# FOSTERING THE IMPORTANCE OF LANGUAGE AWARENESS THROUGH CLIL-MATHEMATICS TEACHING/LEARNING

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*This contribution investigates the role played by a second language in teaching/learning mathematics and how it could strengthen the importance of natural language in mathematics. It is particularly significant to deepen this issue since many European Countries have already introduced or are going to introduce the Content and Language Integrated Learning (CLIL) methodology. CLIL pursues a dual-focused goal promoting at the same time teaching/learning of both a foreign language and a non-linguistic content. This new trend in education asks for analysing limits and potential for using a second language in mathematics education.*

Keywords: CLIL, representations, communication.

## INTRODUCTION

At European level, the importance of mastering at least one non-native language (usually called second language, L2 in short) is widely recognized. In fact, to be fluent in two or more languages has increasingly become a pre-requisite to apply for a job.

The perspective adopted by the European Commission in order to promote the teaching/learning of L2 languages are consistent with the Common European Framework of Reference (CEFR) [1] whose key principle is centred about the importance of developing language competences in meaningful contexts, themselves constituting learning goals. More precisely, the guidelines provided by CEFR aim at promoting teaching/learning contexts where 'language' and 'content' are taught/learnt at the same time. Pursuing this objective, the European Network of Administrators, Researchers and Practitioners (EUROCLIC) [2] in the mid 1990s started to call 'Content and Language Integrated Learning' (CLIL) the methodologies based on an twofold approach to 'language' and 'content' at the same time.

From the beginning, CLIL has been considered as an additional opportunity to develop language skills. In fact CLIL courses are delivered at the same time as L2 courses. As a consequence, since the exposure to the L2 is undoubtedly greater, pedagogical benefits can be expected. However, as far as the content is concerned, it cannot be considered trivial having also pedagogical benefits on the content side. In-depth studies about the role of the language medium to teach a non-linguistic subject are necessary.

In our study we consider mathematics as the non-linguistic content to be taught/learnt through a combined use of L1/L2. The research problem consists of investigating how and to what extent moving from L1 to L2 to teach/learn mathematics can be effective in terms of promoting the learning of mathematics.

## CLIL AND MATHEMATICS

The CLIL methodology encompasses any dual-focused educational context in which a second language is used as a medium to teach/learn a non-language content (Marsh, 2002).

> Within the CLIL classroom, language and subject area content have complementary value. Learners process and use language to acquire new knowledge and skills and as they do so they make progress in both language and subject area content. (Coyle et al., 2009)

It is quite obvious that the use of a L2 to teach/learn non-language contents helps L2 learning. In this view, CLIL has been considered "a catalyst for change in language education" (Marsh & Frigols, 2007, p. 33). Moreover, from a linguistic perspective, several research studies (see for instance Lorenzo & Moore, 2010;) revealed that beside the linguistic resources the students have at their disposal are quite limited, they can develop more strategic competence which allow them to successfully master also content notions.

With regards to mathematics being taught using CLIL methodology, apart from a few papers (e.g. Hofmannová & al., 2004), we can only refer to studies about some important but peculiar teaching contexts, such as bilingual schools (Barton & Neville-Barton, 2003; Barwell, 2002) or multicultural classrooms (Barton & al., 2007; Setati & Adler 2001). However, in the investigated educational contexts pupils are actually taught in a second language, but the educational aims differ, sometimes significantly, to CLIL teaching.

In fact, in these contexts, the classroom language consists in an L2 for all or a part of the students during the whole educational path, whereas this does not happen in a CLIL classroom. In this case, not only is the classroom language a L2 for both all the students and the teacher, but also its use is limited to one or two subjects and a small number of lessons, as most of the subjects is taught/learnt in L1.

Moreover, L2->L1 switching plays a relevant, strategic role, as it contributes to foster the understanding of mathematical terms and concepts. However, language switching in a CLIL based classroom is only partly similar to language switching in other educational contexts such as the one illustrated in Planas & Setati (2009), where the choice of the language (L1 or L2) mainly depends on both the task complexity and the difficulties met by the minority of the students in the mathematics understanding, due to their poor mastering of the classroom language.

For this reason, we decided to start from a literature review on the role of natural language in mathematics, in order to have a reference frame suitable for analysing when an additional language is introduced in maths classroom.

## LANGUAGE TO REPRESENT AND LANGUAGE TO COMMUNICATE IN MATHEMATICS

As stated by Laborde (1990, p.53) the language has a special role in mathematical education since

> Language serves both as a means of representation and as a means of communication.

