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Bilingual Education in the Primary School: Curriculum Study and Experimental Research on Language of Acquisition Effects in the Arithmetic Facts

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Introduction

Due to social and cultural demands raised by the growing international mobility and by the globalization of the human activities, over the last two decades, the issue about multilingualism has become more and more relevant throughout Europe. It is natural that this issue has firstly impacted across Europe at the educational level with lot of attention paid on foreign languages and many innovation efforts concentrated on this aspect.

Grassroots teachers' movements and pilot actions, guidelines drawn by the European Union, attention paid by the national and/or local educational institutions are to be considered the driving forces of the progressive implementation and spread of educational programmes that aim at promoting and developing multilingual skills among the population.

The presence of bilingual pilot educational programmes is a feature that has also characterized the landscape of the school system in Trentino in the last decade. This research is an attempt to reflect on bilingual education in the Primary School and more specifically it focuses on how and to what extent the processes of teaching and learning are affected by the use of a foreign language (FL) as the medium of instruction of non-language contents. This approach is known as Content and Language Integrated Learning (CLIL). Both the European institutions and the scientific and practitioners' communities share the definition of CLIL as a dual-focused educational context that

integrates content and language. The CLIL label can be applied to any teaching and learning experience in which the acquisition of the FL is not considered the end result but an instrument for learning different subjects.

The interest towards this specific topic has arisen from my long experience as a school teacher in different educational contexts and geographical areas and the encounter with CLIL since its first, limited and tentative implementation attempts in the Italian Primary school at the end of the '90s.

Since then, "*CLIL has been a tremendous success story and its influence on practice is currently expanding quickly across Europe and beyond, (…) currently gaining considerable momentum and (…) being integrated into curricula all across Europe*" (Meyer, 2010, 11-12). A brief history of CLIL, its implementation in the European and the Italian school systems, and the state-of-the-art of CLIL research in Europe are reported in Chapter 1.

Going back from the global European perspective to the local context, and considering the CLIL implementation, Trentino has gained an interesting position certainly in the Italian, if not in the European context. The reasons are twofold: (1) the attention paid by the Autonomous Province of Trento (PAT) to the progressive introduction of CLIL-based educational programmes and (2) the numerous CLIL experiences implemented at all the levels of the school system with the involvement of different stakeholders (teachers, students, parents, head teachers). Taking into account the small size of the local school system, the CLIL implementation in Trentino can be considered large and relevant, in terms both of degree of diffusion and of weight.

In this context, a CLIL-based programme has drawn a particular interest from the research point of view. This pilot programme, called *Classi bilingui*, presents features of

absolute innovation and uniqueness at least at the national level. The specific characteristic of this programme stays in the intensity of the tuition in the FL (English) that represents more than the 50% of the school time. It is a semi-immersion programme set in a context that is practically Italian monolingual in which most of the subjects, including Mathematics, are entirely taught using English as the language of instruction.

Precisely this particular group of Italian school children to which Mathematics is taught and practiced at school using a language that is not their mother tongue has triggered the main question addressed by this research:

Are there Language of Learning Arithmetic (LoLA) effects in the automatic activation of the arithmetic facts in Primary school children when the language of instruction for Mathematics is not the children's mother tongue but a FL?

Six experiments conducted in two different school years (2011-12; 2012-13) have been designed in order to investigate in Year 4 and Year 5 Italian Primary school children a) the presence of interference effects in mental arithmetic as evidence for the obligatory activation of the arithmetic facts and b) the presence of LoLA effects in the obligatory activation of the arithmetic facts when the language of acquisition is not the mother tongue but a FL.

The set of experiments, the results and the discussion aiming at shading some light on this specific issue are reported in Chapters 3 and 4.

In parallel to the experimental investigation, the complexity of a topic such as the bilingual education has led to the opportunity to tackle this very complex issue also from a different perspective. Therefore, two more related questions were put and addressed:

1. *How and for which degrees the Classi bilingui programme has impacted on teachers' and parents' perceptions, motivation, expectations, involvement, needs and appreciation?*
2. *How the pilot programme has impacted on the curriculum? In particular, if and how the fact of having a FL as the medium of instruction for more than 50% of the school time has been conceptualized and experienced in the curriculum implementation.*

A three school year (2010-11; 2011-12; 2012-13) investigation has led to a rich description of the *Classi bilingui* educational context based on qualitative content analysis of school documents, interviews, observations of teachers' meeting and on analysis of data from questionnaires and tests. The context analysis and the curriculum study which represent the two faces of the monitoring of the *Classi bilingui* pilot programme are reported in Chapter 2.

Therefore, the research is based on a mixed-design research and encompasses two different methodological perspectives which are, nevertheless, complementary and tightly related.

Teaching and Learning in a Foreign Language

Chapter 1

1.1 Content and Language Integrated Learning (CLIL): A Tentative Definition and a Brief History

Over the past twenty years, the issue about multilingualism has become more and more important throughout Europe, due to the new social and cultural demands raised by the growing international mobility and the globalization of the manufacturing and economic processes. Moreover, multilingualism has been seen as one of the key elements of the European identity and competence in more than one language is an essential aspect of the European citizenship.

In fact, multilingualism has been defined "*part and parcel of both European identity/citizenship and the learning society. Proficiency in languages helps to build up the feeling of being European with all its cultural wealth and diversity and of understanding between the citizens of Europe"* (European Commission, White paper, 1995, 47).

Being multilingual is considered an essential element of both the identity and citizenship of Europe and of the European society; hence, the formation of multilingual skills among the population is fundamental for the integration and cohabitation in a multi-cultural society.

In this perspective, multilingualism represents indeed a big challenge that calls for action from each European country at both cultural and educational policy levels.

This attention on foreign languages has come in response to social and cultural needs linked to the process of internationalisation[1] as expressed in numerous documents and studies of the European Union[2] (e.g., White Paper on Education and Training: Teaching and Learning. Towards the Learning Society, 1995; Promoting language learning and linguistic diversity. An action Plan 2004-2006, 2003; The European Indicator of Language Competence, 2004; A New Framework Strategy for Multilingualism, 2005; Multilingualism: An asset for Europe and a shared commitment, 2008; An updated strategic framework for European cooperation in education and training, 2008; Council conclusions on a strategic framework for European cooperation in education and training ("ET 2020"), 2009; An Inventory of Community actions in the field of multilingualism – 2011 update, 2011), following the European Commission recommendation that "*(...) it is becoming necessary for everyone (...) to be able to acquire and keep up their ability to communicate in at least two Community languages in addition to their mother tongue*" (White Paper, 1995, 47). Therefore "*(...) all European citizens should be able to communicate in at least two languages other than their mother tongue"* (European Commission, 2003, 1).

No surprise that in the last two decades a lot of attention has been paid on foreign languages across Europe, as teaching and learning subjects at all the levels of the educational systems and many innovation efforts have been concentrated on this aspect.

[1] "*The further development of foreign language skills is important to encourage mobility within the Union; it will contribute to the creation of a truly European labour market by allowing citizens to take full advantage of the freedom to work or study in another Member State. Furthermore, a labour force with practical language and intercultural skills enables European enterprise to compete effectively in the global market place*" (Communication from the Commission to the European Parliament and the Council, *The European Indicator of Language Competence*, Brussels, 2005, 3).

[2] Available at http://ec.europa.eu/langauges/documents

Classical theories about the acquisition of a foreign language (e.g., Chomsky's generative grammar[3] and Krashen's studies on second language acquisition[4]) have given the conceptual framework of the communicative approaches that are nowadays an essential reference point for any foreign language teaching method. Without mentioning the differences and the specific features that mark each of the methods, it is relevant to underline the common points such as the importance of the communicative, and not only linguistic, competence as the main goal of the teaching/learning process as well as the essential connection between language and culture. Besides, it is essential to take into account not only the formal, grammatical accuracy of the language but also, and even more, its social effectiveness, namely the ability of a proper use of the language in context. From the same theoretical perspective, starting from the 1990s, the attention has been paid to the so called "integrated" methods that gather issues, suggestions and ideas from different language teaching methods and practices and also from the cognitive sciences.

The word "integrated" leads to CLIL, the acronym of Content and Language Integrated Learning. The name CLIL was coined by David Marsh in 1994[5] and officially launched by Marsh and Ann Maljers in 1996. CLIL cannot be defined as a new methodological approach in itself but it is rather a generic term, an "umbrella" word that encompasses other terms and covers different methodological approaches, all of them in the mainstream of the communicative approach. Nevertheless, according to a

[3] Chomsky, N. (1959), A review of B. F. Skinner's Verbal Behavior. *Language*, XXXV.
Chomsky, N. (1968), Language and Mind. Harcout, Brace and World.

[4] Krashen, S.D., Terrel, T.D. (1983), *The Natural Approach: Language Acquisition in the Classroom*. Oxford, Pergamon.
Krashen, S. D. (1985), *The Input Hypothesis*. London, Longman.

[5] "*CLIL refers to situations where subjects, or part of subjects, are taught through a foreign language with dual-focused aims, namely the learning of content, and simultaneous learning of a foreign language*" (D. Marsh, Bilingual Education & Content and Language Integrated Learning. International Association for Cross-cultural Communication, Language Teaching in the Member States of the European Union, University of Sorbonne, Paris, 1994).

definition that is commonly shared by both the scientific community and the European institutions, "*CLIL refers to any dual-focused educational context in which an additional language, thus not usually the first language of the learners involved, is used as a medium in the teaching and learning of non-language content*" (Marsh and Langè, 2000). CLIL is a teaching practice in which there is integration between content and language and it can be applied to any teaching and learning experience in which the acquisition of the foreign language (FL) is not considered the end result but an instrument for learning different subjects. In this context, the FL is not just a curriculum subject but is part of the means of teaching and learning non-linguistic subjects. CLIL is therefore defined as a dual focused education, in which the two focuses are the content and the language.

"Within CLIL, language is used as a medium for learning content, and the content is used in turn as a resource for learning languages. Students can put the language they are learning into practice instantaneously" (European Commission, 2006)

From the beginning, CLIL has been seen as a solution for providing a larger exposure to the FL within the curricula. It is true that the larger exposure in itself does not reflect an automatic improvement in the quality of the language teaching but when it is conjugated with appropriate methods can certainly work out as a booster. In this respect, CLIL can help in providing an educational context for implementing and achieving good practises in the frame of the available school time and resources.

Clearly, CLIL has not been something completely new on the European scene. In fact, consolidated and well documented examples of bilingual educational programmes (see the extensive research promoted by the European Union and published in 1993[6])

[6] Baetens Beardsmore H., *European Models of Bilingual Education*. Clevedon: Multilingual Matters.

have been pretty widespread in numerous and diverse European countries (e.g., Great Britain, Spain, The Netherlands, Germany). These programmes have been usually active in areas not as large as an entire country but limited to bilingual contexts with the aim of preserving and consolidating the weakest language (e.g., Welsh, Catalan, Basque).

