value" for social, economic and sustainable development (Martins, 2014). Unfortunately, whilst in the last century Science, Medicine and Technology have been impressively evolving, "transferability" of school Science knowledge into "comprehension" of everyday natural phenomena has been poor, as reported by PISA-OECD surveys among others. Recommendations for Science education emphasise the importance of its contextualization and of supporting learners in understanding and constructing concepts over facts and formulas for developing a scientific literacy, to understand and integrate scientific information and to take responsible decisions about socio-scientific issues (Holbrook & Rannikmae, 2009; Roberts & Bybee, 2014). Participation in the real world implies people can communicate adequately, collaboratively and effectively.

Nevertheless, relatively little attention has been devoted to the significance of the language demands in learning scientific topics (Seah & Silver, 2018), although for many students the greatest difficulty is to learn the language of Science, that is, a "range of semiotic modes available to the science teacher" and in Science in general (Wellington & Osborne, 2001, p. 7). As expressed by Lemke, "the natural language of science is a synergistic integration of words

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

[…] visual representation […] mathematical symbolism […] experimental operations [that is] 'the languages of science' in a broader sense [than just specialised languages of scientific fields]" (2003, pp. 4-6), which requires of students a "multimedia literacy" and of teachers awareness and support. Indeed, if formal Science education is a considerable contribution to the citizenship and public scientific understanding, a language-focused Science education is justified, as stated by Wellington and Osborne (2001). A deeper understanding of the role of these various representations[1] in developing Science knowledge and literacy is as crucial as orienting teacher education and professional practices (Tang, Delgado, & Moje, 2014; Yore & Treagust, 2006), so that the learning of the language and literacy practices become an essential part of the Science learning (Seah & Silver, 2018).

Being competent in foreign languages (albeit to varying degrees) is also fundamental (Council of Europe, 2001), not least for people participating in scientific and general discussion. Global demand for learning English and through English has been increasing (Dearden, 2014). English is the language of the international scientific community, as well as of technology and multimedia, often "assumed" in academic curricula (mainly scientific degrees), for professional mobility and cultural encounters (Dearden, 2014; Gimeno, Seiz, de Siqueira, & Martínez, 2010; Jenkins, 2015; Kaire, 2017). It can be seen as "overwhelming" worldwide Science research but the endeavour to explore factors of how the English language might support the learning of Science and vice versa is worthwhile, as discussed below. Moreover, it is nowadays viewed as "global lingua franca" rather than "one of the foreign languages", meaning that a significant teaching of English should be directed to the intercultural opportunities and bridges to other languages (without excluding the learners' mother tongue) that English can offer (Smokotin, Alekseyenko, & Petrova, 2014).

Within school environments, CLIL (Content and Language Integrated Learning), in being a language-aware and content-directed educational approach (see next section) which integrates different curricular fields, is a possible solution to provide an authentic learning of both English and Science. It may foster the development of multimodality for Science knowledge and communication, both in the native and foreign languages, if gradually and iteratively implemented (Meyer, Coyle, Halbach, Schuck, & Ting, 2015). There is still work to be done, as suggested by Scott, Mortimer and Aguiar (2006), to understand how the construction of scientific knowledge develops through language and other modes of communication. Research is also required on CLIL Science learning contexts, in which an additional language has to be learnt besides the mother tongue. Furthermore, a greater collaboration between applied linguists and researchers in subject-specific education is sought (Nikula, Dalton-Puffer, & Llinares, 2013). Most studies in CLIL Science, in fact, originate from the Language research field.

In the Portuguese context, CLIL projects and initiatives across school levels have grown in the last decade: for instance, the "English Plus" project (EP) discussed here, in which Science is taught and learnt with and in English at lower secondary school (Ellison, 2018). The corresponding research on these projects is still localised and many studies are focused on the tertiary level. The relevance of carrying out research on CLIL school programmes devoted to Science education becomes clear. More specifically, the objective of this research is to understand, from teachers involved in the EP programme, the role of Language(s)[2] in the teaching of Science, within "normal" and CLIL practice (where Portuguese and English are used, respectively). Their discussion contributes, in turn, to a reflection on language demands of (CLIL and non-CLIL) Science learning and on teaching practices, in order to improve the learning of both Science and English.

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

The CLIL Approach and (Non-Language) Subject CLIL Teachers

The 1995 White Paper on Education and Training reveals the importance for European citizens of competence in European languages besides their own. CLIL is indicated as one strategy to promote plurilingual and intercultural education (Beacco et al., 2010) and one possible initiative for language education, in the 2011 Civil Society Platform on Multilingualism in Europe. CLIL emerges therefore as a European solution for advancing foreign language (FL) learning, and it shares theoretical underpinnings and methodological concerns with the Canadian immersion in bilingual education (Evnitskaya & Morton, 2011). Though stemming from immersion programmes, differences have arisen over time: for instance, the "non-nativeness" of teachers and students or readapted/scaffolded teaching materials (Lasagabaster & Sierra, 2010), or the degree of collaboration between language and non-language teachers (Pavón Vásquez & Ellison, 2013).