Elaborating on this, we tried to analyse, at a theoretical level, how both considering L2 as a means of representations of mathematical objects and as a means to communicate in the classroom may improve teaching/learning processes. Nevertheless it is difficult to classify when the language is used as a representation tool and when it is used as a communication tool, since often the two functions are interconnected. To investigate the potential for L2 we needed firstly to analyse separately the two L2 functions and then to define a combined theoretical framework to take both jointly into account.

### Natural language as a representation tool

Any language can be used, in a natural way, to represent mathematical objects. In this perspective natural language, and in this case both L2 and L1, can be considered semiotic registers (Halliday, 1978). In a semiotic perspective, the meaning of a mathematical object is linked to its representations and, according to Duval (2006), any mathematical activity can be classified as a treatment in a specific representation or a conversion between representations. Usually treatments are carried out within non-linguistic representations (symbols, graph, tables,…), whereas conversions often involve also the use of linguistic representations (e.g. converting the text of a problem in a formula).

Duval stresses the importance of developing multiple representations of the same mathematical object in order to fully grasp its meaning. In fact, as Peirce (1932) has underlined, a representation is "something which stands to somebody for something in some respect or capacity." As a consequence, using different types of representations allows different features of a mathematical object to be highlighted.

Moreover, in a social semiotics perspective (Morgan, 2006), the semiotic potential of a non-linguistic representation may be unfolded through social interaction in the classroom, which mainly takes place through linguistic representations. In this view, it is clear the role of the natural language as a tool for connecting different types of representations. In doing so, the natural language should act as a meta-representation, constructing the connection between these different representations. In our view this process is delicate and often taken for granted in teaching/learning practices.

Introducing L2 as a natural language, even if it could represent a cognitive obstacle, could reveal the importance of the natural language and unfold its potential in order to deeply understand a mathematical concept.

### Natural language as a communication tool

According to Chapman (1993) mathematical meanings are built through classroom discourses which shift continuously from 'more mathematical' to 'less mathematical' language and vice versa. In this view, Tang et al. (2012, p. 6144) in addition to underlining that 'the most obvious characteristics of mathematical discourse is the use of specialised vocabulary', state that in mathematical verbalization also non-specialised vocabulary is present, and more frequently both specialised and non-specialised vocabulary coexist in 'mixed' sentences.

By the introduction of a second language as a means for teaching/learning mathematics, concepts understanding could be inhibited because of the lack of a wide non-specialised vocabulary, actually available in the native language. However, studying the role of an additional language in mathematics learning, Norén (2011) states that, since the use of a L2 requires giving room to communication, the conceptual discourse is more emphasized than the procedural discourse.

Studies on the linguistic perspective, reinforce this statement arguing that

> rather than being a hindrance, L2processing actually has a strong potential for the learning of subject-specific concepts. (Dalton-Puffer, 2008).

More specifically, Vollmer et al. (2006) argued that linguistic troubles, not only do not usually lead to task abandonment, but often may originate deeper semantic processing (through elaborating and relating details) and more in-depth understanding of non-linguistic concepts.

## USING TWO LANGUAGES IN MATHEMATICAL ACTIVITIES

As already said, in order to make students aware of the relevance of natural language in mathematics learning, it is important to investigate how and to what extent resorting to L1 is needed by students. Moschkovich (2007), when discussing the potential of using two languages to teach/learn mathematics, underlines how the language can be seen as an 'individual cognitive phenomenon', according to psycho-linguistics theoretical perspectives, and as a 'social phenomenon', according to socio-linguistics theoretical perspectives. The author suggests referring to 'language switching' when referring to the combined use of L1/L2 in individual mathematical activities, and to 'code switching' when referring to the combined use of L1/L2 in social mathematical activities. In other words, language switching is internally oriented, the learner decides to change the language because he/she thinks that changing the language may help solve the mathematical task. According to Moschkovich, the language of instruction is preferred by students to process mathematical tasks. This statement can be considered a proof of the close relationship between natural language and non-linguistic representation. In particular, it shows how every mathematical concept embeds a discourse which is easier to unfold through the same language used to introduce it. In practice, since the language of instruction has constituted the medium through which other non-linguistic

representations emerged, students prefer to use L2 when undertaking mathematical tasks, which according to Duval consist of treatments in a representation system and conversions between different representations systems. On the contrary, code-switching is externally oriented. Students come back to L1 since they do not have (or they think not to have) enough resources in L2 to talk about a specific task. Therefore, the use of code-switching cannot be considered a consequence of the use of language switching. In fact, code-switching can also be motivated by affective reasons.