The same can be stated about the French immersion programmes in Canada and the North American bilingual teaching models. Dating back from the 1950s when the impact of the French immersion schools started to be investigated in Montreal's area, a huge amount of research and studies (Dulay, Burt and Krashen, 1982; Swain, 1984; Cummins and Swain, 1986; Cummins, 1979; Genesee, 1987, 1994, 2004; Green 1997; Krashen 1996, 2005; Lyster, 1987; De Jong, 2002) have investigated the linguistic and subject achievements and the cognitive and attitudinal outcomes of the students of these programmes. While the French immersion programmes represent undeniably the predecessors of CLIL, the body of research carried out in North America still plays a crucial role as a reference point. As we will come back later to the detailed results of these studies, for now it is important to underline that the general conclusion that can be drawn up is that FL instruction integrated with content has proved to be more effective than FL instruction in isolation (Genesee, 1994).

However, CLIL cannot simply be seen as a translation or an adaptation of these bilingual programmes into the European context. Even though one of the most distinctive features of CLIL is that it is a multi-faceted approach, some specific methodological and organizational features are highly European-specific and deeply rooted in the European context and in the linguistic and cultural needs of the European Union.

First of all, CLIL is explicitly conceived for the majority group of, if not all, the learners in any European country with the aim of achieving a functional competence as opposed to a native-like competence. As clearly mentioned by the European Community, "*Content and Language Integrated Learning (CLIL), in which pupils learn a subject through the medium of a foreign language, has a major contribution to make to the Union's language learning goals. It can provide effective opportunities for pupils to use their new language skills now, rather than learn them now for use later. It opens doors on languages for a broader range of learners, nurturing self-confidence in young learners and those who have not responded well to formal language instruction in general education*" (European Commission, 2003, 8). In addition, the egalitarianism represents indeed one of the success factors of CLIL that "*it is viewed as inclusive because both below average and above average ability learners have been seen to benefit from exposure*" (Marsh, 2003).

If CLIL is clearly mentioned and considered as a priority intervention area since the Action Plan 2004-2006, the European Symposium on "*The Changing European Classroom – The Potential of Plurilingual Education*" held in Luxemburg in March 2005 firmly stressed the need of introducing CLIL in the mainstream school systems and the pivotal role that should be played by the national and European agencies in promoting the introduction, development, implementation and coordination of CLIL programmes all over the European Union. At the same time it emphasized also the need of specific CLIL training programmes for teachers.

Moreover, the Communication of the European Commission "*A new framework for multilingualism*" (2005) stressed again the success of CLIL as an opportunity for increasing the exposure to a FL within the curricula and the request to the Member

States of promoting this approach, of exchanging information, materials, the best educational practices about CLIL experiences and teachers professional development courses.

In order to summarize the general framework in which CLIL is depicted by the European policy, it is essential to underline that, from the methodological point of view, CLIL is seen as an approach effective both in bridging the delivery gap existing between what is provided as FL education and the outcomes of the learners performance and also in favouring the development of intercultural competences.

The following listed benefits of CLIL are identified and recognized by the European Commission that explicitly claims that "*CLIL's multi-faceted approach can offer a variety of benefits. It:*

- *builds intercultural knowledge and understanding*
- *develops intercultural communication skills*
- *improves language competence and oral communication skills*
- *develops multilingual interests and attitudes*
- *provides opportunities to study content through different perspectives*
- *allows learners more contact with the target language*
- *does not require extra teaching hours*
- *complements other subjects rather than competes with them*
- *diversifies methods and forms of classroom practice*
- *increases learners' motivation and confidence in both the language and the subject being taught*" (European Commission website).

In this perspective, the European Commission and the European Centre of Modern Languages (ECML) have supported many European projects (e.g., CLILCom,

CLIL Matrix, the CLIL Compendium, TIE-CLIL, the CLIL Consortium) that have shown the strong points of CLIL practices in effectively encouraging and fostering an integrated, multilingual, linguistic education. Besides the aim of promoting CLIL and raising awareness on the validity of this approach, these initiatives have above all played a significant role in implementing the exchange of information on best practices through the creation of collaborative nets of researchers and teachers (e.g., CLIL Cascade Network, eCLIL, EuroCLIC). In particular, most of these projects (mainly CLILCom and CLILMatrix) have aimed at increasing the teacher awareness about the necessary abilities and knowledge for putting into action high quality CLIL models.

1.2 CLIL in Europe

Following guidelines and recommendations repeated and reinforced by practically all policy documents, reports and surveys concerning language teaching and learning and linguistic matters issued from the European Commission and Council (for a complete overview see the European Commission website), over the past two decades many European countries have developed an increasing interest towards CLIL that has originated a large amount of practical experiences and applications in the educational field.

Starting with a few pioneer experiences in some European countries, such as Finland, Germany, The Netherlands and Italy, CLIL practice has spread faster in the past fifteen years all over Europe. According to the CLIL/EMILE[7] report, in 2002 it was *"(...) estimated that, overall, some 3% of schools in Europe teach through CLIL (...)*

[7] Acronym of Enseignement d'une matière par l'intégration d'une langue étrangère is the other acronym for Content and Language Integrated Learning

methodologies" providing that *"(...) the scale of activity needs to be considered in terms of exposure which may range from 5-100%"* (CLIL/EMILE, 2002, 89). While the report underlined the difficulty in obtaining figures and statistics on kindergarten and pre-schooling CLIL provision (with an estimation at about 0.5%), Germany, Finland, Spain, Italy, Estonia, Austria and Belgium were reported to be involved in small-scale and project-based CLIL experiences at primary level that encompassed usually English and French as the main target languages but also a few examples, above all in Spain, of trilingual education experiments, involving both the FL and a minority language. On the other hand, it was reported a more widespread and significant CLIL implementation at the secondary and vocational levels, involving all the countries above mentioned and also France, Bulgaria, Czech Republic, Luxembourg, Hungary, The Netherlands, Sweden and The United Kingdom.

The two studies "*Content and Language Integrated Learning (CLIL) at School in Europe"* (2006 and 2012) published by Eurydice European Unit[8] considered the role and the state of CLIL in the educational systems of thirty Member States. The survey highlighted that CLIL is part of mainstream school education at primary and secondary levels in all the European countries with the exception of only four of them (Denmark, Greece, Turkey and Iceland) in which CLIL does not exist at any level of the educational system.

Although CLIL exists in nearly all countries at primary and general secondary levels, it is definitely not widespread. While most of the countries, starting from the 1990s, have introduced a legislation framework to establish CLIL, the main feature of the CLIL landscape in Europe remains its high degree of variability. Ranging from Luxembourg,

[8] www.eurydice.org

Malta and the German-speaking community in Belgium where CLIL provision is offered in all schools throughout the whole education system, to Cyprus, Portugal and the Flemish community in Belgium where CLIL is provided only in schools involved in specific pilot projects, the studies provided figures and statistics also about the wide range of combinations of foreign, regional and/or minority languages associated with CLIL provision. It is also highlighted the great variety of the nature and the scale of the CLIL-based activities in the different countries, regarding the subjects involved and the average and/or minimum amount of weekly CLIL lesson time that, in most of the cases, depend on the regional or even on local school policies, without following any official or national recommendation.

In conclusion, the most distinctive feature of CLIL provision all over Europe is undeniably the great degree of variability, due to the strong differences between the national educational systems and the considerable degree of school autonomy in most of the European countries. In fact, CLIL has been implemented through a myriad of very different and diverse experiences and organizational models, usually being strongly related to the national and specific educational contexts and therefore difficult, if not impossible, to compare.

Except for a few obvious common features, such as teaching non-language subjects using a FL as a tool and the fact that English is by far the most widely taught FL, CLIL implementation has originated an incredible variety of combinations concerning the number of subjects involved, the percentage of CLIL within the curricula, continuity or discontinuity between the different school levels, the starting class, teachers professional requirements and training, the presence or absence of admission criteria as

well as of centralized or school-based CLIL measures, monitoring actions and quality control systems.

In this heterogeneous landscape, what represents indeed a common point is the fact that "*the evaluation of CLIL application in schools is practically nonexistent*" (Perez-Canado, 2011, 320). This remark might not fit only the situation in two countries, Estonia and The Netherlands, in which a national-based CLIL model has been proposed, implemented and assessed but also the one in a few other countries, such as the Czech Republic and Wales which have an established tradition of formal assessment of schools carried out by the educational authorities. However, the undeniable success and spread of CLIL have marked a strong point in favor of promoting the issue also from a theoretical point of view.

1.3 CLIL in Italy

The widespread implementation of CLIL in Italy shares most of the distinctive features of the CLIL provision throughout Europe. Over the last fifteen years CLIL has developed as a grassroots movement, which is particularly difficult to map and to track due to both a lack of documentation and to a total lack of centralized planning and guidelines for CLIL introduction and implementation.

Following the introduction of the law on school autonomy (L. n.59/1997; DPR 275/1999), some CLIL experiences were undertaken by regional and provincial educational authorities in the north of Italy (Lombardia, Piemonte, Veneto, Friuli Venezia Giulia, Trentino) and also by schools and groups of teachers practically on individual basis and often as a result of informal training.

The implementation of CLIL has widely employed a short term organizational model that foresees the planning and the delivery of CLIL modules ranging from 10 to 30 hours of CLIL provision per year. A survey promoted by the Ministry of Education (2001) showed a still very limited implementation of CLIL, more widespread at the secondary level than at the primary level and generally implemented through the activation of short modules based on a team-teaching approach. After that, no data were collected at the national level. The lack of systematic monitoring has, as a result, made it almost impossible to complete a map of the availability of CLIL programmes and therefore to create a clear picture of the CLIL experience in Italy (Infante, Benvenuti, Lastrucci, 2008).

Regarding Northern Italy, the Regional Institute of Research in Education (IRRE) of Lombardia was the coordinator of one of the first European CLIL projects (TIE-CLIL, 1998). The project provided pre- and in-service CLIL training programmes for language teachers and non-linguistic subject teachers.

Later on, the ALI CLIL (2001) project, managed again by IRRE Lombardia, provided professional development courses on CLIL, using also an online platform.

In the same year IRRE Piemonte promoted the SLIL (Science and Language Integrated Learning) focused on teaching modules for scientific contents (Boella, Barbero, 2003).

In 2002 IRRE Veneto in collaboration with "Ca' Foscari" University of Venice started "Apprendo in Lingua 2". The project involved several secondary schools with the aim of evaluating the improvement of the communicative competence in CLIL students and the absence of pitfalls in the content knowledge (Coonan, Marangon, 2007). Also the IRRE of Friuli Venezia Giulia created a net (Rete CLIC\CLIL) of secondary schools in order to share and foster good CLIL practices.

It is also worth mentioning that Laboratorio Itals of "Ca' Foscari" for some years has been organizing a two-year CLIL on line course.

At the national level, for more than a decade, the Italian school system has been subject to a variety of changes and reform laws (L.10-2-2000 n.30; L.53/2003; L.133/2008 and 169/2008) that have impacted upon the organization and the curriculum, even if they have not always been implemented in a systematic and complete way. In this context, foreign languages have undoubtedly represented one of the aspects on which a specific attention has been focused, in response to social and cultural needs linked to the process of internationalization and following recommendations and guidelines expressed by the European Union.

Recently, the law concerning the last school reform (L.169/2008), effective for the Secondary school in 2010 (DPR n.89/2010), has provided a new curriculum with the introduction of a mandatory non-linguistic subject taught through a foreign language, starting from Year 3 for the students on the "language" pathway (Liceo Linguistico) and in the last year (Year 5) for the students of the other Lyceums and Technical Institutes. The gradual introduction of CLIL in Secondary education at the national level has started in the current year in the Liceo Linguistico and should be implemented in Year 5 in all of the different types of Secondary school from the academic year 2014-2015, even though regulations and conditions are still to be clarified.