According to Krashen's theory on Second Language Acquisition, languages are learnt while they are used, and CLIL classes are authentic learning environments to achieve "communicative competence in the target language through […] everyday classroom activities" (Dalton-Puffer & Nikula, 2006, p. 241). Unlike traditional FL classes, where form and structure of the foreign language are the main object of study, within CLIL settings Content (non-language, specific subject which is represented through language) and Language converge in a "dual focus" for learning and teaching, according to referential conceptualizations of CLIL as an educational approach (e.g., Coyle, Hood, & Marsh, 2010; Marsh et al., 2011). Students learn the discipline or a theme and how to use the languages of/for/through learning (the so called "language triptych", cf. Coyle).

Through code-switching, the L1 can also be present to support content learning when needed; major difficulties in the implementation of CLIL classes are caused not by using a FL, but by the lack of appropriate methodology used in class (Barbero, 2006). There is no formula for organising a CLIL programme, the context being the crucial point (Coyle, 2005). Any language can be selected, but one factor to contemplate is the characteristics of the CLIL subject as well as the degree of "proximity" between the students' mother tongue and the CLIL language: disciplines like Philosophy or Literature rely mainly on verbal communication, whereas Biology or Geography are represented also visually; one wants to guarantee that verbal density is not a learning obstacle when using a foreign language.

In Europe, CLIL teachers are usually content teachers who experience a professional and personal challenge through the language (Oattes, Oostdam, de Graaf, & Wilschut, 2018). This can increase teacher awareness of learner linguistic needs and prompt the development of quality teaching and learning strategies in CLIL-based education (Marsh, 2012). When the Science teacher ends up working in a CLIL environment, her/his own non-expertise in the foreign language might make her/him more aware of making content accessible to students and her/his relationship with them less hierarchical (Blanchard, Masserot, & Holbrook, 2014); she/he is engaged in "a constant process of rethinking the way one teaches" (Canet Pladevall & Evnitskaya, 2011, p. 176), which "may favour a more profound treatment of content" (Escobar Urmeneta & Evnitskaya, 2014, p. 178). Hence CLIL settings both provide higher FL exposure/learning and facilitate Science learning, improving Science education and performance (Grandinetti, Langellotti, & Ting, 2013).

CLIL is acknowledged as a "change agent", in converting "monolingual learning contexts into bilingual experiences" (Coyle, 2013, p. 244), and in entailing "language-sensitive content teaching" strategies favourable for preparing CLIL and non-CLIL teachers who work in CLIL-like contexts in European schools; actually, due to increasing migration, conversational and academic competence levels in the schooling language among learners are heterogeneous (Wolff, 2012). The importance of "[equipping] CLIL teachers to bear the challenge of that

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PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

change" is unquestionable (Pérez Cañado, 2016, p. 217), nevertheless, triggering the change of the pedagogical approach of both language and non-language teachers, reflecting on "beliefs, values and practice" is a primary concern (Pavón Vázquez & Ellison, 2013, p. 77). The focus of research in the CLIL field is usually on benefits for the students' foreign language skills, and attitudes towards language learning, having shifted only recently to concerns related to content knowledge acquisition (Meyerhöffer & Dreesmann, 2019). Moreover, to the authors' knowledge, studies specifically directed at CLIL Science classes have not paid attention to the "flux" between the presence of English in CLIL Science classes and teacher practices within Science education in which the language of instruction is, typically, the mother tongue. This is an added value of the present study that aims, as already introduced above, at characterising the practices of "Language(s) of Science" (cf. Lemke, 2003; see note n. 2) in both non-CLIL and CLIL conditions, as related by teachers involved in a Portuguese CLIL project of Science with English.

Research Methodology

Background

Among the CLIL initiatives in Portugal in state-run schools, the top-down "Bilingual Schools Programme"[3] in English (organised by the Ministry of Education and the British Council in Portugal) exists, currently involving 25 state school clusters from pre-primary school levels up to the 9th grade. Interested in bottom-up initiatives wherein teachers design their own CLIL contribution (timetable, strategies, material) through the curriculum, the ongoing "English Plus" (EP) project in one lower secondary school (from the 7th to the 9th grades) in Northern Portugal is described in this article. Its first edition was undertaken between 2010 and 2013 by one English and one History teacher with students of one class and monitored by the authors' research group with regard to stakeholders' perceptions. The project was reactivated in 2014-2015 for the Natural Sciences (NS), involving one Science teacher, and, since 2015-2016, a new collaboration with the same research centre was developed. During this year, out of 20 classes in the school, 2 at 7th grade, 2 at 8th and 1 at 9th were involved with two Science and two English teachers in the EP project.

Participation in the "English Plus" programme was voluntary. EP students attended, on a weekly basis: 45 minutes of theoretical NS with English (EP classes, co-teaching: the subject and the English teachers both present and using English), 45 minutes of theoretical NS mainly in Portuguese (non-EP classes, single-teaching: classes given by the non-language teacher alone) and 45 of "project time" (PT classes, also within the project: English on socio-cultural subject-related topics with the English teacher). The remaining disciplines, including practical Science classes, followed the standard curriculum. Given this specific setting, EP is referred to as a CLIL-type provision. These students were usually also "engaged" in extra-curricular activities: school trips and their organization, cinema sessions, theatre performances, "open day", etc. Science teachers could choose suitable units to teach the content topic by means of the foreign language, rather than covering the whole Science syllabus. No financial reward was provided to EP teachers.

