The Language Dimensions of Physics teaching for learning in CLIL and in the language of schooling

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My PhD research project on the role of language in content teaching for learning was carried out in the same years as I was actively involved as a team member in the EOL project at the ECML in Graz. This article intends to show how the two projects intertwined. After showing what the PhD research owes to the ideas of the Language Policy Programme of the Council of Europe ((formerly the Language Policy Unit) (1), the article illustrates the Italian context in which the research was carried out (2) and focuses on some findings derived from the data collected through the research (3) to show what content teachers do and could actually do (4), in order to turn their lessons and their classes into environments where languages really matter.

1. *The Language Policy Programme of the Council of Europe: main contributions*

Within the EOL project we soon came to realise how some resources - including projects, guides and handbooks, materials - which have been produced over the years by the Language Policy Programme of the Council of Europe and the European Centre of Modern Languages in Graz could be used to create and support "environments where languages flourish". The EOL team chose to prepare a detailed, critical presentation of some of these resources which were selected for their relevance to the implementation of a "learning environment" in which languages matter[1]. The PhD research project on the language dimension in content teaching has been strongly influenced by the projects of the Language Policy Programme of the Council of Europe with their main focus on the place of languages in the whole school curriculum and its key role in the educational process. This includes an important reinterpretation of the notion of plurilingual competence and the inclusion of the language of schooling in the analyses and proposals regarding languages in/for education (Coste, 2014). Two instruments were particularly inspiring: the Council of Europe's Recommendation 5(2014) and the Platform of Resources and References for plurilingual and intercultural education.

The Council of Europe's Recommendation 5(2014) insists that all learners, especially "the most vulnerable", should be exposed to diverse language-learning situations and that educators keep in mind the "cross-cutting effect" that language has on all learning processes. This implies the need for all language users to become aware of the ways in which they can use any language. It is interesting to see how the Recommendation focuses on the concept of language awareness - rather than language proficiency - as a skill. The Platform of Resources and References for plurilingual and intercultural education is a tool which takes inspiration from the values and principles promoted by the Council of Europe. It is "an open and dynamic resource, with systems of definitions, points of reference, descriptions and descriptors, studies and good practices which member states are invited to consult and use in support of their policy to promote equal access to quality education according

[1] Within the EOL project the template which was developed to illustrate the aforementioned resources goes under the name of "Memo".

This is an output of the project "Learning environments where modern languages flourish" (2016-2019) of the European Centre for Modern Languages (ECML). The ECML is a Council of Europe institution promoting excellence in language education in its member states.
http://www.ecml.at/Learningenvironments

to their needs, resources and educational culture"[2]. Figure 1 reproduces the structure of the Platform as it is given online. The entry point to the PhD research project on the language dimension of teaching Physics in the language of schooling and in CLIL, is the role played by the language dimensions in content teaching and learning[3], i.e. the language used to teach and learn content both in the language of schooling and through foreign languages in CLIL.

