Rethink, rewrite, remake or learning to teach science through English

Roser Canet Pladevall
INS Montserrat (Barcelona)

Natalia Evnitskaya
Universitat Autònoma de Barcelona

Abstract

We present here a secondary school science teacher's reflections about science teaching and learning which emerged from the process of designing and piloting teaching tasks and materials addressed to CLIL students in their first year of compulsory secondary education. Task designing process was carried out in cooperation with two professors from the Universitat Autònoma de Barcelona specialised in Language Pedagogy and Science Pedagogy during the course 2008-2009. CLIL materials were piloted the same course in INS Montserrat (Barcelona) with a group of 30 students thanks to an Experimental Project of Foreign Languages funded by the Catalan Education Department. In the process of designing, piloting and revision of CLIL tasks and materials, the researchers identified strategies for science teaching which incorporated specific teaching procedures aimed at promoting comprehension and production of messages in a foreign language which are usual in the foreign language classroom. Discussions emerged from the CLIL materials' designing process caused a broad revision of pedagogical approaches to science teaching which can be generalized to ordinary L1 classrooms. Eventually, it became clear that there is a need for coordination across disciplines among Science and English teachers in the design and implementation of CLIL teaching sequences.
Key words: CLIL, science teaching, foreign language teaching, previous ideas, evidences, values, collaborative teaching.

Resum

Es presenten les reflexions d'una professora de ciències de secundària sobre didàctica de les ciències, sorgides a partir del procés del disseny i pilotatge de tasques i material didàctic per a una aula AICLE de 1r d'ESO. El disseny de les tasques es va realitzar en cooperació amb dues professores de la Universitat Autònoma de Barcelona, especialistes en didàctica de la llengua i en didàctica de les ciències durant el curs 2008-2009. El pilotatge dels materials es va fer el mateix curs acadèmic

a l'INS Montserrat (Barcelona) amb un grup de 30 alumnes dins del Pla Experimental de Llengües Estrangeres (PELE) del Departament d'Educació.

Durant el procés del disseny, el pilotatge i la revisió de tasques i materials, AICLE es van identificar estratègies per ensenyar ciències que incorporen procediments didàctics específics destinats a afavorir la comprensió i l'expressió de missatges en una llengua estrangera, que són habituals a les aules de llengua estrangera. Les discussions sorgides a partir del disseny dels materials van ocasionar una revisió general dels plantejaments didàctics per a l'ensenyament de les ciències generalitzable a aules ordinàries. Finalment, van fer patent la necessitat de coordinació interdisciplinària entre el professorat de ciències i el de llengua estrangera en el disseny i la implementació de seqüències didàctiques AICLE.

Paraules clau: AICLE, didàctica de les ciències, didàctica de la llengua estrangera, idees prèvies, evidències, valors, ensenyament en col·laboració.

1. General context

This article presents the conclusions which emerged from the process of designing and piloting of a set of Content and Language Integrated Learning (CLIL) tasks and materials. These were addressed to twelve-year-old students with competence levels in English below COE A2 (the Common European Framework of Reference for Languages: Learning, Teaching and Assessment, Council of Europe 2001) who learned Natural Science in English in their first year of compulsory secondary education in Barcelona (1st ESO). The process was carried out thanks to a part-time study leave which Roser Canet, a secondary school science teacher, received from the Catalan Department of Education and under the supervision of two professors from the Universitat Autònoma de Barcelona (UAB) specialised in Language Pedagogy and Science Pedagogy[1].

The above mentioned conclusions were drawn from the discussions held by the participants during planning and monitoring conferences at the UAB during the course 2008-2009. The discussions were audiotaped and detailed field notes of them taken. The conferences aimed at (a) reviewing and re-drafting initial versions of CLIL learning tasks and materials for three Biology units, (b) providing supervision during their immediate piloting and (c) final re-drafting after piloting. The materials were piloted by the teacher, who also acted as an action-researcher, with a group of 30 students at a state-funded secondary school (INS Montserrat, Barcelona). After the first successful experimentation, the learning tasks are being implemented again this academic year, 2009-2010, with two groups of 1st ESO students (15 students each) with the support of a university-based researcher and the second author of the present article, acting as a participant observer.