In parallel, in this academic year a few universities have activated specific professional development courses on CLIL methodology for teachers of non-linguistic subjects together with language courses aiming at achieving the C1 level of language competence.

1.4 CLIL in Trentino

Trentino is an autonomous Province in the north-eastern part of Italy. The status of autonomy (Constitutional Law 5/1948, revised and amended in the DPR 670/1972) partly empowers the local government of legislative authority upon matters, such as the school legislation (DPR 405/1988, revised with the DL 346/2003), that in the other Italian Provinces are totally under the national regulation.

Regarding foreign languages, in 1974 Trentino introduced German as a compulsory first FL in the Primary school curriculum from Year 3. It is important to remember that at the national level a mandatory FL was introduced in the Italian Primary school curriculum only in 1991.

Given this background, the promotion of multilingualism has been for some years now an element that strongly characterizes the school system of the Autonomous Province of Trento (PAT).

Following the Provincial Law (LP 11/1997) on FL provision at school, the teaching of a first FL (mostly German) was then extended to all the classes of the Primary school (Year 1-5, age 6-11) and a mandatory second FL (generally English) was introduced in the Middle school (age 11-13). In 2004 the revision and integration of the LP 11/1997 introduced a second mandatory FL in the Primary school from Year 3 and at the same time allowed the schools to organize and implement pilot programmes, taking advantages of the numerous and diverse guidelines for innovation and room for autonomy that the law foresaw, such as the opportunity of employing native speaker teachers at all the school levels (LP 11/97, art.9) and the explicit reference to the possibility of introducing CLIL provision for some portion of the curriculum (LP 11/97, art.2). It is undeniable that strong elements and opportunities for innovation were

already present in the Provincial Law, but it is true that innovation and pilot programmes could really take off and be implemented only later on, after the law on school autonomy (DPGP n.11-12-13/1999, following the Italian law on school autonomy DPR 275/1999).

From 1999 to 2005 the slow but progressive introduction of CLIL initiatives has included also experiences of CLIL with minority languages (cimbro and mocheno) linked to specific local contexts and a bilingual (Italian and German) pilot programme in a public Primary school with a curriculum that integrates Austrian and Italian curricula and foresees teachers' exchanges between the schools in Trento and Innsbruck.

At the same time the Provincial Institute for Research, Professional Development and Innovation in Education (IPRASE) supported the innovation in FL teaching promoting research and professional development projects.

Firstly, from 2002 to 2005 IPRASE was the coordinator of LI.VE. (Lingue Veicolari), a research project in collaboration with the University of Trento, the University of Venice and the IRRE of Veneto and Friuli Venezia Giulia. The project aimed at identifying standard criteria for assuring a quality CLIL provision and some insights about CLIL practices and pedagogy in real classroom contexts (Ricci Garotti, 2006).

Secondly, IPRASE promoted ALIS (Apprendimento delle Lingue Straniere), a multi-year (2003-2007) project for teachers' professional development funded by the European Social Fund. ALIS was mainly addressed to FL teachers in order both to strengthen their language competence and to develop their pedagogical and methodological skills. It also foresaw some activities for non-foreign language teachers of all the levels of the school system, including the nursery school. The aim was to

develop their language competence as the first step towards the implementation of CLIL modules in their schools, in order to favor the progressive introduction of CLIL experiences managed by a teaching team, including the language and non-language teachers, and delivered by the subject teachers (Lucietto, 2006). All these activities were aimed at attaining language certifications based on the Common European Framework of Reference (CEFR) and internationally recognized. No evaluation of the outcomes of the project was undertaken. In between these two projects, IPRASE offered also some consultancy to a few schools involved in the introduction and implementation of CLIL provision (Lucietto, 2008).

More recently, since the school year 2005-2006, the PAT has implemented a project integrating the progressive diffusion of pilot educational programmes in which is foreseen the use of English or German as a means for teaching some parts of the curriculum. These pilot programmes have affected all of the schools, from nursery schools to secondary education, with an increasing involvement especially within Primary schools.

All these programmes have referred to CLIL as the recognised methodology of teaching and learning where the acquisition of the FL is not considered the end result, but an instrument for learning other subject contents. The FL is not just a curriculum subject but part of the weekly timetable is dedicated to the teaching of subjects or subject modules using the FL.

According to the figures released by the technical report[9] of the PAT Dipartimento della Conoscenza, with reference only to the public Primary schools and to the school year 2011-2012, out of 1438 Primary school classes, 865 belong to Istituti

[9] PAT, *Analisi quantitativa esperienze di insegnamento in modalità CLIL (Content and Language Integrated Learning) anno 2012,* a cura di M. Turri, Dipartimento della Conoscenza Servizio Istruzione Provincia, giugno 2012.

Comprensivi[10] (33) that foresee CLIL experiences. It means that 60% of the Istituti Comprensivi (IC) in Trentino provide a school curriculum at Primary level that encompasses CLIL. Among them, 10 ICs offer CLIL in English, 7 in German and 16 in English or in German. Because CLIL is not always offered in all the Primary schools of each IC, regarding to the number of classes, only 312 out of 865 may be defined as 'CLIL classes'. Of these, 196 classes offer CLIL experience in English, 140 in German, with a small number of ICs (4) having classes (35) with CLIL in English or in German. In terms of human resources, the PAT investment for CLIL amounts to 58 additional positions of teaching staff.

Compared to the figures of the previous school year[11], a little increase is observed in the number of ICs with CLIL experience (with two new entries) and also in the number of classes (837 in 2011-2012); it is worth noting that 4 ICs have moved from CLIL only in German to CLIL in German or in English.

The total amount results in 45250 hours delivered in CLIL with an average of 1371 hours per year per IC. The subjects that are mostly involved in CLIL are, in order, Art, Music and Physical Education, followed by Geography and Science.

In the last two years, one of the main objectives of the PAT policy regarding CLIL (Provincial resolution GP 1753/2010) has been the reduction of the differences between the ICs and also within the IC in CLIL provision. Compared to the previous year, a little increase in homogeneity can be perceived but this is mostly due to the

[10] In the Italian system, the Istituto Comprensivo (IC) is an educational institution, established at the end of the '90s, that consists of different schools at different levels. It can include Nursery schools (Scuola Materna, not compulsory, for children from 3 to 5 year old), Primary schools (Scuola Primaria, Year 1-5 for chidren from 6 to 11) and Middle schools (SSDPG, Scuola Secondaria di 1° grado, Year 1-3 for pupils from 11 to 13). In Trentino the ICs include only Primary and Middle schools.

[11] PAT, *Analisi quantitative esperienze di insegnamento in modalità CLIL*, a cura di M. Turri, PAT, giugno 2011.

implementation of CLIL, both in the number of classes and in the number of hours per class, promoted by the ICs with long standing CLIL experience. With reference mostly to these ICs, the picture of CLIL in Trentino shows traits of dynamism and a growing trend.

In conclusion, from a quantitative perspective, the degree of diffusion and the weight of CLIL in relation to the small size of the school system put the CLIL experience in Trentino in an interesting position certainly in the Italian and maybe also in the European context.

1.5 CLIL research

CLIL practices were introduced in schools thanks to the initiative of interested and motivated teachers, often on an individual base or in small groups, with an almost complete lack of presence, action and planning from the side of the national educational systems. The introduction of CLIL can be therefore defined as a grassroots process, parallel to and somehow even preceding the issue and the policy on multilingualism fostered by the European institutions. This is the main reason why the spread of CLIL has originated such a large amount of very diverse and different experiences and implementation models. About this, it can be rightly stated that "*CLIL practice has largely preceded research*" (CLIL Matrix report, 2005, 7).

In the first period, roughly the 1990s, CLIL implementation has been associated for some degrees to large and productive discussions focused mostly on the methodological aspects. The debate was carried on by the first driving force and CLIL experts at the European level, such as David Marsh, Peter Meehisto, Do Coyle, Dietger

Wollf and Gisella Langè that were also the proposers, coordinators and participants of European projects on CLIL. As mentioned before, methodology was the core of the discussion, considering that the methodological issue is the key element for achieving the full integration of language and content that is the essential trait of good quality CLIL. Given that "*changing the medium of instruction, for whatever reason, without adaptation of methods can easily lead to poor overall outcomes*" (CLIL Matrix report, 2005, 6), the attempt of strengthening the CLIL identity has clarified and pinned down the methodological essence of CLIL and highlighted the essential and necessary features that a specific CLIL methodology should encompass.

First of all, the adoption of a language-sensitive and at the same time a content-based approach that makes concrete the cross-curricular perspective. In particular, the Secondary school CLIL methodology needs to take into account the central role of reading and the promotion of reading skills and strategies.

Moreover, CLIL asks for a change of the educational philosophy, concerning especially a general rethink about class management and organization. In fact, CLIL activities are based more on interaction than on teacher's talk and favour pair and group work, usually inspired by the Cooperative Learning approach (Johnson & Johnson, 1994).

Once the methodological issue has been framed and with the progressive spread of CLIL in Europe, research on CLIL has developed basically in two directions: action research in CLIL classes and collection of good teaching practices.

Regarding the first category, most of the research consists of exploratory studies based on analysis of lesson excerpts, class interactions and observations, focusing mainly on language competence and attitude towards the FL of the students involved in CLIL programmes compared to students in monolingual classes (Jarvinen, 1999, 2005; Airey,

2004; Sylven, 2006; Stotz and Meuter, 2003; Lasagabaster, 2008; Lorenzo et al., 2009). The background and the reference point of these studies are represented by the above mentioned research about the Canadian French immersion programmes. These studies have demonstrated, first of all, that schooling in a FL does not cause any negative 'side effect', given that the development of the first language skills is not at all impaired and the achievement in the subject matters taught in a FL is positive. Secondly, they have attested extremely positive results in the students' attitude towards the FL and also in the receptive skills, in which the students attain a native-like competence. However, far less positive results have been found for the productive skills, especially speaking and also for grammar competence and vocabulary knowledge. The consideration of these weaknesses have led to state that exposure and authentic communication are not enough, pushing more recently some authors (Genesee, 1994; Lyster 1998, 2006; Ranta and Lyster, 2007) to highlight the need of inserting FL in the curriculum as a subject, with a systematic focus on language objectives, form, metalinguistic awareness and opportunities for production practice.

Regarding the second category, a series of studies have investigated students, parents and teachers perceptions on CLIL through qualitative research paradigm (Romu and Sjoberg-Heino, 1999; Sodergard, 2006; Coonan, 2008; Mehisto and Asser, 2007) and FL teaching in CLIL with the aim of identifying the indicators of an effective CLIL pedagogy (Admiraal et al., 2006; Serra, 2007; De Graaff et al., 2007), while other studies have produced a wide collection of good and effective teaching methodologies and class materials, such as teaching and class management strategies, lesson plans, class activities, cross-curricular projects (Coonan, 2002; Ricci Garotti, 2006).

Despite the growing literature and number of studies on the implementation and effect of CLIL, only few of them (Dalton Puffer, 2007, 2008; Ruiz de Zarobe, 2011) can be defined as outcome-oriented research as much as it can be asserted that "*solid empirical studies have been sparse. As Navés (2009) underscores, in the last two decades, whereas North America has been busy researching the features and effects of successful bilingual programs, Europe has merely been occupied in describing their benefits"* (Pérez-Canado, 2011, 329).