Instruments and Procedures

Considering the specific characteristics of the project, in 2015-2016 a descriptive-explanatory case study was designed, within a PhD research project. The student participated extensively in the project and school activities and gathered perspectives from both teachers and students. The focus of this specific work is on the project teachers and their voices: two

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

Science (one with two years' experience with the project and one in her first year of EP, in 2015-2016) and two English (one coordinating the two EP editions, one at an observation stage in 2015-2016) teachers. It is worth saying that the Science teachers learnt English mainly in private institutes and used to practice it (reading papers, going to conferences, etc.) during their degrees in Biology; the English teachers studied Science until the 9th grade. Qualitative information gathered through (selected questions from) teacher interview is the main corpus of analysis here, and is complemented with data resulting from secondary methods (observation, mainly enabling the context characterization; student questionnaire and interviews, used to support the discussion).

Broadly based on competence areas drawn from the CLIL Teacher's competences Grid (Bertaux et al., 2010), a semi-structured interview guide was developed. The first part contained questions regarding the interviewee's education and work as a teacher, their linguistic/scientific profile, strategies and resources used in classroom practices and socio-cultural implications of the subject they teach, as well as questions linking Science with (foreign) languages (see first part of Research Results). The second group of questions (see second part in Research Results) referred to knowledge and/or experiences they have with the CLIL or CLIL-type approach, at an organizational and educational level. In order to validate the interviewing process and questions themselves, young researchers with teaching experience were interviewed first. With the interviewee's consent, participant teachers were interviewed and audio-recorded at their school before the start of the 2015-2016 school year, in their native language (Portuguese) so that they felt comfortable in understanding questions and expressing themselves.

Data Analysis

Qualitative content analysis was performed on verbatim transcribed interviews, forming categories inductively; coding was examined with the project teachers and with peers for validation of the coding (process) and of its coherence with constituted fields, as explained below. For the purpose of this paper, the results associated with participants' points of view on the Science teacher also being a teacher of language(s), relationship between Science and English at school, and the teacher's experience in the planning and implementation of CLIL Science classes, are presented[4] and discussed. Personal information was kept confidential.

In table 1 within the appendix, coded answers given by the project English and Science teachers to the questions indicated in the following sections are shown; relevant examples are provided (referred to in the text by number). The interpretation of this coding also allowed for the classification of the sub-codes in terms of the range of "languages" within Science education (cf. Lemke, 2003; see note n. 2), both in non-project and project classes (with Portuguese and English being spoken, respectively).

Research Results

Representational Forms within Science Education – Non-Project Classes

Forms or modes for the Science representation/communication resulted mainly from answers to *What is your position about the statement "Science teacher is a Language teacher"[5]?* Science was declared to have, as any subject does, a specific lexicon (1a. sub-code in the appendix), which is a language according to both English teachers (Ex.: 1). The teaching of all disciplines including Science must help the students to master their own mother tongue (1b. sub-code), as acknowledged by teachers from both areas (2, 6). This question intentionally did not mention the "English Plus" project, meaning to gauge opinions irrespective of it and its additional language, but the foreign languages (mainly English, 1c. sub-code) being bound

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PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

to Science education arose as a further aspect. They were considered fundamental to study any course at university by one language teacher (3). The two Science teachers mentioned the intense presence of English in: subject vocabulary; textbooks, online resources and material as well as the learner's search for them; (educational) videos with or without subtitles (8 and 9); news and magazines related to Science; activities (in the lab or through debates) performed using English (because of the project). Science communication was viewed, then, as essential and "embedded" within the nature of Science itself, both in the native and foreign languages (7).

Some of the resources and activities disclosed by the non-language teachers as being in English were introduced as regular scaffolding strategies or learning settings in Science education (1d. sub-code in the appendix) when the interviewer mentioned the term *linguagens*[6] of Science, which better suggested the idea of "Science languages", that is, a diversity of representational choices for conveying Science concepts and processes. Actually, teachers reported, also through answering questions about practices to support and involve learners (such as *Can you talk about examples in the planning and implementation of your classes to make concepts and topics understandable for your students?*), the use of: visual support through videos (8, 9) and concept maps modelling the information through previous personal representations and besides the language (10); simulations and other practical activities; questions and debates (11).

Aimed at exploring through teachers a conceptual/methodological relationship between Science education and English practice in non-project conditions and at extending the understanding of Science languages through the English practice within the EP teaching, the question *What connections can you highlight between the education of Science and the practice of English?* was asked, which was not immediately clear and probably sounded "authoritarian" to the Science teachers because of the mention of the term *didática*[7] (their discourse showed a few pauses in answering and they appeared to question the correctness of their own methodological practices). It led one language teacher to identify activities or strategies that English teachers could learn from the example of Science practical lessons (4). One Science colleague thought, on a different level, of the universality of Science teaching across a diversity of languages (12). The language used in/for the discipline (1e. sub-code in the appendix) was, from the English teachers' point of view (5), a concept of language applicable not just to Science. Both Science teachers, more specifically, associated the English language with Science at school and in general, as already emerged from answers to the previous question: the quantity of English terms used in Science (DNA, HIV, etc.) as well as English being the international language used in and for Science (13).