The conferences ended up being highly important, as not only scientific content in each proposed task, but also their type and the relation between teaching and learning science and learning the English language were constantly examined and rethought. It was discussed that, as teachers, we need our students to be able to express their own ideas in English, to contrast them with current science knowledge and to abstract those areas of knowledge that are basic for going on

1. This experience was carried out under the supervision of Dr. Escobar Urmeneta, from the Department of Language Pedagogy, in collaboration with Dr. Sanmarti, from the Department of Science Pedagogy. The research was conducted within the 2008ARIE00034 project funded by the AGAUR and the EDU2010-15783 project funded by the MICINN. The materials produced are available at: http://grupsderecerca.uab.cat/clilsi/content/ciències

learning. It was also agreed that mere memorising of scientific terms, an habitual task in traditional science textbooks, should not be used to a great degree, but rather, motivating activities with scientific problems and a set of tools to help students to solve them through the use of a less formal, more everyday content-compatible language (Snow, Met and Genesee 1989).

Here we present some of the issues that were put under thorough consideration during the conferences at the UAB and which turned out to be the key issues when CLIL tasks were piloted with students (course 2008-2009). In the pages below, each discussed issue is followed by examples from teaching materials used and students' works produced in this experience.

2. Previous ideas

Before beginning a unit, it is important to know what ideas do our students have about what will be taught, since 'certainly *learning* science is easier when science teaching builds on students' backgrounds' (Lemke 1990: 144). In doing it, we should avoid science stereotypes and at the same time provide the students with linguistic resources.

Thus, for example, in unit 1 *Life* we could think of an open question like: 'Which are the characteristics of living things?' However, it can be argued that this would not be a suitable question, for two main reasons. First, most students would answer what they had learnt by heart, such as: 'Living things are born, grow, reproduce and die', or something similar. Simple 'parroting' (Lemke 1990) of sentences like this in no way means that students actually know the main features of living things. Secondly, we should offer our students, who have a limited competence in English, linguistic scaffolding so that they were able to a) understand the demands coming from the teacher, and b) provide an answer which is both linguistic and meaningful to such a question (Escobar Urmeneta 2009).

In the collaborative discussion on this point held at the UAB, it was decided to substitute the traditional question mentioned above by a multiple-choice question with different possible answers like the one in Figure 1, which would foster high thinking skills at a low communicative challenge.

Figure 1. Example of a multiple-choice question to test students' previous ideas

Choose the correct answers:

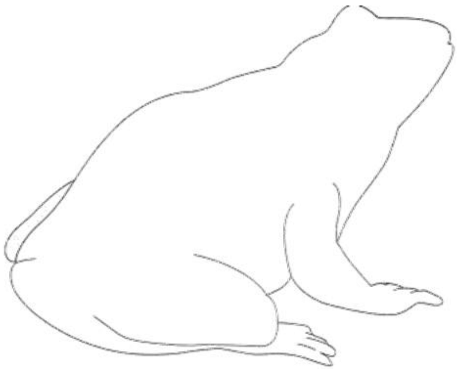
All living things:

a) eat to get energy
b) can move
c) can grow
d) die
e) interact with the environment

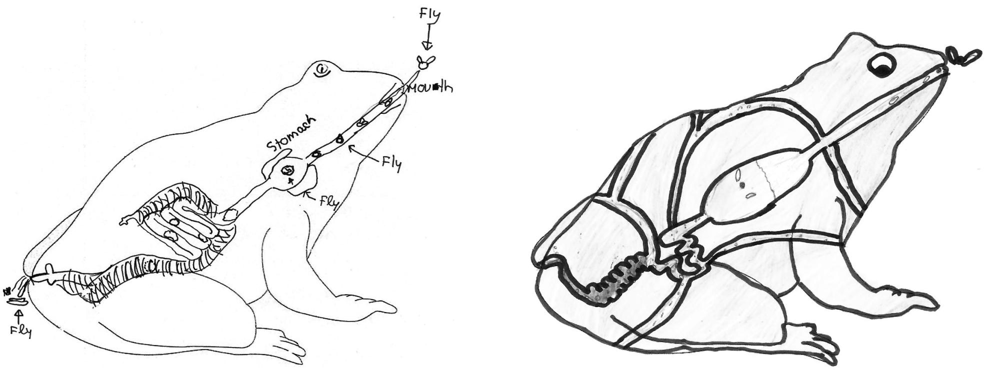
During the implementation, this change not only helped students to answer the question with more confidence but also provided them with necessary linguistic resources in the foreign language for later stages. The posterior class plenary during which the teacher analysed the students' answers and discussed the right and the wrong ones served as a space for sharing their previous knowledge using their own words and not just mechanically memorized expressions. At this moment, it is a good idea to leave some questions to be answered during the unit, by saying, for example, that 'Not all living things die' and that all together they will find out 'why' during the unit (more exactly, when studying bacteria).