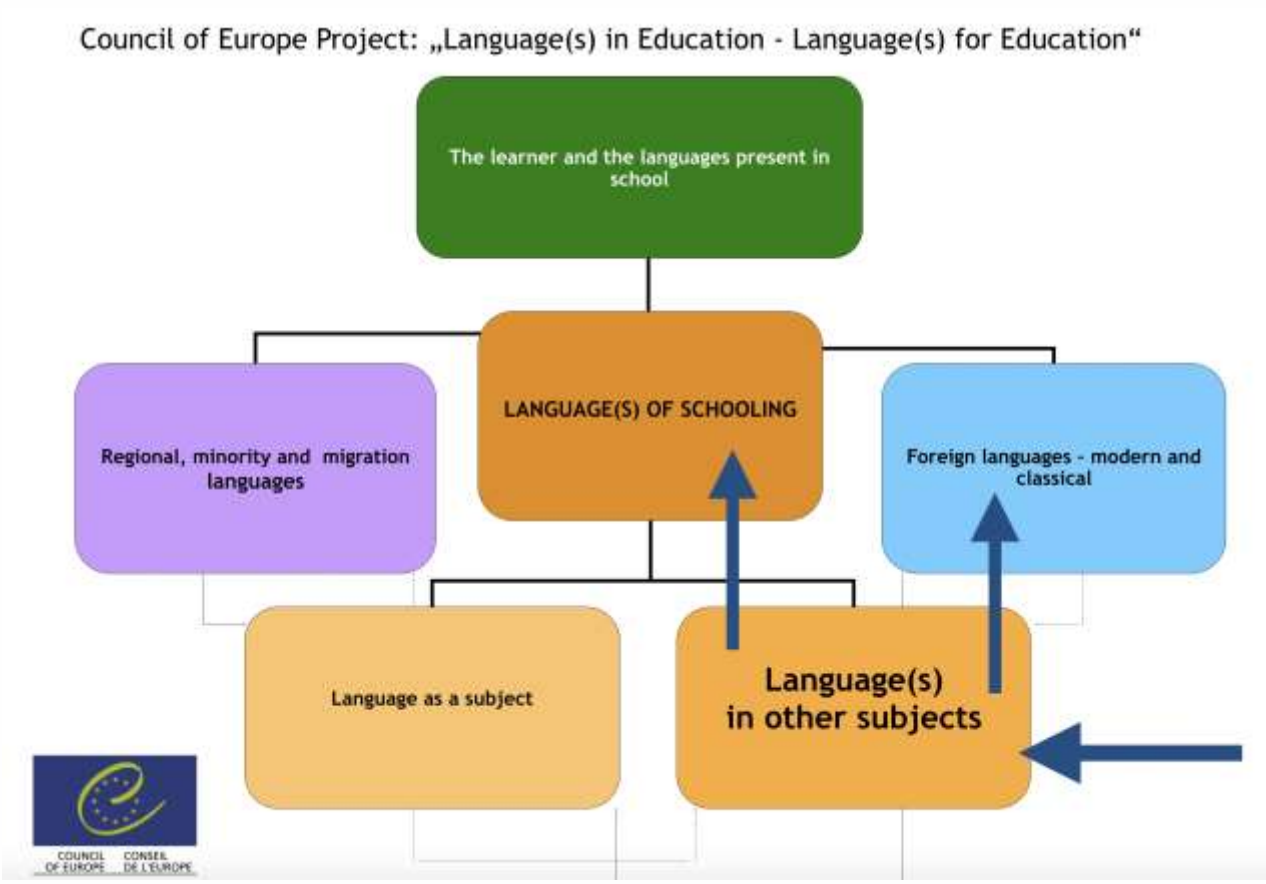

Figure 1: The project "Language(s) in Education - Language(s) for Education" of the Council of Europe.

Among the many resources and projects which have been developed by the Council of Europe, the PhD research on the language dimension in content teaching was especially inspired by *The Language Dimension in All Subjects - A Handbook for Curriculum Development and Teacher Training* (2016) and the ECML project *A Pluriliteracies Approach to Teaching for Learning* (PTL[4]). Drawing on these two resources, the following points have been researched within the PhD project:

[2] cf. the online presentation of the Platform (retrieved from https://www.coe.int/en/web/platform-plurilingual-intercultural-language-education/the-platform-in-the-context-of-the-language-policy-programme - 24 August, 2019).

[3] CLIL is most commonly known as a "dual focused educational approach in which an additional language is used for the learning and teaching of both content *and* language" (Coyle, Hood, & Marsh, 2010: 1 - emphasis in the original text).

[4] The project website can be found at https://pluriliteracies.ecml.at.

- the role of **language as a constituent part of subject competence**: "being good at science, for example, also means being good at talking and writing about science, in a specific, conventionalized way. Acquiring knowledge at school therefore means becoming familiar with forms of communication specific to the communities which produce that knowledge, and appropriating these forms, at least to some extent" (2016: 23);
- the development of **subject specific literacies,** which includes six points: "comprehending/understanding in-depth (the meaning of an utterance, a text, a problem); communicating and negotiating knowledge; reflecting on the acquisitional process, the learning outcomes and their personal as well as social uses; applying knowledge to and within other contexts; participating in the socio-scientific world and transferring generalisable knowledge, skills, attitudes" (2016: 29). The role of subject specific literacies has been highlighted by the PTL project as follows: "a pluriliteracies approach to teaching for learning (PTL) puts subject literacy development in more than one language at the core of learning because we believe subject literacies are the key to deep learning and the development of transferable skills. This approach focuses on helping learners become literate in content subjects or topics and to empower them to successfully and appropriately communicate that knowledge across cultures and languages" (Meyer at al., 2015: 2).