Representational Forms within CLIL Science – Project Classes

In this case, teachers answered questions[8] connected with the CLIL-type approach used in the "English Plus" project and coded responses were organized through fields of the teacher professional practice (in-service education, planning, implementation and assessment). Only the results associated with the planning and implementation of EP classes (Science taught/learnt with English) – especially emerging from the teachers who already worked in a CLIL environment – are presented here.

Regarding the planning level (2a. and 2b. in the appendix), teachers already experienced with the project tended to relate practical aspects, such as the preparation of: the scaffolding for the teacher to know the verbal sequence of the lesson (26) and for the learners in terms of visual or multimodal support (19 and 29), as well as of brand new material (20 and 30). They reported the importance of scheduled meetings to avoid time-consuming email exchanges for designing presentations of the subject topics and checking correctness of the foreign language (21 and

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

31). The two teachers not familiar with EP hypothesised about teacher teamwork, also to come up with diversified strategies for students (22) and with an adequate educational organization for Science learning through another language (32). The latter aspect was complemented by the experienced English teacher who identified the significant effort required of Science teachers as CLIL teachers (14). They had to learn the scientific English themselves (Ex.: 27), relying for this on the language colleague's collaboration and knowledge, to become familiar with the English version of specific terms, as described by both sides (15, 28). The English teachers, on the other hand, would need to acquire this specific lexicon (16) and to (re)learn some Science concepts, to feel comfortable with the Science content (17, 18).

According to the experienced EP teachers, within the co-taught CLIL-type EP classes (2c. sub-code), the Science and English teachers used to have different specific roles. While the subject teacher implemented Science classes in English, involving students, the language one highlighted terms and concepts in English on the board (23 and 33). The concern about having to use a foreign language was confirmed by the Science teachers who declared, as subject CLIL teachers, that they felt a double responsibility with the pedagogy and education of Science and the language mastery, mainly in terms of speaking and written level (34) and that they were afraid of forgetting how to move forward through the lesson while using another language (35), without a side sheet as said before. Moreover, the need for having the visual support ready and functioning for learners to get to the English word was described, an "assembling" not necessary with the Portuguese mother tongue (36). Finally, the language teacher reinforced the importance of "supplying" students with the Science lexicon in English, images being necessary to support the learning of new terms (24) as much as non-just-written resources to appeal to students (25). The subject teacher actually mentioned how her colleague, during PT classes, used to verify concepts students acquired in EP classes or prepare them with terminology to later use in EP classes (37), using the English language.

Discussion

Teachers do not immediately associate Science with a multiplicity of languages and representation modalities. The Science teachers identified English as the inevitable language used in their discipline in answering different questions [sub-codes: 1c. foreign language; 1e. (English) language and (Science) subject, Table 1 in the appendix], whereas the existence of technical terms in Science was, curiously, only reported by the English teachers (specific lexicon in Table 1). Apparently, specific lexicon is not thus recognised as a learning obstacle by non-language teachers but it represents something to learn for non-experts – the language teachers, here, or younger students (Piacentini, Simões, & Vieira, 2016) – in line with the idea that Science language is like a foreign language to learn (Wellington & Osborne, 2001) and "nobody's language", as highlighted by Do Coyle during an event on CLIL[9]. In defiance of these aspects and as argued by these researchers and Sanmartí (2007), the language teachers and one subject teacher acknowledged Science lessons as also being a context for literacy development in the students' mother tongue; in fact, the importance of Science being communicated and becoming available for a wider audience, to be "finished Science", is perceived.

Science relies on words for its communication but also on other semiotic modes such as images, equations, actions, etc. (Klein & Kirkpatrick, 2010; Lemke, 2003; Sanmartí, 2007; Wellington & Osborne, 2001; Tang et al. 2014), as implied by the use of *linguagens* (see Results). One teacher, actually, stated that the mental construction goes beyond languages in the ways Science knowledge is represented (through diagrams, concept maps, models, etc.). Presumably, teachers should reflect on how a graph or diagram conveys and constructs meaning, implying the use of a diversity of signs (terms, arrows, colours, symbols, etc.) whose comprehension, in Portuguese or English, is required for learners to overcome difficulties and understand any

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subject content (Piacentini et al., 2016). In Lemke's words, students may not "decipher the languages in which we are saying and showing it" (2003, p. 11). To improve learning, teachers need to become aware of and effective with the multiple semiotic systems or languages of Science, as scholars from different fields (CLIL and non-CLIL) diversely advocate (Coyle et al., 2010; Klein & Kirkpatrick, 2010; Lemke, 2003; Llinares, Morton, & Whittaker, 2012; Lyon, Bunch, & Shaw, 2012; Polias, 2006; Wellington & Osborne, 2001).

Until this point, "normal" Science classes have been discussed, that is, classes where the teacher and students use their native language (Portuguese) as the verbal language. However, English is notably present in resources the Science teachers frequently work with, such as educational videos. The presence of subtitles (in the same language as in the video) is considered to improve both the knowledge of the (English) language in terms of oral and written skills, and to support the understanding of a (Science) topic, providing an extra language scaffold to learn through. Also, in agreement with Lin and Lo (2017), a "dialogic way" between the foreign language and the mother tongue, both shifting from colloquial to scientific ways of speaking and vice versa, is relevant. This means that the use of the two linguistic systems should be encouraged in classes within the project but, according to observations, Portuguese was almost forbidden for students or "confined" to the preparation for final exams, while "translanguaging" is desirable and recommended in CLIL (Coyle et al., 2010) and CLIL-like settings (Karlsson, Nygård Larsson, & Jakobsson, 2018). Meyerhöffer and Dreesmann stated that "in its basic form, this [the incorporation of English in the biology classroom] could even refer to acquiring scientific information that is then talked about in students' native language" (2019, p. 16).