At this point it seems that is still very much up-to-date the remark that "*research on CLIL is, unfortunately, still in its infancy*" (Wolff, CLILMatrix report, 2005, 20) and that the development of more substantial evidence-based studies is considered the main challenge to be addressed (Meyer, 2010).

In this respect, one of the crucial urgencies is the need of empirical studies based on research designs that can be mixed, combining both quantitative and qualitative research methods, and that can favour a longitudinal perspective.

In addition to this, among the different fields of research interests, whereas the one concerning the acquisition of the linguistic competence in CLIL classrooms has been by far the most tackled, other areas have been less well researched. At the extreme, research both on the acquisition of subjects' competence and research focuses on subject-specific pedagogy are almost completely neglected. It might be that the main reason lies in the fact that most of the researchers are linguists, applied linguists or specialists in foreign language pedagogy.

However, it is clear that the most recent European perspectives on teaching and learning in CLIL (De Graaff, 2013) have drawn the need for a shift from language learning to subject learning that means a shift from the subjects intended as contexts for language

learning to the language as a vehicle for subjects learning. This assumption implies an explicit demand for a more careful focus on the subjects' conceptual development that should be considered a priority compared to language proficiency. Moreover, the need for an assessment concerning both language and content knowledge runs parallel to this perspective.

In conclusion, a subject class is also a language class as the language is always the means though which teaching and learning take place. Whereas CLIL explicitly takes the challenge of teaching subject contents in a language other than the mother tongue, its added value should not be delimited or related only to the FL language learning. In this respect, CLIL can be considered as an educational approach that emphasizes the role of the language, being either the L1 or a FL or a regional or minority language, and of the language learning throughout the all curriculum.

In this perspective the definition of CLIL as "*a dual-focused educational approach in which an additional language is used for the learning and teaching of content and language*" (Coyle, Hood and Marsh, 2010) can be rephrased by the following: "*CLIL is a dual-focused educational approach in which there is an additional focus on language for the learning and teaching of the content, which also support language learning*" (De Graaff, 2013).

Hence, if CLIL has been considered, probably in a too optimistic and triumphalist way, the most important innovation in foreign language teaching in the last decades, the latter definition allows the chance that in the near future CLIL might hopefully become an important innovation for subject teaching and learning.

Monitoring a CLIL Pilot Programme at Primary School in Italy: Context Analysis and Curriculum Study

Chapter 2

Canavesio, M. L., De Graaff, R. (in preparation), Monitoring a CLIL Pilot Programme at Primary School in Italy: Context Analysis and Curriculum Study.

2.1 The *Classi bilingui* Pilot Programme

The *Classi bilingui* programme is by all means inserted in the CLIL implementation policy of the Provincia Autonoma di Trento, even though the peculiarity of this programme presents features of absolute innovation and uniqueness at least at the national level.

The *Classi bilingui* programme started in the a.y. 2008-2009[12] with a pilot class of 23 pupils. In the a.y. 20012-13 five classes were involved, from Year 1 to Year 5, for a total number of 111 pupils. The programme was established in a urban Primary school that has been one of the first offering CLIL provision and that has always been represented as the flagship of PAT's policy on CLIL implementation. In fact, since the

[12] Availing of the provincial regulation GP 1418, 6/5/2008, sustained by art.72 of the 2008 financial law that for the very first time in Italy allows schools to appoint non-permanent teaching positions to native speakers.

a.y. 2005-06 all the classes of this school have been progressively involved into an educational programme, called *Inglese veicolare diffuso,* that encompasses 238 CLIL hours per class per year with subjects like Music, Art, Physical Education and Geography totally or partially taught in English.

The *Classi bilingui* programme distinguishes from the previous one in terms of intensity of tuition in English. Specifically, the programme encompasses 544 hours per year of tuition *in* English in Year 1 and 2 and 510 in Year 3, 4 and 5 with all the subjects, excluding Italian, History and Religion, entirely taught using English as vehicular language. Moreover, 102 hours per year *of* English language lessons need to be taken into account, reaching a total amount of 19 weekly hours *of* and *in* English in Year 1 and 2 and 18 hours per week in the other grades. The difference between the amount of hours between Year 1 and 2 and the other grades is explained by the introduction from Year 3 of 2 hours of German, as it is foreseen by the curriculum for Primary school in the PAT.

The key element of the programme is that it is organized to provide an educational semi-immersion programme set in a context that is practically monolingual and it is addressed to children who, in the grand majority of cases, are exclusively Italian, and for whom English is in all respects a foreign language.

As clearly stated in the official document of the *Classi Bilingui*[13], the programme "*aims to have pupils achieve:*

- *a grade-appropriate proficiency in speaking, reading and writing in Italian*
- *grade-appropriate levels of academic achievement in all subjects taught in English*

[13] Available at www.istitutotrento5.it

- *the ability to understand and use the English language in everyday contexts, for general communication, to learn across the subject areas and to express their own opinions and ideas; the ability to speak, read and write confidently in English*
- *a heightened communicative and linguistic sensibility*
- *an understanding and appreciation of the cultures linked with the languages*
- *age-appropriate cognitive and social skills.*" (*Classi bilingui*: A Pilot Programme in the Primary School, 2013, 23)

The teaching team for each pilot class includes the Italian Teacher, in charge of Italian and History, and the English teacher who teaches English, Geography, Science, Art, Music and Physical Education. The two teachers are both in charge of Mathematics, usually being both physically present in the classroom during the Mathematics classes that are delivered by the English Teacher. The team includes also the teacher of Religion and, from the Year 3 on, the teacher of German. In addition to the teaching hours and the different types of school meetings, the *Classi bilingui* teacher's schedule encompasses four hours per week (instead of the standard two) of class team lesson planning, two hours of which are dedicated to Mathematics.

2.2 Research Method

2.2.1 Rationale

The research reported in this paper focuses on monitoring the *Classi bilingui* programme. In this respect, no prior reference is available since no evaluation or

assessment have been carried out by the local education authorities during the programme at any level of its implementation.

The first research question focuses on the impact of the *Classi bilingui* programme on:

- teachers' perceptions, motivation, needs and working environment
- parents' involvement, expectations, perceptions and appreciation.

In their study about CLIL programme management in Estonia, Mehisto and Asser (2007) stressed the importance of including and taking into account the stakeholders' (e.g., teachers, head teachers, parents) perspectives in assessing CLIL programmes' implementation and management. Given that the stakeholders' involvement is an essential element in any educational experience, and even more in the case of a pilot innovative programme, the first part of this research aims at drawing a context analysis by surveying and identifying the stakeholders' motivation, perceptions, needs, feelings and feedback. These aspects are very relevant in pointing out the factors that have been fundamental at the initial stage of the programme and in providing additional insights for the effective and successful development of the programme in the future.

The second research question focuses on the impact of the programme on the curriculum, and particularly if and how the fact of having a FL as the medium of instruction for more than 50% of the school time has been conceptualized and experienced in the implementation of the curriculum. In planning the study, the two Van den Akker (2003)'s frameworks of curriculum development and evaluation have been taken into account.

The first framework is articulated in five different levels of curriculum development. The first one, the supra level, refers to the international level, whereas the

second, the macro level, refers to the national educational system. Then, the meso level is the one considering single schools and institutions, followed by the micro level that refers to teachers and classrooms. The last one, the nano level, refers to the pupils. This study focuses on the meso, the micro and, partially, on the nano level.

The second framework for curriculum evaluation describes the different levels in which a curriculum can be represented. The representation of the *intended curriculum* refers to the original vision, the general pedagogical perspective, the rationale and the underlying intentions that can be found in the curriculum documents. The second representation is the *implemented curriculum* that can be split into the *perceived curriculum* as it is interpreted by the teachers in terms of what the curriculum implies and into the *operational curriculum* that refers to the instructional process, namely the daily practise of teaching and assessment. The last curriculum representation, the *attained curriculum* refers to the learning achievement and the outcomes of the students.

The second framework in particular provides a practical and effective comprehensive framework for identifying and investigating the different curriculum components and elements and in providing a guideline for their specific and detailed description. Moreover, it helps in paying attention to the specific intentions expressed at the intended curriculum level and on how they are then translated at the operational level by the teachers.

The main goal of this study is a rich description of the educational context of the *Classi bilingui* programme in order to:

- overcome subjective and individual impressions
- get a detailed overview on this specific school context, programme, organizational structure and environment

- explore how and to what extent the curriculum has been implemented
- identify the key elements concerning the context, the process, the organization and the product
- highlight the strengths and the weaknesses

so as to pin down (1) the factors that have mostly contributed to the success of the programme, (2) the necessary conditions required for its sustainability and finally (3) the measures and the actions that need to be embraced in the next future for developing, improving and enhancing the programme.

2.2.2 Method and Sample

The following table lists the instruments used to collect the data:

Context Analysis	▪ teachers' questionnaire (April 2013) ▪ parents' questionnaire (March 2013) ▪ observation and field notes of the *Classi bilingui* teachers' group meetings (18 hours in 2011 and 2012) ▪ semi-structured interviews with the Head Teacher and the coordinator of the programme (2012-2013) ▪ examination of the *Classi bilingui* teachers' group reports (end of the a.y. 2010-2011, 2011-12, 2012-2013)	
	Intended curriculum	▪ examination of the *Classi bilingui*'s official document "*Classi bilingui": A Pilot Programme in the Primary School*, chapter 3. *The Policy* ▪ examination of the *Classi bilingui*'s Plans of Study (PSI)

Curriculum Study		▪ observation of all the *Classi bilingui* teachers' meetings especially dedicated to the writing of *Classi bilingui*'s PSI (16 hours in the a.y. 2010-2011, 19 hours in 2011-12, 6 hours in 2012-13)
	Implemented curriculum	▪ examination of the official document "*Classi bilingui": A Pilot Programme in the Primary School*, chapter 4. *The Methodology* ▪ examination of school documents: annual class planning, two-month class planning (a.y. 2010-2011, 2011-2012, 2012-2013) ▪ English teachers' methodological questionnaire delivered in March 2013 ▪ semi-structured interviews with four teachers (June 2013)
	Attained curriculum	▪ examination of school documents: end of the year class evaluation reports (a.y. 2011-2012, 2012-2013) ▪ outcomes of the standardized tests (Italian and Maths) administered to the *Classi bilingui* pupils (Spring 2013)

The teachers' questionnaire was set up also taking into account the recurrent themes and issues arisen during the *Classi bilingui* teachers' group meetings. It aimed at surveying the motivation and the feelings about the teaching experience in the *Classi*

bilingui, the quality of the training and of the relationship with the parents, the teachers' perceptions about the problematic, critical and successful features of the programme.

The parents' questionnaire aimed at surveying the parental reasons for enrolling the children in the programme, the degree of appreciation of different aspects of the programme, such as the quality of the education and of the relationship with the teachers, the children competence achievements in the different subjects and in the English language, the need of extra information. Additionally, the first part of the questionnaire was specifically designed in order to get information about the family linguistic context and the pupils' extra-school exposure to the English language. A month before the delivery, the questionnaire was examined by the parents' class representatives (2 per class for a total of 10 people) during a scheduled school-class representatives meeting. The pre-test focused on checking the clarity of the items and the easiness of comprehension from the parents' point of view. Moreover, in that meeting the importance of having the questionnaire filled in by the great majority of the parents was highlighted, also with the support of the head teacher.