An essential starting point in the research project on the language dimensions in content teaching was an investigation of existing literature about the **language competences** involved in subject literacy, i.e.

- processing and acquiring subject knowledge (through listening and reading activities) and in-depth understanding of texts that deal with subject-matter issues;
- negotiating the meaning of new knowledge items in relation to already existing ones;
- reflecting on how a new insight developed and was acquired;
- considering the validity and use of knowledge, applying it to other/new contexts;
- preparing for and participating in socio-scientific debates and the relevant discourse outside school;
- questioning critically the meaning and scope of rules or conventions, generalizing the acquired procedural knowledge and skills (as part of one's general education)" (2016: 26).

With this theoretical framework in mind the research had to come to terms with the way CLIL was started in the Italian education system.

2. The Italian context of the research

In the Italian school legislation CLIL is described as an "approccio metodologico che prevede l'insegnamento di una disciplina non linguistica, in lingua straniera veicolare al fine di integrare l'apprendimento della lingua e l'acquisizione di contenuti disciplinari, creando ambienti di apprendimento che favoriscano atteggiamenti plurilingui e sviluppino la consapevolezza multiculturale" (MIUR 2010: 86)[5].

[5] "A methodological approach which implies teaching a curricular subject in a foreign language with the aim of integrating language learning and content acquisition, thus producing learning environments which promote plurilingual attitudes and develop multicultural awareness" (translated by author). It is interesting to note the focus on "learning environments" as the final result of CLIL.

In Italy CLIL is mandatory in upper secondary education: "since 2010 in Italy, all students in the last year of upper secondary education have had to learn one non-language subject through a foreign language. Those on the "language" pathway must learn one non-language subject through their first foreign language by the age of 16, and a second through their second foreign language from age 17" (Eurydice, 2017: 57). The reform does not affect vocational schools and schools below upper secondary, which have continued to promote CLIL projects autonomously. Guidelines for teacher professional development, qualifications and for curriculum hours were also provided by the Ministry of Education (MIUR). The languages and content areas used for CLIL in any given school depend on the professional resources the school has. The teachers in CLIL courses are content teachers with a good command of the foreign language in which they teach their subjects, the original (2010) provision being a C1 level which was later lowered to B2 if teachers were actively engaged in language training with the aim of achieving C1 recognition (Ministero dell'Istruzione, 2014/15). The courses for learning CLIL methodology which had to be provided to CLIL teachers were organised by different universities all around Italy.

3. *Research questions*

With CLIL being "language-sensitive content teaching"[6] , the research was based on the idea that a CLIL teacher should have developed a certain degree of awareness of the role of the language (be it a FL or the language of schooling) as a medium for teaching and learning. In particular, I started my research with this hypothesis in mind and the desire to see how "the language [...] is used to construct knowledge, for meta-cognitive and communicative purposes as well as reflective intervention on learning" (Coyle, 2015: 90).

I chose to concentrate on the micro-level of language teaching and learning and, in particular, on the linguistic features of Physics lessons in CLIL and in the language of schooling. The micro-level of analysis of this research focuses on the characteristics of the language that content teachers use when teaching their discipline in the language of schooling and through a foreign language. Within a social constructivist understanding of learning, the discursive practices in the classroom were used as an analytical window onto the joint development and construction of knowledge (Mercer, 2000).

The guiding questions were:

a) *What language resources* are there in the "multilingual space" of a Physics lesson?
b) *How* are the language resources used to enhance learning within the framework of a Physics lesson?
c) What *cognitive discourse functions* are to be found in a Physics lesson in the language of schooling / in CLIL?
d) How does the awareness of the language dimensions in learning shape and change the way content is taught in the language of schooling? And in CLIL? Is there an area where language teachers and subject teachers should / can work together?

[6] cf. Leisen's definition of CLIL, i.e. "Sprachsensibler Fachunterricht", namely a "language-sensitive content lesson" (Leisen 2010).