## THE RESEARCH STUDY

In Italy, the use of a L2 can be considered as an 'artificial tool' to teach/learn maths since the classroom language represents a non-native language for nearly all maths teachers and students. Nevertheless, the use of a L2, can make the classroom context more homogeneous (compared to multilingual classrooms), thus allowing the role played by an additional language to emerge without being influenced by social context factors. The critical issues we wanted to investigate, in order to study the impact of using L2 as an additional language to develop mathematical meanings, are the following:

- How and to what extent the introduction of an additional language in teaching/learning mathematics can make students aware of the role played by the language both as a representation tool and as a communication tool?
- How and to what extent the introduction of an additional language in teaching/learning mathematics can facilitate deeper understanding of concepts?

Research findings to the above questions could lead to uncover possible links between the language role awareness and the mathematics concepts understanding. The rationale of the research study is framed within a social semiotics perspective:

> Every instance of mathematical communication is thus conceived to involve not only signification of mathematical concepts and relationships but also interpersonal meanings, attitudes and beliefs. (Morgan, 2006, pp.220-221)

According to this statement, which underlines the importance of the development of 'interpersonal meanings, attitudes and beliefs', we hypothesized a new classroom dynamics. In comparison with the usual maths lesson it involves different cognitive aspects and originates different meta-cognitive attitudes towards mathematics.

Our first research goal consisted of investigating the influence of L2 language in teaching/learning mathematics through the students' view about this new experience. In fact, the innovative methodology of CLIL lacks related studies on its influence on the non-language content teaching/learning. Therefore we believed it is useful first of all, to analyse the learners' perspective in order to investigate whether the critical points we addressed before really emerge. Then, further research studies can be designed to address more specifically such issues.

## THE PILOTING

In order to address the research questions reported above, a teaching/learning sequence was planned. We decided to pilot a CLIL module in Upper Secondary Schools with a scientific curriculum (in Italy, these schools are called Licei Scientifici) where maths is an important subject. A group of maths and language teachers from these schools collaborated to design the classroom activities. In all the schools the second language taught was English so we had no possibility to use a different foreign language in the piloting. We chose to plan CLIL activities for a school grade that allowed which ensured enough autonomy by students to produce simple mathematical statements in English. Therefore, 11$^{th}$ grade students (3$^{rd}$ year of Upper Secondary School) were selected to take part in the piloting. The maths curriculum in this grade is based on analytical geometry. During the first semester students are introduced to the Cartesian plane, working with points, segments, straight lines, whereas the second semester is completely devoted to the study of the conic sections. The second semester was chosen to develop the CLIL module. This made it possible to work with completely new concepts, and to refer the basic concepts already used in the first semester. The piloting consisted of five one-hour sessions in classroom and an one-hour final test. The didactical goal consisted in introducing the parabola as a locus of points, identifying the relationships between the coefficients in the equation of the curve and its graphical characteristics, and finding the intersections between a parabola and a straight line. Three classrooms took part to the piloting, but for reason of brevity, from now on we only refer to a single classroom. It was composed of 22 students, out of whom 9 were considered low-achievers in maths, 7 low-achievers in English, and 4 low-achievers in both subjects. The teacher behaved in the classroom as he used to do: making students confronting themselves (also in small groups) with a new task, providing them a worksheet, and then discussing together the solution in order to formalize mathematical concepts emerged. At the end, students reported, as usual, on what they had learnt during the lesson, but during the CLIL piloting they had been asked to report also positive/negative comments about the lesson.

In our perspective - teaching and learning maths in L2 but also in L1 - a list of mathematical words (specialised words) in L2 with the translation into L1 was given to the students at the beginning of each session to ease their task.

As already said, our main interest was to analyse possible changes at a meta-cognitive level in order to refine our research questions about the impact of the CLIL methodology at a cognitive level. In this perspective, both some excerpts from students report and from some teacher's interview are analysed.

The teacher who piloted the CLIL module was asked the following questions:

1. Did you notice any difference in the students' behaviour during CLIL lessons?
2. Did the use of a different language affect your teaching practice?

3. Do you think that can be taken for granted that mathematical concepts introduced and learnt in English by students are simultaneously and similarly understood and mastered in Italian, the mother tongue?

The analysis of both students' reports and teachers' answers in this and other similar contexts should allow our research questions to be addressed more in depth and to refine the research framework.

## FIRST FINDINGS

We started analysing an extract from the teacher's interview so as to gather an overview of the classroom scenario. The teacher says that low-achievers in maths (as well as high-achievers/low-achievers in English) participated more actively than in the usual maths lesson; he states: 'the maths seems to be different to the students'. On the other hand, high-achievers in maths (as well as high-achievers/low achievers in English) tend to participate less actively; the teacher says: 'probably they are not sure about using the right English words and they do not want to risk'. At first, then, it seems that classroom dynamics changes dramatically during a CLIL lesson.