The question asked to explore possible connections between Science education and English practice could have seemed less "academic", with the use of "teaching/learning of Science" instead of *Didática das Ciências*. However, the existence of an "educational reciprocity" between Science and English, whether within the CLIL approach or not, is still not acknowledged. Teachers involved in the "English Plus" project did express the transferability of the practical nature of some Science classes to English learning and also the inextricable link between knowledge (both achieved and constructed) development and language development (Klein & Kirkpatrick, 2010; Sanmartí, 2007), but the following question reformulation would have better explored the relationship and reciprocity between Science education and English learning: *How could teachers put Science and English "each in service of the other", in planning and implementing Science classes?*.

It is interesting to highlight that, when engaged in the CLIL methodology through EP (second part in results), teachers seem to assume a different attitude. The Science teachers, who previously had not taken into account (possible learning difficulties connected with) the Science lexicon, realise the language demand in the learning of terminology (Seah & Silver, 2018), because of themselves experiencing the "linguistic pressure" of teaching in the second language (Oattes et al., 2018), in terms of both communication and scientific terms. Through the challenges encountered using English, they become aware of the need for supporting the understanding with a diversity of languages (visual scaffold but also other modes), in order to facilitate both the learner's meaning making and their own structuring/management of the classroom. Previous studies on the EP students' point of view noted that the subject teacher's difficulties with English enabled her, to some extent, to develop a clear verbal input to express meaning and to adapt teaching strategies to overcome the language obstacle (Piacentini et al., 2018). Here we are reminded by Blanchard, Masserot and Holbrook (2014) that a less distant relationship with students and one more focused on meaning clarification than on the right term can emerge when a language other than the teacher's and learners' native language is present.

In addition, observation of EP and PT classes (see section about research context) revealed what teachers had described, a constant work mainly from the English teacher on both common and Science terms, "labelling, explaining, differentiating and selecting" as illustrated by Seah

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

and Silver (2018, p. 11). The "comprehensibility" of the language makes the specific content more "accessible", promoting the understanding of English and Science (Grandinetti et al., 2013). All project teachers remarked upon the importance of collaboration among colleagues and of combining competences in both the language and non-language subjects. Furthermore, they were observed engaging learners with alternative activities (using online resources, hands-on, debates, song- or game-based, etc.) during CLIL Science classroom practices, as also related by the older students interviewed about EP classes (co-teaching of the specific subject through English) and non-EP classes (non-language teacher, using Portuguese or English). Based on Piacentini, Simões and Vieira (2018), the practice of "a different and effective teaching method (explicit, interactive, not conventional, etc.) is a crucial positive outcome" for the students' learning, permeating even classes given by the subject teacher alone and outside of the project, "beyond just the mere translation" of subject topics into English.

The use of (Science) representational forms other than verbal is not exclusive to project settings, as results demonstrate, nevertheless teachers seem to reflect more on learning problems associated with the understanding of languages and on the importance of multimedia representations and resources, with an additional language. These results are consistent with referential literature. Owing to the presence of a FL, teaching through CLIL makes subject teachers become language-aware (Coyle et al., 2010; Wolff, 2012) and exhibit quality educational strategies (Marsh, 2012), which may improve the learning of both English and Science (Canet Pladevall & Evnitskaya, 2011; Grandinetti et al., 2013). In integrating Science education with English learning, EP teachers asserted the need for and displayed availability and capacity for teamwork, learning from and with each other (Pavón Vázquez & Ellison, 2013), and showed open-mindedness to participating in further educational opportunities with the authors' research group.

However, more effort is fundamental, together with them, to understand, reflect on and put into practice the use of Language during Science classes (Lin & Lo, 2017; Piacentini et al., 2017), with its genres and registers, allowing for the identification and adjustment of teaching practice patterns in this methodological environment, to continue moving toward quality (CLIL) Science planning and implementation and to equip teachers with opportunities for professional development.

Conclusions

Science language(s) is far from just specific terminology, in Portuguese as much as in English; a diversity of functions (classifying, describing, evaluating, etc.) need to be assumed and practiced, in order to "serve" the Science genres and to develop literacy in both the student mother tongue and any additional language. At the same time, teachers agree that Science classes also enable students to become natively literate and on the necessity of Science communication. In their "standard" classes, the Science teachers contemplate semiotic modes other than words – though the impact of languages in them is not fully appreciated – while their teaching of Science with English also entails a greater and more reasoned use of visual scaffold. Speaking this foreign language during the project, thus, apparently gives the "lenses to the subject teachers" to perceive the language demand, at least of the Science lexicon.