4. The data: results and discussion

The research is based on the transcriptions of the Physics lessons of four Italian teachers who work in four upper-secondary schools located in different parts of the country. In each school a Physics teacher volunteered to take part in the research and allowed me to record at least three lessons within the same module of Physics in Italian and another three lessons within the same module of Physics in CLIL. After the lessons I also met each teacher for a semi-structured interview which I then transcribed and analysed.

Table 1 gives a detailed overview of the whole corpus of the research[7].

	ITALIAN, language of schooling		**CLIL**		
Teachers	***words***	***recordings***	***words***	***recordings***	***interview***
BA (English)	7880	73'30''	7723	117'29''	yes
CB (English)	14137	141'41''	10958	138'16''	yes
EB (German)	13727	135'42''	5118	139'05''	yes
SG (French)	14542	131'45''	6464	127'48''	yes
	50286	*8h 2min 38sec*	**30263**	*8h 42min 38sec*	4

Table 1: the corpus of the research

At the micro level of analysis I assumed that

- discourse is "a locus of co-construction" (Hüttner, Dalton-Puffer & Smit, 2013: 4), a form of social action in terms of "discourse as mediated action" which only takes place in an interactional context (Scollon, 1998);

- the focus is "on the close-up analysis of what happens in the classroom and on the processes through which CLIL is carried out, rather than on the resulting products" (Evnitskaya & Morton, 2011: 110);

[7] Next to the initials of the names of the teachers there is the indication of the foreign language they used in CLIL.

- as to Physics “the primary activity students encounter and participate in, in a physics course, is representing” (Lemke, 1998: 9).

4.1. The content lesson: languages and representations

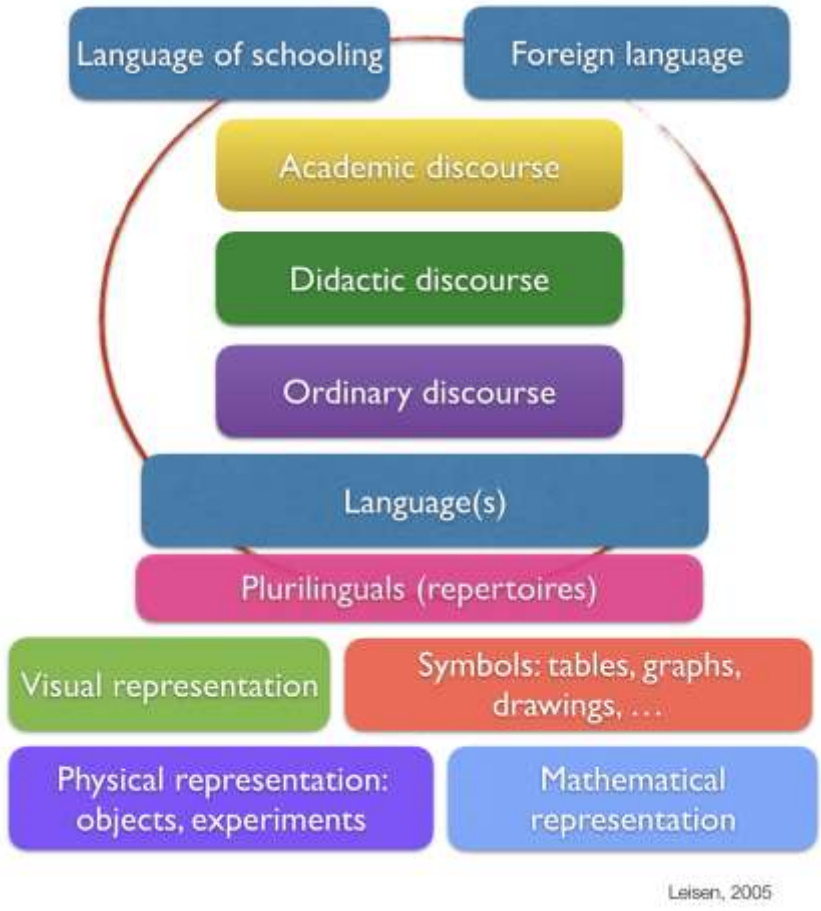

Figure 2: representing in a Physics lesson.
The multilingual space of a Physics lesson.