Here below, a transcription of the teacher's interview, in which he addresses all the three questions, is reported.

> Teacher: I think they understand the content and surprisingly a student who wanted to reach a good mark (he had 5 [3] and, you know, the school year is about to finish) asked me to have the oral test in English. Sometimes, during the test, he also used Italian but he seemed to have understood the content. We did not switch much during our lessons from English to Italian, my concern was to maintain English language as the language of the classroom and I did my best using gestures and drawings when I did not know how to express something in English. Sometimes students helped me to find the word I was looking for. I could say that also students are able to deal with this content in Italian, since I assigned them exercises from the textbook and they did not report problems with the language.

Many issues we pointed out at the theoretical level seem to emerge from this excerpt. Firstly, the recourse to L2 to perform mathematical activities based on concepts taught/learnt in that language. Secondly, a combined use of different non-linguistic representation by the teacher to overcome language difficulties. In the following, some comments about the CLIL experience by students, collected at the end of the piloting, are reported. They have been selected from a final written report about the CLIL experience, and even if some language errors are evident, the mentioned issues address, somehow, our research questions.

> Laura: I think the lesson is an interesting experience for application of English in other fields […] The only concern refers to a possible problem of understanding the concepts of the lesson; this lesson flowed linear, but in other occasion I noticed students who missed out a word and they ask the teacher to repeat it….the use of practical representation are really useful in

that cases. The use of English language encourages students to pay more attention in classroom also to maths since the language is important.

The student's comment is focused on the L2 as a medium to drive students' attention towards the language used in maths-lesson. She also considered a positive action the recourse to non-linguistic representations by the teacher so as to make the communication easier. Also the following comment by Marco highlights positive influence on students' concentration.

Marco: The lesson was interesting and helped students to concentrate more in mathematics. Important is to have a paper with some key-words, I will ask the teacher if it is possible or not.

Marco, besides commenting on how the language helps concentrating on maths, also shows a different attitude towards classroom activities when he says he will ask the teacher to provide students with some key-words.

Claudio: My impression is that this lesson but also the others we had are functional for not only improving the language, but for understanding maths better too. When the teacher speaks Italian sometimes I miss some words since I think are not important discourses and I can think about a different things, in English I cannot miss a word. I think it do a great change in the lesson.

Claudio says explicitly that maths learning can improve through the use of English. He explains why maths can benefit from the use of English. In English the 'discourses' one can refer to are not as well-developed as in Italian so the student has to build new semantic nets.

The next three excerpts show difficulties met by students during the lesson, but a positive attitude towards the CLIL-methodology is shown by all students.

Mattia: Honestly it was a little hard for me to follow the lesson entirely in English but it was very interesting and very productive because the teacher explains every passages and at the end I understand.

Mattia points out his difficulty but also the support by the teacher who took great care in explaining everything. It seems that the teacher's behaviour has changed compared to the math lesson in Italian.

Marco: The lesson was really cool! The teacher was happy to teach in English and he teach well! To be serious, English helps to think and reason in other ways because of its phrase construction so I think study maths in English can be useful. Maybe I could have good marks. Now I have five.

Marco highlights the potential of the specific L2 used, as a powerful means, because its phrase construction helps better represent mathematical concepts.

Silvia: I have problem in maths but not in English, also this lesson seems easier to me, maybe I could have a good mark also in maths?

The last comment by Silvia, who declares to be a low-achiever in maths but not in English, shows a different attitude towards maths. It seems that the change of the language of instruction may positively affect her achievement in maths.

## CONCLUSION

Even though the piloting was very limited, the role played by the use of a L2 in making the importance of maths language emerge seems to be shown by the students' comments. How and to what extent focusing on the language (when it is not a native one) can affect the conceptual view of mathematics needs further in-depth investigation. In our view, this concern requires the development of the analysis we began, namely how the communication is affected by the use of L2 in mathematics, how L2 serves as representing a mathematical situation and how language switching could be used as a complementary resource to teach/learn mathematics. This can be carried out by designing long-term piloting. In this perspective, further research is also needed on meta-cognitive aspects, concerning the role of the teacher, and the change in classroom dynamics. In particular, it may happen that the maths teacher is no longer the only expert in the classroom, because of the possible presence of students' with better language L2- skills.

## NOTES

1. http://www.coe.int/T/DG4/Linguistic/CADRE_EN.asp
2. http://www.euroclic.net
3. In Italian upper secondary school the marks range from 1 (minimum) to 10 (maximum)

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