Another example could be a learning task designed during the UAB conferences for unit 3 *How do living things work?* In order to know students' previous ideas about animal nutrition, it was agreed to show them an empty silhouette of an animal, a frog, for example, and ask them to draw the food chain from the mouth to the anus following a fly eaten by the frog (Figure 2). Our experience with the 1st ESO students showed that even though initial linguistic demand was very low in this activity, the posterior whole class discussion about the food chain drawings not only resulted to be cognitively demanding (Cummins 1984) but also allowed the students to practice in producing complex academic language (Escobar Urmeneta 2008). The teacher elicited students' talk and helped them to re-phrase their ideas by writing down key words and expressions on the board.

Figure 2. Alternative task to check students' previous ideas



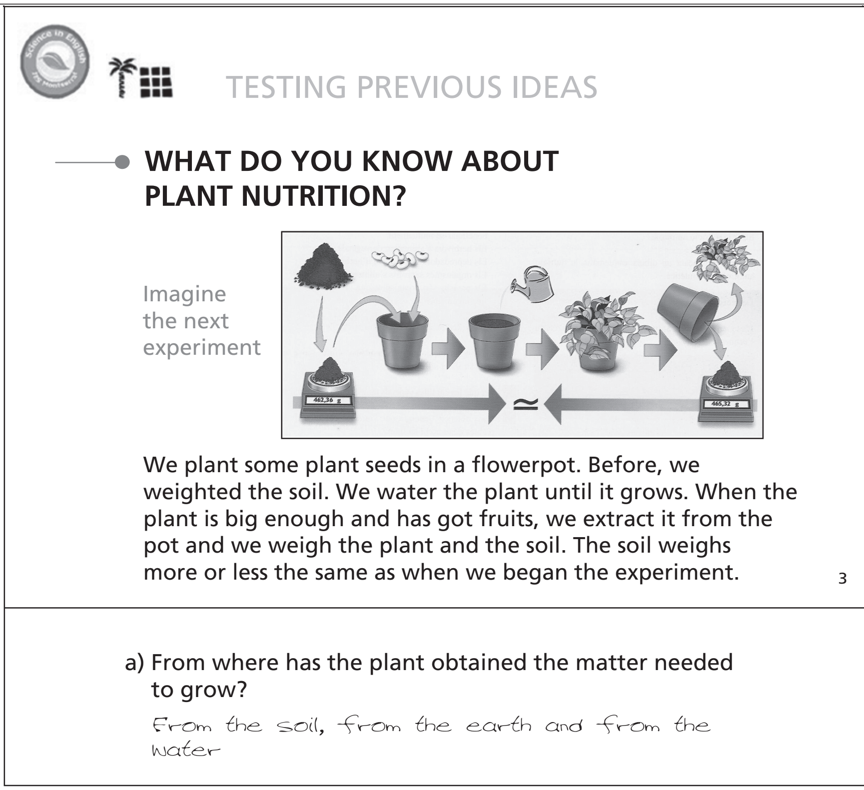
A: Empty image of a frog



B: Students' drawings

A third example of how to explore students' ideas, in this case about plant nutrition, could be a short teacher's explanation with pictures about the transformation of a seed into a plant with roots, stem and leaves. Here we could ask an apparently simple question like: 'From where has the plant obtained the matter needed to grow?' It could be considered an example of a good and stimulating question, as it states a problem and invites students to observe or make a new experiment in order to find a solution (Màrquez, Roca and Via 2003). In our case, we could detect that most of our students did not mention air (Carbon dioxide) (Figure 3).