For the EOL project, the most relevant part of the research is question 1 as it focuses on people (the teacher and the students) interacting in a Physics class while being aware they have resources in terms of language they can rely on to teach and learn content. The answer to question 1 show the wealth of representations which characterise a Physics lesson, as shown in figure 2.

The focus of the research was on the upper part of this graph as it concentrates on the language(s) used to teach Physics in the language of schooling and in CLIL while distinguishing three levels of discourse, i.e. academic, didactic and ordinary. It soon became clear from the data that the multilingual space is inhabited by plurilinguals, i.e. individuals such as the teacher and the students who master languages at different levels of competence and use all their resources when teaching and learning contents in a Physics lesson.

The excerpt presented here comes from a CLIL lesson in French. The class[8] has a good level of the French language and the teacher had, at the time of the recording, a B2 level of French. The lesson is about nuclear reactions and the class is reading a text about nuclear fusion and fission reactions[9].

1. T "Réactions nucléaires provoquées"
2. St [una studentessa legge ad alta voce]
3. T éclate, éclater
4. St è come la guerre [in francese], la guerre éclate.
5. T Quindi, "scoppia"? La guerra scoppia [raccoglie il commento della St]. E qui invece?
6. St La stessa cosa
7. St Commence
8. Sts [varie voci non chiare che si accavallano]
9. T Esplode?
10. Sts éclate? Ma in italiano, diremmo che cosa?
11. St La guerra scoppia.
12. St Sì. Lo scoppio della guerra.
13. T Sì, ho capito. Ma un nucleo scoppia? No, un nucleo si separa, si divide. [gesto della mano]
14. St Scinde
15. T Si scinde … sotto l'impatto, sotto l'impatto. Sous l'impacte d'un neutron.

The teacher (T) interrupts the student (St) who is reading the passage aloud to draw the attention to the meaning of the verb "éclater". In French the verb "éclater" (4) collocates with both the noun "la guerre" (the war) and the noun "le noyau" (the nucleus of an atom). In Italian "la guerra scoppia" (11. the war breaks out), but "il nucleo si scinde" (the nucleus splits). At first the students do not make the distinction. It is only when the teacher reproduces with a gesture of his hand the movement of the nuclear fission (13) that one of the students uses the exact verb that is needed in Italian (14). The use of the language of schooling becomes important for the students to understand the exact meaning of the verb "éclater" and the concept it conveys. All the language resources are drawn on in this small excerpt to get to understand a nuclear fission reaction, which depends on the splitting of the atom. This short example shows how "le plurilinguisme (mise en contact des langues) enrichit la construction des savoirs" (Gajo, 2018).

4.2. The content lesson: languages and mediation

Question 1 has also been used to investigate the central role of reformulation in Physics lessons. Reformulation has the essential function of mediating concepts through all the linguistic resources

[8] It is an ESABAC class. EsaBac is a Franco-Italian high-school double degree program which allows Italian and French students to consequently obtain two high-school degrees, Italian Maturità and French Baccalauréat, just in one exam. In their final year (5th form) students have at least a B2 level of French.

[9] By being bombarded with neutrons, nuclei with heavy atoms can be divided into several fragments formed by nuclei with lighter atoms, with neutron emission and a large release of energy. This type of nuclear reaction is called "nuclear fission reaction".

which exist within the space of a content lesson. From a quantitative point of view what has emerged is a wider use of reformulation in Physics lessons in Italian than in CLIL, as shown in table 2.

Teachers	Italian	CLIL
BA	126	32
CB	155	95
EB	133	30
SG	123	26

Table 2: reformulations

It is not easy to find a justification for such a discrepancy. However, the strategies to explain a new concept described in the Companion Volume of the CEFR (2018), under the heading “adapting language”, imply a high level of command of the language. This may account for a limited use of reformulation strategies in the CLIL lessons apart from those of teacher CB who has a C2 level of English. This hypothesis needs, however, further exploration and data to be fully confirmed.

What is missing is the awareness of the mediating role of language(s) in learning the content and the fact that teachers do not sometimes know how to balance different types of discursive resources in order to scaffold content learning both in the language of schooling and in CLIL.