Regarding the attained curriculum, with reference to the use of standardized tests for assessing the pupils' competence achievements in Italian and Mathematics, it is important to mention that, as far as we know, these are the only ones available in Italy and none is provided for testing the level of competence in a foreign language.

Moreover, concerning the attained curriculum, unfortunately there was no time for eliciting and collecting the pupils' "voice" in an organized and structured way. At the same time, and for the same reason, there was no chance of setting up an observation protocol encompassing the adoption of common observation tools and systematic observation sessions per each class.

The sample consists of the following people:

- the *Classi bilingui* teachers (6 in the a.y. 2010-2011, 8 in 2011-12, 10 in 2012-13)
- the Head teacher of the school and the coordinator of the *Classi bilingui* programme
- the parents of all the *Classi bilingui* students in the a.y. 2012-2013
- the *Classi bilingui* pupils in the a.y. 2012-2013.

2.2.3 Data Analysis

The observations carried out during the teachers' group meetings were reported in field notes that were coded and tabulated through qualitative content analysis. The aim was to identify the type and the frequency of themes and issues that were faced and discussed during the meetings. Insights and interesting remarks were also taken into account, even when expressed by a single teacher.

The interviews were recorded and analysed in the same way.

The school documents were examined to the extent to which they seemed to have implemented and developed the curriculum at every level.

Data from the questionnaires and from the tests were collected and graphs were created based on frequency tables. Unfortunately, no comparisons with the other classes of the school were made due to the lack of availability in administering the questionnaires and the pupils' tests in the classes following the regular CLIL programme.

2.3 Context Analysis

2.3.1 Parental Perspective

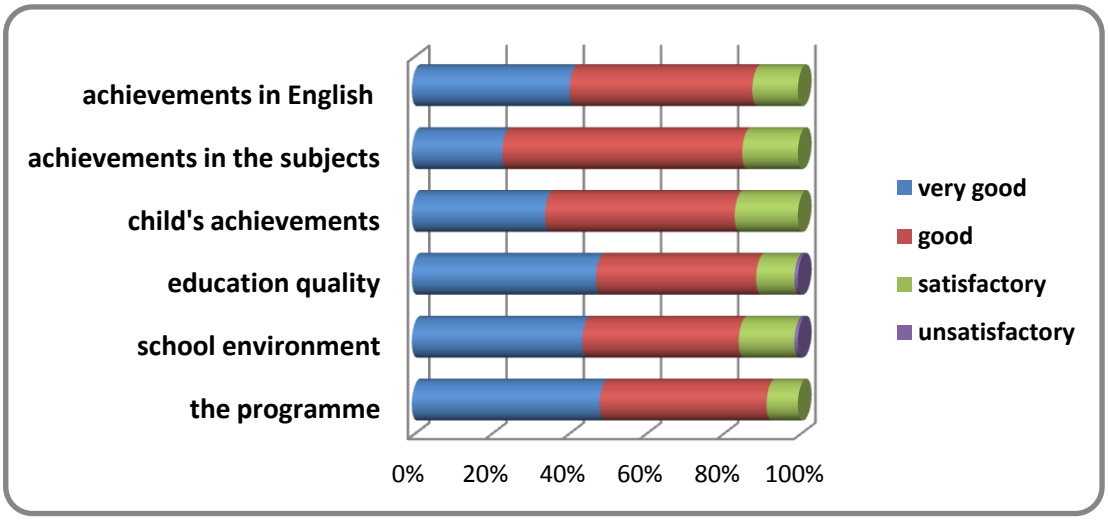
All families returned the questionnaire (return rate 100%).

The 19 items were grouped in five themes: motivation, degree of appreciation, relationship with the teachers, need of information about the programme, pupils' use of the English language.

The data about the parents' motivation for enrolling the children in the *Classi bilingui* confirmed the perception of an innovative and challenging programme and also a high degree of expectation towards the achievement of competences in English.

The degree of appreciation proved to be very high as shown in Figure 1.

Figure 1. Parents' appreciation rating



The quality of the relationship with the teachers was reported as being very good (75%), good (21%) and satisfactory (4%). The 75% of the parents who wished to have more information were mostly interested in the programme development in the following years and on how the parents can support.

2.3.2 The Linguistic Context

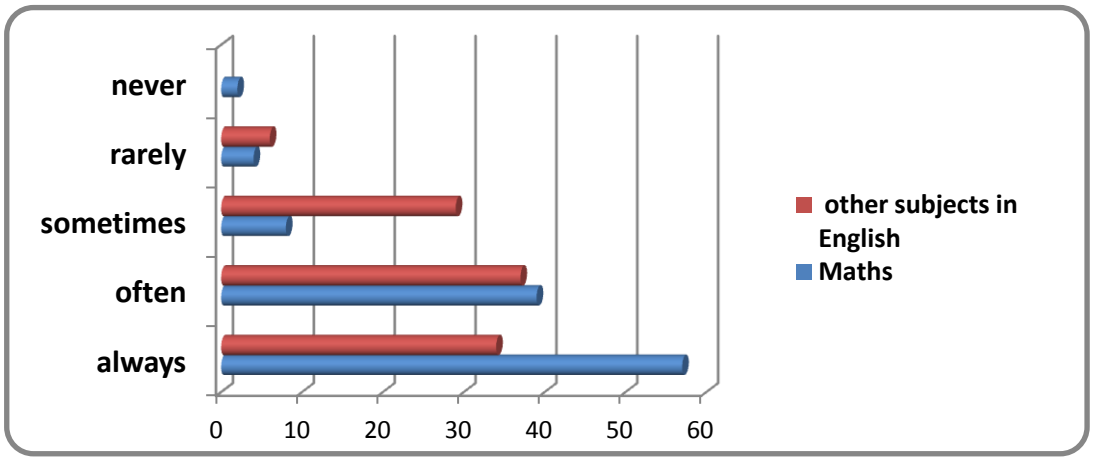
As mentioned before, part of the parents' questionnaire was specifically designed to get information about the family linguistic context and the pupils' extra-school exposure to

the English language. The data concerning the family environment led to the following figures: in the 65% of the *Classi bilingui* families Italian is the only spoken language, whereas 35% of the pupils are, at different degrees, exposed to a language other than Italian. A more detailed analysis of the frequency indicates a everyday exposure in 24% of these cases (9% to German, 5% to English, and the other 10% distributed within Russian, Polish, Romanian, Spanish, Portuguese, Swedish and Hindi). The data confirmed the presence of a very limited number of English bilingual children and the fact that the pilot programme involved children that in the grand majority of the cases were exclusively Italian.

Parents reported that the frequency of the extra-school exposure to the English language was sporadic for the 35% of the pupils, it could be defined as weekly contact for the 31% and daily contact for the 23%. The different typologies of the extra-school contact showed the relevance of the TV (79%) and of Internet/computer (71%); the percentage for contact with native speakers (73%) should have been downsized taking into account the fact that in the great majority of cases the degree of frequency was reported as sporadic.

The information given by parents about the pupils' use of English outside the school revealed interesting figures about the spontaneous use (42% daily, 31% weekly, 4% monthly frequency and 17% rarely) and about the use of English in activities related to school (e.g. homework) that showed a more frequent use in Maths activities than in the other subjects taught in English as shown in Figure 2.

Figure 2. Pupils' use of English at home in school-related activities



2.3.3 Teachers' Perspective

Questionnaire

All the 10 teachers of the *Classi bilingui* returned the teachers' questionnaire (return rate 100%).

The 56 items were grouped in 7 themes: perceptions, motivation, in-service training and support, relationship with the parents, problematic aspects at the beginning of the teaching experience in the *Classi bilingui*, success factors and critical aspects.

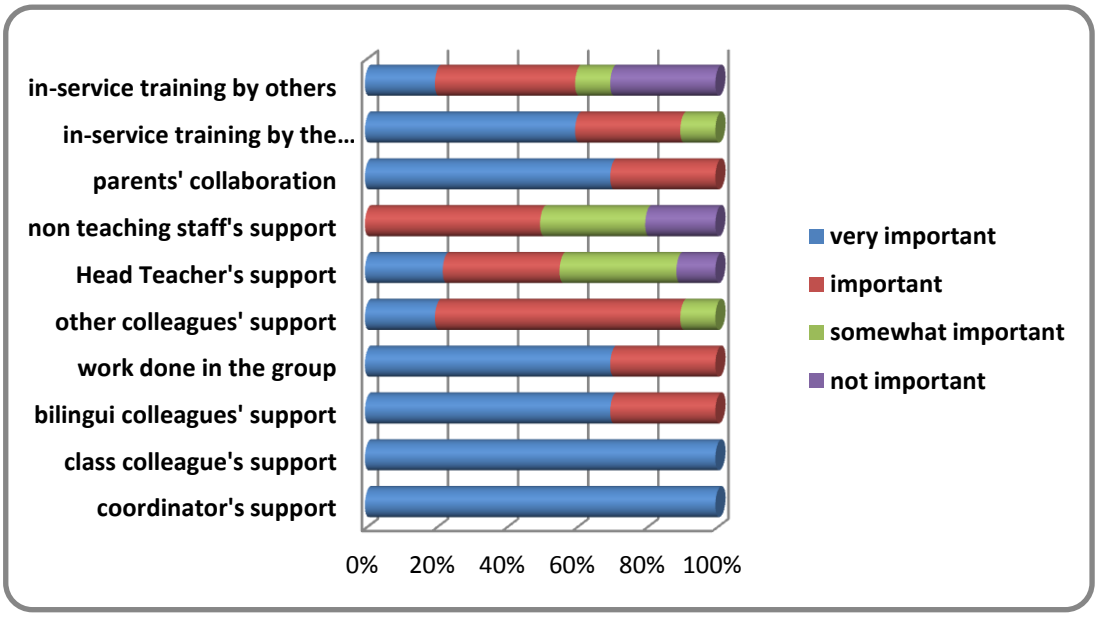
Teaching in the *Classi bilingui* was reported being rewarding (80% strongly agree, 20% agree), challenging (70% strongly agree, 30% agree) and also demanding (30% strongly agree, 30% agree, 30% partially agree, 10% disagree).

Among the different types of motivation the strongest were the ones related to the relationship with the pupils and to the pupils' achievements (both rated 90% very motivating and 10% motivating), followed by the fact of being part of the *Classi bilingui* teachers' group and by the opportunity of getting new cultural stimulus. The aspect perceived not motivating was the economical recognition.

The initial and in-service training were mainly rated very good and good, as well as the support received from the *Classi bilingui* colleagues (80% very good, 10% good, 10% satisfactory) and from the other colleagues (70% very good, 10% good, 20% satisfactory), the quality of the relationship with the parents was rated very good (60%), good (30%) and satisfactory (10%).

For the success of the programme the class colleagues' collaboration and the coordinator's support were rated very important by the unanimity of the teachers, shortly followed by the *Classi bilingui* colleagues' support, the work done by the teachers' group and the parental collaboration as shown in Figure 3.