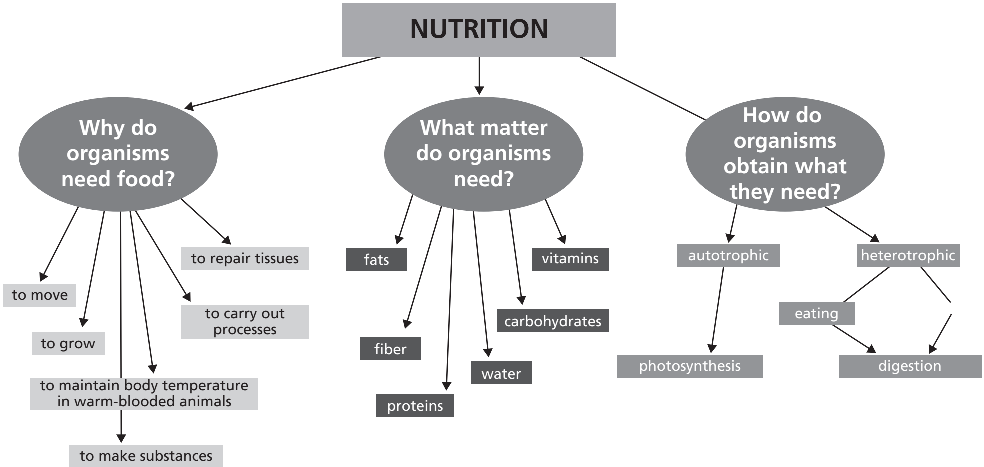
Figure 3. Teaching material on plant nutrition and the example of a student's answer



3. Structure of the unit

After detecting students' background knowledge, it is very useful to present them the didactic objectives of the unit. During the conferences at the UAB, both specialists in Pedagogy highlighted that it is necessary and essential for the learning process that the students know *what* they are going to learn. Thus it was recommended to use *mind maps* at this stage. We can write down a few questions (three to four) which will be answered during the unit and summed up at the end in order to complete the mind map (Figure 4). This resource allows the students to be situated during the teaching-learning process at any time.

Figure 4. An example of a filled mind map on one of the unit's objectives, Nutrition



The use of connectors in mind maps is crucial. Here, the English teacher has got an important role since in language lessons students can practice both orally and in written form expressions they will need for constructing mind maps and producing scientific texts in their science classes. The science we teach is not something lineal, but our students have a tendency towards lineal sentences, such as: 'It… and… then… after…' (Franco and Sanmartí 2003).

The experience described here clearly demonstrated that in the CLIL classroom the science teacher often has to face both linguistic and scientific demands in order to teach the students the use of cause-effect, adversative sentences, predictions, hypotheses, etc. (Halliwell 1992). This point is very important for the development of our students' science knowledge; to achieve it a very tight and close coordination between the science and the English teacher is necessary.

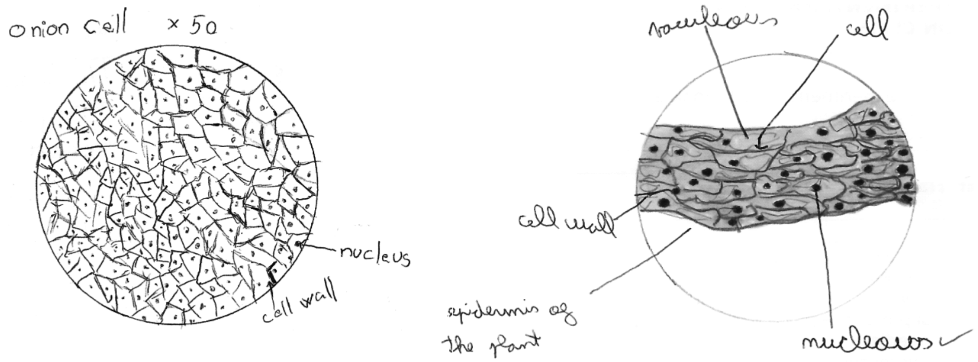
4. Identifying evidences

In traditional teaching materials used in our schools, we usually find content which is highly nominative and mechanical. Therefore, we claim that it is much more productive and effective to learn by identifying evidence. The following are some examples of this.

According to traditional teaching practice, in the unit dedicated to living things learners have to study that all living things are made up of cells and that these in turn are made up of many different structures, etc. As a consequence, they are faced with a lot of new vocabulary that more often than not is strange and alien to them. We are used, at first, to make our students learn by heart long lists of specialized scientific terms and names and only then, and if there is a possibility, we take them to the lab to make a few slides of cells.