4.3. The content lesson: languages and genres

The last aspect which can be investigated through question 1 is the use of different languages in the CLIL lessons. Table 3 shows the results. For each teacher there is the indication of the foreign language used in the CLIL lessons and their levels of proficiency in the language used.

	BA (English) B2	CB (English) C2	EB (German) B2	SG (French) B2
corpus (nr of words)	7723	10958	5118	6464
FL	7531	4628	4980	4071
%	97,51%	42,3%	97,3%	62,97%
% students	1,8%	8,32%	65%	4,8%

Table 3: the use of languages in CLIL Lessons

It is interesting to see the lowest percentage of use of the foreign language in CLIL lessons belongs to the teacher (CB) with the highest level of proficiency. In the interview he says that he always repeats the most complex or important concepts twice, first in English and then in Italian. He also says "if I am describing something, I mean when I describe a phenomenon or an experiment I don't use any Italian. There's no need. But if there is a logical chain to follow, a deduction to make, if the steps are not banal, when following the different steps of a logical process in another language may cause the loss of some parts or links in terms of cause and effect, I usually first use the English language and then I repeat everything in Italian"[10]. There seems to be a high level of awareness in CB of the role of the language of schooling which is used when things get too complicated in conceptual terms. The same awareness can be seen in the distinction made in terms of genres: a description is easier to understand than a logical chain of causes and consequences.

In the research these aspects of the lesson have been examined, thanks to the PTL project, within the framework of Systemic Functional Linguistics (SFL) (Halliday 1961, Halliday & Matthiessen 2004). One of the central tenets of SFL is that lexis (a structured system of signs which serves to organise the vocabulary of a language) and grammar (a structured system of choices which serves to organise sequences of signs into texts) form a unified stratum in the language which is referred to as the *lexicogrammar*. Another central assumption of SFL is that no aspect of lexis or grammar can be properly defined without reference to its typical context of use (or 'co-text'), i.e. in actual stretches of texts or discourse. It follows that the language as a system is constantly interacting with and being shaped by *different types of speech event* within a community of speakers. Everything in the language, from lexical items and grammatical constructions to whole texts, has evolved to express very specific *discourse functions*, in the form of situational *registers*, as well as *genres* (Martin, 2011). It is this focus on the underlying communicative functions of language and the systemic choices that are made available by the language system that make SFL distinct from other models of language (Gledhill, 2011; Meyer, 2015)[11].

5. Concluding remarks

My PhD research project was carried out at the same time as I was taking part, as a team member, in the EOL project at the ECML. In the article I wanted to share my findings to focus on the complex interaction of different linguistic factors within a content lesson. The eco-systemic approach to language learning (cf. EOL) teaches us that, in the implementation of a learning environment in which languages flourish, the intentionally consistent use of all the linguistic resources existing within the class (cf. EOL, micro-level) should be designed to promote the development of the plurilingual competences of the students. This leads us to, at least three concluding remarks.

First, much language learning takes place in a discipline-based curriculum, as students are confronted with learning tasks which require them to learn the vocabulary of the discipline, as well

[10] The interview is originally in Italian. It has been translated by the author of the article.

[11] Question 2 in the research has investigated the use of different genres in the Physics lesson, which in *The Language Dimension - A Handbook* (2016) are: Presentation by the teacher; Presentation with directed interaction (scripted lesson); Questioning and discussion; Exchanges among pupils; Note-taking and summarizing; Presentation by one or more pupils; Reading the textbook or authentic texts; Production of written texts

as discipline-specific syntactic structures and the discourse features or genres that define the "culture" of each discipline, i.e. those unique ways of talking, arguing, observing, and thinking.
Second, students require carefully guided instructional intervention on the part of the teachers to acquire the discourses of schooling. Data shows that the successful acquisition of what is commonly called "academic language" requires attention and intention on the part of the students and the teachers in specific learning through language approaches.
Third, students can also learn about the language whenever they are guided to acquire and to use successful strategies for manipulating the language in different tasks and activities.
EOL and the research project share the same commitment to the language learning triad - learning language(s), learning through language(s) and learning about language(s) (Halliday, 1993) - which assumes an eco-systemic approach as the EOL project has started to promote within the network of schools it has created.