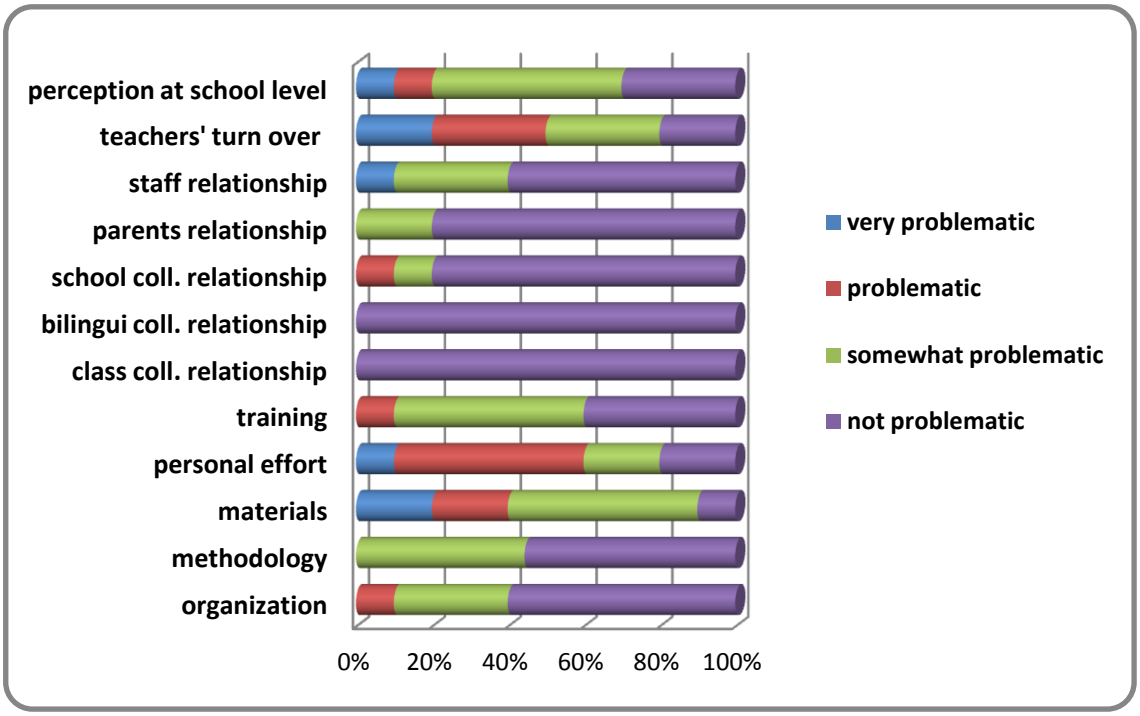
Figure 3. Teachers' rating about the programme's successful factors



As shown in Figure 4, among the aspects perceived as problematic, the lack of materials was the most critical point, especially for the English teachers (40% very problematic, 20% problematic, 40% somewhat problematic, 20% not problematic), followed by the teachers' turn over, the perception of the pilot programme at the school level and the working load in terms of extra hours and personal effort. On the other hand, the

relationship with the class colleague and with the *Classi bilingui* colleagues were perceived as not problematic at all (both 100% not problematic).

Figure 4. Teachers' rating about problematic aspects



The Classi bilingui Teachers' Group Observations

Regarding the themes and issues discussed in the teachers' meetings as they emerged from the content analysis, it is worth noticing that the methodological issues were by far the most recurrent ones, ranging from presentation of teaching strategies and techniques (e.g., use of visual aids, gestures and children kinaesthetic involvement) to the discussion and shared experiences about didactic paths of learning reinforcement and consolidation. The issues related to the parents were the second most recurrent ones, well ahead the themes related to the organization, to the identity and the duties of the teachers' group and to the implementation of the curriculum. About the latter, it is important to take into account that a relevant amount of extra-meetings was dedicated

explicitly to the reflection and writing about the Plans of Study (see the next section about the *Curriculum Study*). Worries and concerns about the level of competence achieved by the pupils, mainly in Mathematics, were also recurrent, expressed mostly by the Italian teachers, together with the remark on the difficulty in the procedures for assessing and on the lack of comparison with other "regular" classes. In addition, examples of the most discussed matters were the need of a precise and written school policy about the relationship between parents and teachers, together with the role of the teachers' group in this respect, suggestions and advices for the parents' support of the pupils' learning process and personal growth, the need for calling and organising assemblies seen as informative and formative opportunities for parents.

2.3.4 Context Analysis Conclusions

The high degree of motivation, collaboration and undertaking of responsibility both from the teachers' and parents' sides emerge as the distinctive features of the *Classi bilingui* programme that is perceived overall as a positive and rewarding experience, highly satisfactory. In particular, the context relational environment is extremely positive, characterized by very good relationships among the teachers, between teachers and parents and vice versa.

In addition, in three years' time, the teachers group has gradually become the "engine" of the programme, the place for supporting and mutual helping, for exchanging and sharing experiences, ideas and materials, for listening and reflecting, for monitoring, self-evaluation and training. The teachers' group, under the effective and valuable management of the coordinator, has been able to build and foster an identity as a group in which each component has started to assume different roles based on his/her diverse

competences and expertise. This effective "team play" has triggered a "virtuous circle" between the teachers' group and each class team.

The main drawback of this organization is the relevant number of extra hours for planning and tutoring that reduce the time needed for regular class planning and the setting up of materials; this situation leads the teachers to a lot of extra personal effort and "after school" time. Moreover, the time for common planning and exchanging with the non *Classi bilingui* colleagues is very limited, especially for the English teachers.

2.4 Curriculum Study

2.4.1 Intended Curriculum

The general pedagogical perspective emerges both informally in the teachers' group meetings and formally in the official document of the *Classi bilingui* in which the fundamental pillars of the pedagogical framework and the teaching and learning policy are explicitly declared.

As clearly highlighted in the official document, the general pedagogical framework has its theoretical cornerstones in (1) the Cognitivist learning theory[14] and in its core concept of the sequential development of the cognitive abilities, (2) the Sociocultural[15] perspective of the learning as a process that occurs in social contexts and takes place through social interactions in which the language plays a key role and finally (3) the idea of instructional scaffolding[16]. Consequently, the fundamental pillars of the *Classi bilingui* teaching and learning policy are identified in the class as a pupil-

[14] Bruner (1966, 1990), Piaget (1959), Vygotsky (1934, 1978)
[15] Brown, Collins and Duguid (1989), Lantolf (1994)
[16] Balaban (1995)

centered environment in which the teachers act as facilitators in promoting active learning and building knowledge starting from pupils' experiences, abilities and attitudes. This promotion can be achieved mainly through the creation of a rich and challenging environment with a wide range of different activities, according to the pupils' different learning styles and that encourages learners to interact, discover, adopt problem-based and inquiry methods and also through the systematic use of cooperative, group and peer work.

Additionally, given the specific linguistic feature of the programme, the main principle of the bilingual education, namely the linguistic interdependence[17], represents another essential point of reference. According to this principle, "*the experience of different languages can and must be oriented at the promotion of the development of not only greater linguistic competence, but also and above all of cross-cognitive skills and common competences across the languages*" (*Classi bilingui*: A Pilot Programme in the Primary School, p.17). In this perspective, the main goal is the additive language learning[18] in which the foreign language is learned in addition to the mother tongue and at no cost to its competence which continues to be developed and considered of a primary importance.

The Plans of Study are the formal, written curriculum and represent an essential part of the *intended curriculum*. Currently, the Plans are the result of a relevant amount of group work and writing (16 hours for the Mathematics Plan of Study in the a.y. 2010-2011, 19 hours for the Plans of Study of the other subjects in the a.y. 2011-12, 6 hours for the revision of the Science Plan of Study in the a.y. 2012-13).

[17] Cummins (1979).
[18] Swain (1983)

The *Classi bilingui* Plans of Study (PSI) are based upon the guidelines and the list of competences for each subject provided by the Provincial Plans of Study (PSP) which in turn are based upon the Italian National Curriculum for the Primary school. Starting from the competences listed in the PSP, the identification of the skills and knowledge for each subject represents the outcome of teachers' discussion and shared reflection on the methodological choices and on the educational curriculum implemented in the first years of the programme. The urge of a general review of the objectives for all the subjects has led to the necessity of identifying the fundamental skills and knowledge for each of them. Regarding the skills, their sequential nature and the graduation in their development are the principles that have been taken into account together with the transferability that can be achieved through a cross-curricular approach and the construction of a spiral curriculum. Moreover, the document clearly states that the rich list of contents for each subject needs a flexible implementation that allows selection, anticipation and delay in the arc of the years in order to answer to the specific needs of different groups of pupils. Consequently, the entire Plans of Study need to be considered as a work in progress, "open" to future integrations and revisions based upon the design, monitoring and adjustment of the curriculum development and implementation in the years to come.

2.4.2 Implemented Curriculum

The implementation of the curriculum and the daily practise of teaching have been repeatedly discussed in the teachers' group meetings and during the writing of the Plans of Study, being the "how", namely the methodology, essentially linked to the "what", namely the Plans of Study. From a formal point of view, Chapter 4 of the official *Classi*

bilingui document is the main reference point for the implications of the curriculum as they are perceived by the teachers. In this part of the document, the general methodological framework is defined as a language-sensitive approach that highlights the deep relationship between language and content. Consequently, an integrated cross-subjects and cross-contents pedagogy is proposed and considered effective in any of the languages used as medium of instruction. Among the key elements of this pedagogy there are "*the use of a similar methodological framework and strategies, the definition of parallel and complementary objectives, the emphasis on the development of oral skills through participation in meaningful discussions, the stress on reading comprehension through the use of strategic and purposeful reading strategies, the adoption of the same grammatical framework, the use of etymology to illustrate the common roots in both Italian and English words*" (*Classi bilingui*: A Pilot Programme in the Primary School, p.20). These elements have been taken into account in the lesson plans that, both for the subjects taught in Italian and in English, foresee, for example, the extensive use of visual aids, outlines, visual organizers (e.g., mental map, spider-gram, table, etc.), activities for developing and recycling vocabulary, pre/while/post listening and reading activities for both Italian and English texts, the allocation of adequate room for pupils' language production (e.g., planned talk).

In addition, the connection between language and content has produced an operative "translation" in the class planning. In fact, in the two-month planning, the teachers indicate the cross-curricular links between the proposed activities and the different contents/subjects through which they are developed. Furthermore, since the a.y. 2011-12 in the class planning format a column entitled "Language: keywords and key phrases" has been added. This column includes the language objectives, namely the

content-specific lexis and the language structures derived from the content and linked to the selected knowledge and skills.

The document presents also the methodological introductions for Italian, English, Maths and Science in which the specific methodological framework, the strategies and techniques to be adopted, the primary learning objectives are expressed. Specifically for the Italian and English literacy, some very clear guidelines are stated as the result of precise teachers' methodological choices that are to be known by the parents and based on which parents' collaboration is required. Particularly, regarding the Italian literacy, the methodological session stresses the importance of the development of the L1 (in this case Italian) for the psychological and cognitive well-being of the pupil and also for the acquisition of language competences in the FL. Consequently, a strong foundation in Italian reading and writing is the main learning objective in the first two years of the Primary school. Hence, precise guidelines about the literacy method, the introduction and use of the different cases, typologies of activities and assessment are reported.