We argue that the sequence should be the opposite. Having practiced in the lab and made several different slides of cells (the onion epidermis, leaves, etc.), students then draw what they have seen in the microscopes in their notebooks and try to identify the main cell structures (e.g. membrane, cell wall, nucleus, vacuole, chloroplasts) (Figure 5). This activity is interesting and useful for another reason: it can be used as an assessment task in which students can play a highly active role. In the experience we describe here, once the lab practice was carried out and the drawings were ready, the students worked in small groups evaluating each other's pictures. They decided which were the best and the most correct ones and established the evaluation criteria, agreed among all students and based on consensus with the teacher, for what made a really good scientific image (whether it was realistic, complete, labelled, magnified, had the correct proportions, etc.).

Figure 5. Students' drawings of onion cell



5. Connecting reality with abstraction

We would like to highlight that whatever students do in the classroom or in the lab must be in no way something distant from reality. Meaningful science means doing science in a context near to our students' world. What does this mean? Here, we give an example. To begin the study of biomolecules the teacher usually explains their composition by saying that they can be divided into different groups (carbohydrates, lipids or fats, proteins, vitamins, etc.), writes down some formulae, gives examples, explains their functions, and so forth. However, we can argue that this way of learning is too abstract and decontextualized and, therefore, concepts are more difficult to learn without any connection with the students' own everyday experiences, needs and interests (Sanmartí 2002).

Thus, to introduce such a difficult topic, an activity to be done in pairs was designed. In it students had to read, analyse and compare the composition of Catalan and English milk labels and the way their components were named in each language (Figure 6). This activity and the posterior class plenary based on the teacher's questions not only made a potentially difficult and abstract topic more familiar to the students, who showed more interest in it, but also allowed them to understand in a better and deeper way the substances that living things are made up of.

Figure 6. Activity which allows students to connect real facts with abstract concepts

INFORMACIÓ NUTRICIONAL (valors mitjans per 100 ml)

	SENCERA	SEMIDESNATADA	DESNATADA
Valor energètic	63 Kcal (264 Kj)	45 Kcal (190 Kj)	34Kcal (145 Kj)
Proteïnes	3,10	3,15	3,20
Hidrats de Carboni	4,60	4,65	4,70
dels quals sucres	4,60	4,65	4,70
Greixos	3,60	1,55	0,30
dels quals saturats	2,45	1,05	0,20
Monoinsaturats	1,04	0,45	0,09
Polisaturats	0,11	0,06	0,009
Fibra	0,00	0,00	0,00
Sodi	0,04	0,04	0,04
Calci	120 mg (15% QDR)	120 mg (15% QDR)	120 mg (15% QDR)

QDR: Quantitat diària recomanada

a) Look at the nutritional facts of English and Catalan milk. Write down the three substances that are in the highest percentage.
b) Which mineral/s does milk contain? What is its/their function?
c) After looking at the milk label, can you say if milk is highly nutritious? Why?
d) Which component is missing?

6. Coordination between Science teachers and English teachers

As was highlighted before, close coordination between teachers with different backgrounds is a powerful strategy as CLIL is after all an interdisciplinary endeavour. We believe that English teachers should reconsider the role that traditional foreign language textbooks and their structural syllabuses full of meaningless activities and artificial texts are to play in the CLIL programme. Science and English teachers should be flexible and open to alternative ways of presenting work in order to adapt their lessons to the needs of the learners. English teachers could, for example, dedicate enough time to cover not only scientific vocabulary, but also grammar forms typical of science (passive voice, noun forms of verbs), the way of formulating different kinds of questions and logical relationships (cause-consequence, hypothesis, comparison), useful expressions and connectors for arguing, reasoning, predicting, summarising, etc. in order to help students progress properly and improve their competence in science and in the target language.