In working within a CLIL-type context such as the "English Plus" project teachers (believe they) can grow professionally, through team working and co-teaching, cross-curricular experience and the development of adequate strategies for the new learning settings. The benefits of CLIL to students are widely acknowledged but, as some authors note, CLIL also means to teachers a different pedagogical "path" that "forces" them to change how they relate with the subject they teach. In an extreme case, one may conclude that the adoption of the CLIL approach with an aware use of the teacher's and students' native language (CMIL, Content and

Mother tongue Integrated Learning) might still encourage teachers to revise their practices: within Science education, for instance, teaching in the languages of Science as much as teaching how to use those languages.

Research demands further endeavour to better characterise the intentionality of teachers with regard to the use of Science representational forms, and a more focused observation of how knowledge construction is linked with language progression during both conventional and project Science classes. Nevertheless, the present work contributes to extending research on practice in CLIL Science with English in European countries (macro level). Although it is limited to only a few teachers and their reported practices, it represents a contribution to understanding, in particular, what use or non-use teachers make of language issues and communication modalities to support learners in Science education, and how this can be enhanced through adequate practices when an additional language is "interwoven" with a specific subject. A stronger triangulation of sources and methods and of data gathered at different times will be sought, to pinpoint the influence of an additional language (English, in this case) in the improvement of Science teaching/learning within the CLIL-type EP programme, that might facilitate the learning of Science through English and the practice of English through Science.

Due to the presence of a foreign language and its integration into the specific subject learning, CLIL constitutes a context to understand and review the "weight" given to languages of Science in Science education, as in the case with the "English Plus" project studied by this research, and to orientate classroom practices. Furthermore, it might offer opportunities to investigate "connections" between underpinnings and teaching methods typical of Science with the practice of English vocabulary and discourse structures, to improve the learning of both. Therefore, it may suit the language-focused approach for Science education recommended in literature, to be discussed with and adopted by teachers.

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References

Barbero, T. (2006). Insegnare in lingua straniera: quali sfide? Quali difficoltà? [Teaching in a foreign language: what challenges? What difficulties?]. In C. M. Coonan (Ed.), *CLIL: un nuovo ambiente di apprendimento. Sviluppi e riflessioni sull'uso veicolare di una lingua seconda/straniera*. Venezia, settembre 2004 (pp. 105–117). Venezia: Libreria Editrice Cafoscarina.

Beacco, J.-C., Byram, M., Cavalli, M., Coste, D., Cuenat, M. E., Goullier, F., & Panthier, J. (2010). *Guide for the development and implementation of curricula for plurilingual and intercultural education*. Retrieved from http://www.coe.int/t/dg4/linguistic/Publications_en.asp.

Bertaux, P., Coonan, C. M., Frigols-Martín, M. J., & Mehisto, P. (2010). *The CLIL teacher's competences Grid* (CLIL Cascade Network). Retrieved from http://tplusm.net/CLIL_Competences_Grid_31.12.09.pdf.

Blanchard, B., Masserot, V., & Holbrook, J. (2014). The PROFILES project promoting science teaching in a foreign language. *Science Education International, 25*(2), 78–96. Retrieved from http://www.icaseonline.net/sei/june2014/p4.pdf.

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

Canet Pladevall, R., & Evnitskaya, N. (2011). *Rethink*, *rewrite*, *remake*, or learning to teach science through English. In C. Escobar Urmeneta, N. Evnitskaya, E. Moore, & A. Patiño (Eds.), *AICLE – CLIL – EMILE: Educació plurilingüe. Experiencias, research & polítiques* (pp. 167–177). Bellaterra: Servei de Publicacions de la Universitat Autònoma de Barcelona.

Council of Europe. (2001). *Common European framework of reference for languages: Learning, teaching, assessment (CEFR)*. Retrieved from https://www.coe.int/en/web/common-european-framework-reference-languages.

Coyle, D. (2005). *CLIL Planning tools for Teachers* (University of Nottingham). Retrieved from www.unifg.it/sites/default/files/allegatiparagrafo/20-01-2014/coyle_clil_planningtool_kit.pdf.

Coyle, D. (2013). Listening to learners: An investigation into 'successful learning' across CLIL contexts. *International Journal of Bilingual Education and Bilingualism, 16*(3), 244–266. doi: 10.1080/13670050.2013.777384.

Coyle, D., Hood, P., & Marsh, D. (2010). *CLIL Content and Language Integrated Learning*. Cambridge: Cambridge University Press.

Dalton-Puffer, C., & Nikula, T. (2006). Pragmatics of content-based instruction: Teacher and student directives in Finnish and Austrian classrooms. *Applied Linguistics, 27*(2), 241–267. doi: 10.1093/applin/aml007.

Dearden, J. (2014). *English as a medium of instruction – a growing global phenomenon*. Retrieved from https://www.britishcouncil.org/education/ihe/knowledge-centre/english-language-higher-education/report-english-medium-instruction.

Escobar Urmeneta, C., & Evnitskaya, N. (2014). 'Do you know Actimel?' The adaptive nature of dialogic teacher-led discussions in the CLIL science classroom: A case study. *The Language Learning Journal, 42*(2), 165–180. doi: 10.1080/09571736.2014.889507.

Ellison, M. (2018). Net(Working) CLIL in Portugal. *eTEALS, 9*(s1), 4-22. Retrieved from https://ojs.letras.up.pt/index.php/et/article/view/6102.

European Commission. (1995). *White Paper on Education and Training. Teaching and Learning*. Retrieved from https://publications.europa.eu/en/publication-detail/-/publication/d0a8aa7a-5311-4eee-904c-98fa541108d8/language-en.