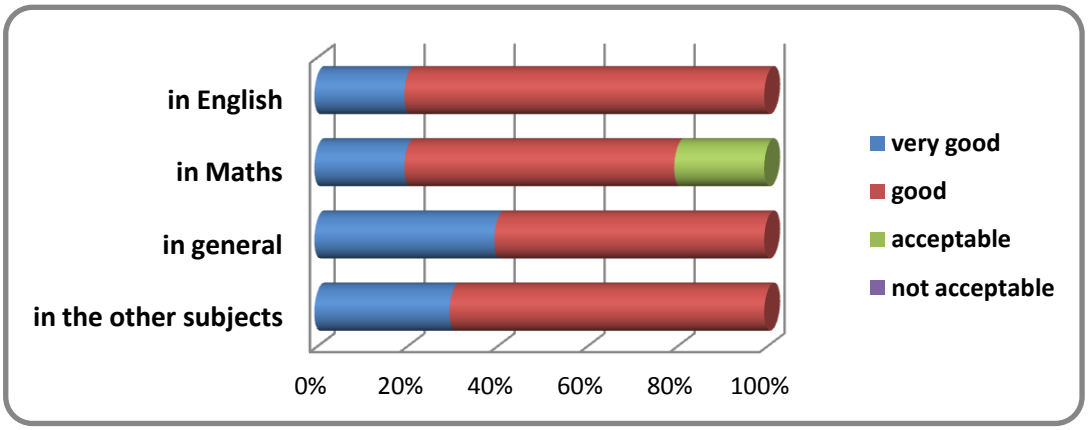
Concerning English, given the fact that the great majority of the pupils enter the Primary school with no competence in English at all, it is underlined that the focus of the first two years is on building the children's comprehension and therefore the pupils are not pressured to speak English. Whereas teachers use purposeful, intentional and planned actions in order to promote the language competence with and along the content objectives, the specific language methodology pays careful attention to the teacher discourse, communication and interaction in class as well as to the creation of a supportive and encouraging environment where the children feel comfortable to express themselves either in English or in Italian. Even though speech production is not in focus, nevertheless the children are encouraged to use English for everyday requests

using key language in school situations and limited subject-related keywords and phrases. From Year 3 on, pupils are expected to communicate with the English Teacher only in English, to express ideas, opinions and to explain their reasoning using the English language. At the first stage, along with the teachers' use of different resources and methodological procedures in order to make the learning accessible and the input comprehensible, the children are not required to try to read any English, even though they are exposed to the written English language in the school context (e.g. instructions on worksheets, poster, etc.). Only in the second half of Year 2, English literacy skills are formally introduced using the 'Read Write Phonics Inc.' method, slightly adapted in order to fit the needs of non-native learners of English.

2.4.3 Attained Curriculum

The pupils' levels of competence and outcomes have been firstly considered looking at the teachers' evaluations and analyzing their answers to specific prompts in the questionnaire. The levels of competence achieved in the different subjects and by the classes overall have been reported by the teachers as good and very good as shown in Figure 5.

Figure 5. Teachers' evaluation of the pupils' level of achieved competence



The teachers' assessment is consistent with the analyses of the end of the year class evaluation reports and marks. According to these, the number of pupils in the low level is limited; teachers reported also, especially in some classes, a high degree of diversification and variability due to coexistence of very different levels of competence in the same class.

In addition to the class testing and assessment procedures, in the last a.y. the *Classi bilingui* teachers agreed upon the administering to all the classes of standardized tests for the evaluation of the Italian reading comprehension competence (Cornoldi, Colpo, 2011), of the orthography accuracy (Bozzo et al., 2000) and for of numeracy and problem solving competences (Cornoldi, Lucangeli, Bellina, 2012). According to the teachers' point of view, these tests are to be considered tools among the others usually employed for assessing with the strength of allowing the comparison with the score of a "standard" Italian pupil. The tests employ a evaluation scale based on three different levels (level 1= competence non achieved; level 2= competence achieved and level 3= competence totally achieved).

The analysis of the aggregate score of the total number of the *Classi bilingui* pupils showed that in the reading comprehension test 57% of the students achieved level 2, 37% level 3 and 6% did not achieve the competence. In the orthography test, 35% of the pupils achieved level 2, 59% level 3 and 6% did not achieve the competence. In the numeracy test, 51% of the children achieved level 2, 42% level 3 and 7% did not achieve the competence. The problem solving test is foreseen only in Year 3, 4 and 5. The scores are distributed in the following figures: 42% of the students achieved level 2, 28% level 3 and for 30% the level was 1.

The data analysis indicates a positive picture that reveals no critical situations and an average degree of variability in the score distribution. The gradual overall improvement of the pupils' performance from Year 1 to Year 5 (e.g., in the numeracy test Year 1: 10% level 1, 51% level 2, 39% level 3 vs. Year 5: 36.5% level 2 and 63.5% level 3) is a positive finding as well as the fact that especially in Year 4 and 5 the scores are mainly concentrated in the medium and upper-medium level with a relevant number of pupils also at the top level (e.g., in the orthography test Year 4: 38% level 2, 62% level 3; Year 5: 23% level 2 and 77% level 3). In general, data do not show any delays or drawbacks both in Italian and in Mathematics. In conclusion, it seems reasonable to state that the use of English for more than 50% of the school time and as the language of instruction for Maths does not hamper the *Classi bilingui* performances and it does not have negative effects on the learning outcomes in Italian and Mathematics. Concerning specifically the Maths testing, the results are extremely positive in terms of numeracy (written calculations, numerical knowledge, accuracy and speed in mental arithmetic). On the other hand, the problem solving scores showed a non residual percentage of students at level 1 and also a less percentage at level 3 compared to the score in the numeracy test. This issue will be a topic of discussion during the teachers' group meetings in the following a.y.

2.4.4 Curriculum Study Conclusions

The elaboration and implementation of the *Classi bilingui* Plans of Study have been the trigger for the setting-up and development of a shared educational project. This common course has played also a substantial role in fostering the group identity.

The lack of reference points has led to the necessity of capitalizing the teachers' expertise, especially of the long-experienced ones, and the insights and impulses coming from diverse cultural perspectives and experiences, sometimes very different from each other. The absence of reference points and above all the lack of curriculum developers' support have been at the same time the weakness and the strength of this programme. Concerning the latter, the reflected and shared adoption of common procedures for setting-up, planning and evaluating together with common instructional practices could be considered effective and deeply context-rooted ways of answering to the specific educational needs and requests that the programme implies. Moreover, this situation has also led the group of teachers to assume a permanent attitude towards a systematic monitoring and redefinition of the proposed didactic segments. On the other hand, the weakness of this approach is the teachers' permanent state of uncertainty about a work that, be it at individual or group level, has its distinctive feature in being always a work in progress, sometimes without a precise idea about the degree of competences that could or should be achieved by the pupils and uncovering onwards the implications and the complexity of this programme.

2.5 Final Conclusions

The study examined 1) the impact of a bilingual pilot programme in the Primary school on stakeholders' perceptions, namely teachers' and parents' motivation, needs, feelings and feedback and 2) the impact of this programme on the curriculum at the intended level (e.g., general pedagogical perspective, school policy, plans of study), at the implemented level (e.g., methodology, lesson plans and the daily practice of

teaching) and at the attained level (e.g., pupils' level of competence and learning outcomes).

Firstly, a context analysis based upon teachers' and parents' questionnaires, teachers' interviews and regular observations of the teachers' group meetings revealed an extremely positive relational environment characterized by very good relationships between teachers and families. The latter expressed a high degree of appreciation towards the programme, the quality assured and towards the educational experience overall. A high degree of motivation, collaboration and undertaking of responsibility emerged as distinctive features of the *Classi bilingui* context. The teachers' perceptions on the programme revealed a great degree of motivation and satisfaction but also the awareness of the challenges and the high amount of extra personal effort and time the programme implies. The importance of the colleagues' collaboration, of the coordinator's support and of the teachers' group meetings emerged as the factors that mostly contributed in supporting the teachers, both in growing and fostering their professional expertise and in building their identity as a group that was totally in charge and responsible for the programme implementation and development.

Secondly, the descriptive analysis of the diverse elements and components of the curriculum at the different levels of representation highlighted the fact that, in general, the implementation of the curriculum has triggered the setting up and the development of a shared educational project that has played also a relevant role in fostering the identity of the teachers' as a group of professionals. The specific linguistic feature of the programme foresees a great amount of exposure to the FL and most of the subjects taught from Year 1 entirely using English as the medium of instruction. Hence, a CLIL programme with such a degree of intensity has required a careful consideration and a

systematic and continuous reflection on the challenges the programme implies, both at the content and at methodological level. At the intended curriculum level, the pedagogical framework has incorporated the main issues and principles of the bilingual education, namely the linguistic interdependence and the concept of additive bilingual learning. The latter has led to extensive discussions about the need of defining precise guidelines for the role of the two languages and the level of linguistic competence that the pupils are expected to achieve. Staying at the intended curriculum level, the Plans of study reflected the urge of identifying the list of skills and knowledge for each subject, taking firstly into account the guidelines and the competences provided by the Provincial Plans of study. On the other hand, the relevant amount of group work needed for the writing of the *Classi bilingui* curriculum became the trigger for an extensive reflection on the educational curriculum implemented in the very first years of the programme, on the methodological choices and on the how and to what extent the methodological aspects needed to be improved, developed, shared and framed. The writing of the Plans automatically led to the necessity of a deeper methodological reflection on the core-issue of the relationship between language and content and on the "how" the content can be effectively delivered in any of the language used as medium of instruction. In this respect, deeply rooted in a language-sensitive approach, an integrated cross-subject and cross-content language pedagogy is proposed. Its key principles are explicitly mentioned and taken into account at the curriculum implementation level, both in the methodological introductions to the subjects and in the lesson plans of each class.

Finally, at the attained curriculum level, the decision of administering standardized tests in Italian and Mathematics is to be seen as a first, partial attempt of

answering to the question about the level of competence achieved by the *Classi bilingui* pupils and especially to the need of a better understanding concerning the effect on the pupils' performance of the massive use of English and the parallel reduction of the use of the mother tongue.

In conclusion, the factors that have mainly contributed to the success of the *Classi bilingui* programme can be identified as the following:

– teachers' and parents' high degree of motivation and collaboration

– a positive and productive environment characterized by very good relationships between teachers and parents and teachers among them

– the *Classi bilingui* group as the "engine" of the pilot programme that has gradually become the structured and organized space for mutual support, for exchanging and sharing experiences, instructional practises, ideas, materials, for listening and reflecting, for coping with problems and trying to answer to doubts and uncertainties, for monitoring, self-evaluation and training

– the expert and effective management of the group's coordinator

– the successful group "team play" that has triggered a "virtuous circle" between the teachers' group and each class team

– the common construction of an educational course as innovative as rooted in the local context; the programme has been gradually developed, be it at the content and the methodological level, through discussions, diffuse reflection, adoption of common instructional practises and procedures for setting-up, planning, assessment and self-evaluation.

Among the necessary conditions for the sustainability of the programme the following are to be considered of primary interest:

– the recognition of flexibility as the distinctive feature of the programme at any level

– an adequate amount, or at least not less than the current one, of recognized extra hours as a necessary condition for assuring and maintaining a group *ethos* based on mutual support, collaboration, professional growth and sharing

– classroom technological equipments that work properly

In addition, the feedback and suggestions provided by the teachers' group in the mid-term and end of the year assessment activities suggested the following measures and actions to be undertaken in order to improve and consolidate the programme. These recommendations refer mainly to the refinement and development of monitoring and self-evaluation practices.