Thus, for example, in the first unit, our students had to compare things (e.g. animal and plant cells). To carry out this task successfully, they needed to learn to compare and become familiar with comparative and superlative forms of adjectives (content-obligatory language, Snow et al. 1992). However, according to their English syllabus, they first had to learn simple adjectives and thus comparisons could not be found in the very first lesson of their English textbooks. So, it was necessary to adapt the traditional lineal progression to the linguistic demands set by the scientific content, i.e. to compare. It was essential that very early our students learned to describe processes, make generalisations, express facts and contrasts as well as causes and results, make impersonal statements, classify, etc. So, the English teacher's collaboration in the process and the work done with the students on the use of the passive voice, the imperative, the conditional, prepositions, etc. resulted to be very useful and important because it equipped them with linguistic resources and skills necessary for our science lessons.

Thus, on the one hand, when using (i.e. reading, listening, writing, speaking and interacting in) the language required by subject-matter contents to learn the latter, students at the same time learn to use the target language (Navés and Muñoz 2000; Escobar Urmeneta 2004). On the other hand, we think that learning science through a foreign language gives students the support they need to learn better (Marsh, Marsland and Nikula 1997) since the teacher has to provide them with more scaffolding, use pair/group work and promote a learner-centred teaching approach (Centre for Science Education 1992).

However, it is very important to teach the students how to "build" sentences in a proper way, with appropriate scientific terms and verbs (Franco and Sanmartí 2003). Without our guidance and help they can easily produce scientific errors (Lemke 1990). For example, the following sentences sound very similar: 'Plants change to adapt to the environment' and 'Plants are adapted to where they live' (which means that if they are not adapted, they do not survive). However, there is an enormous difference between them because behind each one there is an opposite theory of evolution: the first one follows Lamarck's theory of acquired characteristics while the second one expresses Darwin's theory of natural selection.

On the other hand, in English classes, the teacher can take advantage of the CLIL approach by connecting language learning to its usage in a real and meaningful context and doing more interesting tasks (Deller and Price 2007). These can include reading texts from scientific journals, watching popular science films, playing cognitively and linguistically demanding games, preparing Power Point presentations, doing speaking/listening activities on a scientific topic, etc.

Another example of collaboration between both teachers could be a series of assessment tasks on vertebrate animals in which students would have to prepare a naturalistic description of a certain animal in their science class, while in English class it would be one literary narrative description and one poetic.

Finally, we wish to highlight that because of their developing competence in English, students are expected to produce some linguistic errors; however our aim is that all tasks be carried out competently in English, which implies that they produce intelligible English texts, whose scientific content is basically correct. Year by year, they will surely improve their competence in the target language and in later (advanced) courses will be able to self-repair their mistakes in English.

7. Values

The last point we would like to comment on is that we are not only interested in linguistic and scientific competences, but also in educating conscious and responsible individuals. Our students are future citizens that will need to have opinions with a sound foundation. They will live in a world which is always changing and where responsibility and respect are essential.

In each unit, we insisted on working on values. We did not study animals or plants *per se*, but we worked on them from various positions and points of view: for example, after studying the characteristics of different plant or animal groups, some students prepared a Power Point presentation about endangered species in which they analysed the causes of the extinction of a particular species while others carried out a study on abandoned animals in the city or adopted an animal from the zoo. As it can be seen, there are a lot of activities we can do in the science classroom to link subject-matter content with values.

During the UAB conferences it was highlighted that it is not worth studying the parts of a flower if at the end the students do not learn, after understanding its importance, not to pull the plants or flowers up. In other words, we claim that there is no use learning lists of words or concepts by heart if this does not involve a change of attitude in our students. We cannot, however, fill their heads with certain ideas or rules: they must come to formulate them by themselves; it must be they who decide what is appropriate behaviour and what is not.

We would also like to emphasize that our task as teachers will be successful only if our students, apart from understanding scientific facts and processes and learning to solve problematic situations, are able to face the world they live in, in a respectful and responsible way.

8. Conclusions

To conclude, it should be highlighted that the reflections about science teaching and learning which emerged from the process of designing and piloting CLIL tasks and materials were highly useful for us in order to learn how to teach in a different way. It was necessary to reconsider in depth the manner science was to be taught and at the same time to be aware that our students had very limited knowledge of English. Being a secondary school science teacher, this is what turned out to be the most enriching in the experience.

We think that all secondary school teachers should have the opportunity to collaborate with specialists in teaching (in our case, the designing process was carried out in cooperation with two specialists, one in the teaching of languages and the other in the teaching of science) as the teaching-learning process is no doubt very complex. As teachers, we need to prepare ourselves for a changing school reality and to recycle our professional and pedagogical knowledge since we cannot continue teaching science in the 21st century with the approaches of the 19th century.