European Commission. (2006). *Content and Language Integrated Learning (CLIL) at School in Europe*. Retrieved from http://eacea.ec.europa.eu/education/eurydice/all_publications_en.php

European Commission. (2011). *Civil Society Platform on Multilingualism*. Retrieved from https://elen.ngo/wp-content/uploads/2016/05/report-civil-society_en.pdf.

Evnitskaya, N., & Morton, T. (2011). Knowledge construction, meaning-making and interaction in CLIL science classroom communities of practice. *Language and Education, 25*(2), 109–127. doi: 10.1080/09500782.2010.547199.

Gimeno, A., Seiz, R., de Siqueira, J. M., & Martínez, A. (2010). Content and language integrated learning in higher technical education using the *inGenio* online multimedia authoring tool. *Procedia - Social and Behavioral Sciences, 2*(2010), 3170–3174. doi: 10.1016/j.sbspro.2010.03.484.

Grandinetti, M., Langellotti, M., & Ting, Y.-L. T. (2013). How CLIL can provide a pragmatic means to renovate science education – even in a sub-optimally bilingual context. *International Journal of Bilingual Education and Bilingualism, 16*(3), 354–374. doi: 10.1080/13670050.2013.777390.

Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental & Science Education, 4*(3), 275–288. Retrieved from http://www.ijese.net/makale/1394.

Jenkins, J. (2015). Repositioning English and multilingualism in English as a Lingua Franca. *Englishes in Practice, 2*(3), 49–85. doi: 10.1515/eip-2015-0003.

Kaire, S. (2017). We are on the same boat, but still I am from another culture: The lived experiences of learning in groups. *Encyclopaideia, 21*(47), 29-48. doi: 10.6092/issn.1825-8670/6946.

Karlsson, A., Nygård Larsson, P., & Jakobsson, A. (2018). Multilingual students' use of translanguaging in science classrooms. *International Journal of Science Education*, 1-21. doi: 10.1080/09500693.2018.1477261.

Klein, P. D., & Kirkpatrick, L. C. (2010). Multimodal literacies in science: Currency, coherence and focus. *Research in Science Education, 40*(1), 87–92. doi: 10.1007/s11165-009-9159-4.

Lasagabaster, D., & Sierra, J. M. (2010). Immersion and CLIL in English: more differences than similarities. *ELT Journal, 64*(4), 367–375. doi: 10.1093/elt/ccp082

Lemke, J. (2003). *Teaching all the languages of Science: words, symbols, images, and actions*. English version of the paper presented at the conference on Science education in Barcelona, Spain (1998, January). Retrieved from www.jaylemke.com/science-education/.

Lin, A. M. Y., & Lo, Y. Y. (2017). Trans/languaging and the triadic dialogue in content and language integrated learning (CLIL) classrooms. *Language and Education, 31*(1), 26-45. doi: 10.1080/09500782.2016.1230125.

Llinares, A., Morton, T., & Whittaker, R. (2012). *The role of Language in CLIL*. Cambridge: Cambridge University Press.

Lyon, E. G., Bunch, G. C., & Shaw, J. M. (2012). Navigating the language demands of an inquiry-based science performance assessment: Classroom challenges and opportunities for English learners. *Science Education, 96*(4), 631–651. doi: 10.1002/sce.21008.

Marsh, D. (2012). *Content and Language Integrated Learning (CLIL). A development trajectory*. Cordoba: Servicio de Publicaciones de la Universidad de Córdoba.

Marsh, D., Mehisto, P., Wolff, D., & Frigols Martín, M. J. (2011). *European Framework for CLIL Teacher Education*. Graz: ECML.

Martins, I. P. (2014). Políticas públicas e formação de professores em educação CTS [Public policies and teacher education in STS education]. *Uni-Pluri/versidad, 14*(2), 50–62. Retrieved from http://aia-cts.web.ua.pt/artigo.pdf.

Meyer, O., Coyle, D., Halbach, A., Schuck, K., & Ting, T. (2015). A pluriliteracies approach to content and language integrated learning – mapping learner progressions in knowledge construction and meaning-making. *Language, Culture and Curriculum, 28*(1), 41–57. doi: 10.1080/07908318.2014.1000924.

Meyerhöffer, N., & Dreesmann, D. C. (2019). The exclusive language of science? Comparing knowledge gains and motivation in English-bilingual biology lessons between non-selected and preselected classes. *International Journal of Science Education, 41*(1), 1-20. doi: 10.1080/09500693.2018.1529446

Nikula, T., Dalton-Puffer, C., & Llinares, A. (2013). CLIL classroom discourse: Research from Europe. *Journal of Immersion and Content-Based Language, 1*(1), 70–100. doi: 10.1075/jicb.1.1.04nik.

Oattes, H., Oostdam, R., de Graaf, R., & Wilschut, A. (2018). The challenge of balancing content and language: Perceptions of Dutch bilingual education history teachers. *Teaching and Teacher Education, 70*, 165-174. doi: 10.1016/j.tate.2017.11.022.

Pavón Vázquez, V., & Ellison, M. (2013). Examining teacher roles and competences in Content and Language Integrated Learning (CLIL). *Lingvarvm Arena, 4*, 65–78. Retrieved from http://ler.letras.up.pt/uploads/ficheiros/12007.pdf.