As teachers, we neither want our students to learn passively as mere receptors who come to our classes to listen to information directly transmitted to them. We want them to be able to construct their own knowledge. In order to make science meaningful for them, they should participate actively in classroom activities, share their previous ideas on the topics and the way they comprehend the surrounding world in discussions, describe and analyse, explain and justify, etc. And in order to do all this, they should learn to effectively communicate their point of view both orally and in written form.

In the described experience, the CLIL approach allowed us to reconsider methodologies and techniques traditionally used to communicate the subject-matter contents, in our case facts of nature related to living and non-living things; in adddition, it permitted our students to learn in a more significant and participative way.

We hope the experience presented in this article will be useful for other secondary school teachers, both of specific disciplines and foreign languages, who are already trying to be CLIL teachers. We hope it will help them not only improve their everyday teaching practices, but also realize that our profession can be as creative, enjoyable and self-reflective as many others. As, finally, being a CLIL science teacher is a constant process of rethinking the way one teaches, as well as rewriting and remaking teaching materials; in a word, learning to teach Science through English.

9. References

Centre for Science Education, Scheffield City Polytechnic (1992). *Active teaching and learning approaches in Science*. Collins Educational.

Council of Europe (2001). *A Common European Framework of Reference for Languages Learning, Teaching Assessment*. Cambridge: Cambridge University Press.

Cummins, J. (1984). *Bilingualism and special Education: Issues in Assessment and Pedagogy*. Clevedon: Multilingual Matters.

Deller, S. and Price, C. (2007). *Teaching other subjects through English. Resource books for teachers*. Oxford.

Escobar Urmeneta, C. (2004). Content and language integrated learning: Do they learn content? Do they learn language? In J.D. Anderson, J.M. Oro and J. Varela, eds., *Linguistic Perspectives from the classroom: Language teaching in a multicultural Europe*. Universidade de Santiago de Compostela: 27-38.

Escobar Urmeneta, C. (2008). Talking English to learn Science. A CLIL experience in Barcelona. In M. Dooly, ed., *How we're going about it.' Teachers' voices on innovative approaches to teaching and learning languages*. Cambridge: Cambridge Scholar Press. 154-169.

Escobar Urmeneta, C. (2009). Cuando la lengua de la escuela es diferente de la lengua familiar. In *Monográfico Aprender en ingles. Cuadernos de Pedagogía* 395: 46-51.

Franco, R. and Sanmartí, N. (2003). Descriure: establir la manera de mirar els fets. In N. Santmartí, coord., *Aprendre ciències tot aprenent a escriure ciencia*. Barcelona: Edicions 62. 59-78.

Halliwell, S. (1992). Integrating language work in other subjects. In S. Halliwell, ed., *Teaching English in the Primary Classroom*. Harlow: Longman. 130-169.

Lemke, J.L. (1990). *Talking science: language, learning and values*. Norwood, NJ: Ablex.

Màrquez, C., Roca, M. and Via, A. (2003). Plantejar bones preguntes: el punt de partida per mirar, veure i explicar amb sentit. In N. Santmartí, coord., *Aprendre ciències tot aprenent a escriure ciencia*. Barcelona: Edicions 62. 29-58.

Marsh, D., Marsland, B. and Nikula, T., eds. (1997). Aspects of Implementing Plurilingual Education: seminar and field notes. *Research and Field Reports* 29. Jyväskylä: University of Jyväskylä.

Navés, T. and Muñoz, C. (2000). Usar las lenguas para aprender y aprender a usar las lenguas extranjeras. Una introducción a AICLE para madres, padres y jóvenes. In D. Marsh and G. Langé, eds., *Using Languages to Learn and Learning to Use* Languages. Jyväskylä. University of Jyväskylä - TIE-CLIL. 1-16.

Sanmartí, N. (2002). *Didáctica de las ciencias en la educación secundaria obligatoria. Didáctica de las Ciencias Experimentales*. Madrid: Síntesis Educación.

Snow, M.A.; Met, M. and Genesee, F. (1989). A conceptual framework for the integration of language and content in second/foreign language instruction. *TESOL Quarterly* 23 (2): 201-217.