Pérez Cañado, M. L. (2016). Are teachers ready for CLIL? Evidence from a European study. *European Journal of Teacher Education, 39*(2), 202–221. doi: 10.1080/02619768.2016.1138104.

Piacentini, V., Simões, A. R., & Vieira, R. M. (2016). Abordagem holística no sistema educativo Português para desenvolver a(s) literacia(s) das ciências integradas com o Inglês [Holistic approach in the Portuguese education system to develop literacies of science integrated with English]. *Indagatio Didactica, 8*(1), 1975–1992. Retrieved from http://revistas.ua.pt/index.php/ID/article/view/3981/3663.

Piacentini, V., Simões, A. R., & Vieira, R. M. (2017). The language focus of Science education integrated with English learning. *Enseñanza de Las Ciencias, Extra*(2017), 399–404. Retrieved from http://ddd.uab.cat/record/184622.

Piacentini, V., Simões, A. R., & Vieira, R. M. (2018). What students tell teachers about practices that integrate subjects with English in a lower secondary school in Portugal. *eTEALS, 9*(s1), 57-76. Retrieved from https://ojs.letras.up.pt/ojs/index.php/et/article/view/6105/0.

Polias, J. (2006). Assessing learning: A language-based approach. *Symposium*, 40–65. Retrieved from www.su.se/polopoly_fs/1.84020.1333710072!/menu/standard/file/2006_3_Polias.pdf.

Roberts, D. A., & Bybee, R. W. (2014). Scientific literacy, science literacy, and science education. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education. Volume II* (pp. 545–558). New York: Routledge.

Sanmartí, N. (2007). Hablar, leer y escribir para aprender ciencia [Speaking, reading and writing to learn science]. In P. Fernández (Ed.), *La competencia en comunicación lingüística en las áreas del currículo* (pp. 103–128). Madrid: MEC.

Scott, P. H., Mortimer, E. F., & Aguiar, O. G. (2006). The tension between authoritative and dialogic discourse: A fundamental characteristic of meaning making interactions in high school science lessons. *Science Education, 90*(4), 605–631. doi: 10.1002/sce.20131.

Seah, L. H., & Silver, R. E. (2018). Attending to science language demands in multilingual classrooms: A case study. *International Journal of Science Education*, 1-19. doi: 10.1080/09500693.2018.1504177.

Smokotin, V. M., Alekseyenko, A. S., & Petrova, G. I. (2014). The phenomenon of linguistic globalization: English as the Global Lingua Franca (EGLF). *Procedia - Social and Behavioral Sciences, 154*(2014), 509–513. doi: 10.1016/j.sbspro.2014.10.177.

Tang, K.-S., Delgado, C., & Moje, E. B. (2014). An integrative framework for the analysis of multiple and multimodal representations for meaning-making in science education. *Science Education, 98*(2), 305-326. doi: 10.1002/sce.21099.

Wellington, J., & Osborne, J. (2001). *Language and literacy in Science education*. Buckingam/ Philadephia: Open University Press.

Wolff, D. (2012). The European framework for CLIL teacher education. *Synergies Italie,* 8, 105–116. Retrieved from http://gerflint.fr/Base/Italie8/dieter_wolff.pdf.

Yore, L. D., & Treagust, D. F. (2006). Current realities and future possibilities: Language and science literacy-empowering research and informing instruction. *International Journal of Science Education, 28*(2–3), 291–314. doi: 10.1080/09500690500336973.

Endnotes

1 Studies of Science education research are devoted to both "multiple representations" (representing to students the same concept through different forms) and "multimodality" (simultaneous use of different modalities within and across representations). The goal of this paper is not to differentiate them or discuss a "multirepresentational framework" (Tang et al., 2014). Furthermore, multiple media or modes or semiotic systems are equally associated, here, to the adjectives multimedia or multimodal (cf. Lemke).

2 Opportunities for representing and communicating Science concepts and processes, through different languages (cf. Lemke): verbal (spoken and written), visual (graphs, tables, diagrams and drawings), mathematical (formulas, equations, calculations), kinaesthetic (action and observation to make sense within experimental procedures and operations), etc.

3 For further information, www.dge.mec.pt/programa-escolas-bilinguesbilingual-schools-programme

4 Questions asked to participants and their responses, within the results, are typed in italic and have been translated from Portuguese by the researcher.

5 Claimed by Wellington and Osborne (see references), but also by Coyle (a referential author in CLIL research and practice) as a provocation in CLIL events.

6 In English, the differentiation between *línguas* (as in distinct foreign languages) and *linguagens* (as in the language of a particular field) is not possible, as opposed to Latin languages.

7 Though *Didática das Ciências* can be broadly translated as Science education, the Portuguese term is more specifically associated with the idea of teaching methods and practices.

8 *Do you think you have already implemented classes through this approach?*; *What responsibilities does a teacher have as a CLIL teacher?*; *How do you conceive the assessment of modules using CLIL?*; *What needs does a teacher have as a CLIL teacher?*; *Do you think this approach implies extra work?*.

9 https://cetaps.wixsite.com/workingclil1/copy-of-venue

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Vol. 77, No. 5, 2019

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