Context analysis:

– "give voice" to the pupils through the organized and structured planning of time and spaces explicitly dedicated to the elicitation and collection of their perspectives, expectations, experiences about the school and the programme

Intended curriculum:

– continue the review of the Plans of Study

– integrate the *Classi bilingui*'s official document adding a specific chapter about evaluation, assessment procedures and tools

Implemented curriculum:

– complete the methodological chapter of the *Classi bilingui* official document, adding specific methodological introductions for the missing subjects (Geography, History, Art, Music and Physical Education)

– propose a professional development course and self-training meetings about the pedagogical and methodological competences that teachers need in order to cope with the heterogeneity of the classes and to set up and plan different learning paths

– the adoption of a common observation protocol that foresees planned and systematic observation sessions per each class conducted by an external observer (given the fact that observation is a very time and resource-consuming activity, the observer is likely to be a colleague) with a previous agreement on the observation focus and the adoption of *ad hoc* tools for the registration and the collection of the data (e.g. observation grids, etc.)

Attained curriculum:

– continue the monitoring of the learning outcomes, adding the systematic and common-planned assessment of the linguistic competence in English.

2.6 Discussion

In this study we have presented a context analysis and a Curriculum Study that refer specifically to an intensive CLIL pilot programme in an Italian primary school. The collection and the analysis of the stakeholders' perceptions in terms of motivation, appreciation, feelings, needs and feedback were particularly useful in identifying the specific features of the *Classi bilingui* context. Moreover, they contributed in shading a light on the main factors that have been fundamental in the first years of the programme implementation and finally in providing additional insights for the further development and improvement of the programme in the next future. The adoption of the Van den Akker's framework provided a practical lineout for considering, analysing and describing the diverse elements of the curriculum. Moreover, the second framework

resulted in being particularly effective firstly in driven the attention to the general pedagogical approach and the intentions expressed at the intended curriculum level and secondly in following their translations in concrete teachers' decisions, methodological choices and lesson planning at the operational curriculum level.

Despite the small scale of the research, the effort to integrate qualitative and quantitative approaches in identifying the key elements concerning the linguistic and scholastic context, the process and the product has uncovered some of the major issues and questions that are likely to emerge in any CLIL implementation programme.

The research has highlighted how the teachers' extensive and collective reflection on what the programme implies, both at the content and at the methodological level, has led to the gradual construction and development of an innovative, shared and at the same time deeply context-rooted educational course.

The careful consideration of the complex nature of establishing a bilingual programme has prioritized the need of adding to the school general pedagogical perspective a conceptual methodological framework for the integration of languages and content. The integration is based upon the adoption of a comprehensive, integrated, cross-subjects, cross-contents and language-sensitive approach as well as some clear teaching and practical guidance as results of precise teachers' methodological choices. The use of common instructional practices, procedures and templates for setting-up, planning, material development, assessment and self-evaluation could be considered as tools through which the school ensures quality teaching and learning and a successful CLIL implementation.

On the other hand, regarding the attained curriculum, the study highlighted the need of further in-depth research and analysis. Firstly, the necessity of a systematic

assessment of the pupils' performance in English. The availability of a standardized proficiency test for Primary school children, set up by the local Educational Department or by a recognized institution, would be definitely beneficial. Secondly, the opportunity to compare the *Classi bilingui* pupils' outcomes with the ones of the regular CLIL classes and the ones of standard classes of the same age and from the same local context would make the results' interpretation more grounded and informative. This would not only be valid with reference to the English testing but to all the evaluation procedures. Despite the complexity of this kind of analysis, nevertheless it could allow the identification of patterns, tendencies and possible significant differences.

Arithmetic Facts and Language of Acquisition Effects in Primary School Children

Chapter 3

Canavesio M. L., Sulpizio S., Job R. (submitted), Arithmetic Facts and Language of Acquisition Effects in Primary School Children. Proceedings of the International CLIL MEPP 2013 Conference, April 2013, Ustron, Poland.

3.1 Introduction

In the last few decades a large amount of studies and research have addressed the mechanisms and the cognitive processes that underlie mental calculations. Models of cognitive architecture for numerical processing (Campbell, 1994; Dehaene & Cohen, 1995; McCloskey, 1992) and theories of mental arithmetic (Ashcraft, 1982, 1992; Siegler & Shrager, 1984) share the assumption that the results of basic arithmetic calculations, such as additions with single-digit operands and multiplications of the timetables, are retrieved through a direct access to the arithmetic facts stored in the long term memory in which they are represented as nodes in a network of associative links. This means that upon the presentation of an arithmetic problem (e.g., 5+2), the activation of the number nodes (5 and 2 in the example) spreads automatically along associative links from these nodes to the related nodes, such as the sum and the product

(7 and 10 in the example). From a developmental perspective, Siegler (1988) has proposed a model in which the practice and the feedback about the correctness of the answers are the crucial elements for the development of a stable number network in which the associative relations are established and strengthened with the practice of arithmetic problems. A strong network of arithmetic facts is indeed crucial for the acquisition of a skilled arithmetic competence. There is much evidence that individual differences in arithmetic facts retrieval are closely related to individual differences in general measures of arithmetical performance. Of course, facts retrieval is not the only factor associated with arithmetic performance but has been proved that arithmetically skilled people tend to be better than others at arithmetic facts retrieval (Gray & Mulhern, 1995).

In the arithmetical domain, automaticity has been investigated (e.g., Tzelgov, Yehene and Naveh-Benjamin, 1997) focusing firstly on interference effects, such as the cross-operation (Winkelman & Schmidt, 1974; Zbrodoff & Logan, 1986) and the within-operation (Stazyk, Ashcraft & Haman, 1982) interference in verification task experiments. With simple additions and multiplications, the cross-operation effect shows up with longer response times (RT) for false arithmetic problems when the proposed solution is the correct solution of another operation (e.g., 3x2=5 has slower RTs in refusing than 3x2=7), while the within-operation effect shows up with longer response times in rejecting the stated result of a problem when it is a multiple of the first operand (e.g., 3x4=9 has slower RTs than 3x4=10). Therefore, these interference effects represent the behavioral evidence of the presence of associative processes in mental arithmetic and it has been interpreted as a measure of the automatic activation of the arithmetic facts. However, recent discussions (e.g., Rusconi, Galfano and Job, 2007)

have questioned that the effect observed in a task in which the participants are asked to judge the correctness of arithmetical problems can be considered a measure of automaticity. In fact, obligatory activation might not be the only criterion to be considered in pinning down automaticity. An automatic process is defined as an autonomous process that does not demand attention resources and intentional processing (Zbrodoff & Logan, 1986). In this perspective, the verification task activates in itself an arithmetic "mode" and, therefore, it seems not fully appropriate to test the automaticity because it does not fulfill all the automaticity criterions. Moreover, it seems even to affect some of the distinguishing features of automaticity, namely the autonomy and the lack of intention, since the participants are explicitly required to perform arithmetic calculations.

In this perspective, the automaticity criterions seem to be better fulfilled with the use of an indirect task that neither implies any arithmetical knowledge nor requires any calculation competence. An example is the paradigm introduced by LeFevre, Bisanz and Mrkonjic (1988) in order to investigate the existence of associative processes in mental arithmetic through a number matching task. A sequence of numerical stimuli is shown to the participants. In each trial a pair of numbers appears (e.g., 2 3) shortly followed by the target, which is a single number (e.g., 5). The participants have to press the "yes" key if the target matches one of the numbers in the pair (matching) or the "no" key in the other case (non matching). This paradigm is a modified Stroop procedure in which arithmetic is clearly irrelevant and unnecessary in performing the task, since the participants are only required to match numerical symbols. The results of LeFevre et al. (1988) show that for the no response (non matching) the rejecting RTs are significantly longer when the target is the sum of the initial pair of numbers than the RTs when the

target is not the sum. The presence of this sum-based interference effect supports the hypothesis that obligatory activation of arithmetic facts is triggered by the mere visual presentation of a pair of numbers that activate the related sum node. Therefore, if the target matches a number, namely the sum, activated by the presented pair via associative links, the decision of rejecting the sum is more difficult and extra-processing and longer time is needed to inhibit the activated sum node. The findings confirm also the prediction that this type of interference effect is mostly or only detectable at some relatively short stimulus onset asynchrony (SOA) between the pair of numbers and the target. Interestingly, the results of other two experiments (LeFevre et al., 1988) show also that the effect is not influenced by the format of the pair. In fact, the sum-based interference effect is obtained both when the numbers in the pair appeared in word format and when the plus sign is missing.

Another study (Thibodeau, LeFevre and Bisanz, 1996) employed the same paradigm to investigate the interference effect in the multiplication network. Based on the same pattern of results, but still keeping the multiplication sign in the pair of numbers, a multiplication-based interference effect has been proven when the target is the product of the numbers in the initial pair. More recent studies (Galfano, Rusconi and Umiltà, 2003; Rusconi, Galfano, Speriani and Umiltà, 2004) have found the same effect regardless of the presence of the multiplication sign (e.g., 4 3) and also when the target is a multiple adjacent to the product, namely the nodes above (e.g., 16) or below (e.g., 8) the product.

From a developmental perspective, the role of retrieval processes in basic mental arithmetic in children and the question whether the associative network structure is already strong enough to lead to automatic activation have been extensively investigated

using verification task experiments aimed at testing associative confusion effects (e.g. Ashcraft, 1987; Lemaire, Fayol and Abdi, 1991; Svenson & Sjoberg, 1982, 1983).

Only a few studies (LeFevre, Kulak and Bisanz, 1991; Lemaire, Barret, Fayol and Abdi, 1994) have addressed the issue whether and when the network of arithmetic facts is mature in Primary school children using the number matching task. Even omitting the discussion about some relevant methodological issues about the proposed stimuli (e.g., pair with the plus sign in LeFevre et al., 1991, all the single digit numbers preceded by a zero in Lemaire et al., 1994), the results are rather controversial and definitely not straightforward to interpret, ranging from a weak and unstable sum-based interference effect found only in accuracy at 120ms SOA in Year 3 children in the LeFevre's study to a significant effect found in latencies at 150ms SOA in Year 3, 4 and 5 children in the other study.

Additionally, another crucial and controversial issue concerning the cognitive arithmetic is the relationship between language and number cognition (e.g. Noel, Fias and Brysbaert, 1997; Campbell, 1998; Noel, Robert and Brysbaert, 1998; Gelman & Butterworth, 2005) and particularly the question about the possible role of the language in the representation of the arithmetic facts in the long term memory. The different models of cognitive architecture for number processing assign different roles to the language in the domain of numbers. In this respect, the Abstract Code Model proposed by McCloskey (1992) foresees that the arithmetic facts are stored, like any other arithmetic knowledge, in an abstract, a-modal format which is totally independent from the different numerical formats (Arabic digits, word numbers, spoken numbers). It follows that all the numerical stimuli are transcoded into an a-modal representation before being processed and that these processes operate independently of the surface

formats. In this way, the model denies that language can somehow influence the number processing. On the contrary, the Triple Code Model (Dehaene et al., 1995) proposes three representations of numbers and one of these is the verbal code that is in charge of simple counting and retrieving the results of the arithmetic facts in the long term memory. This is due to the point that arithmetic facts are learned by rote repetition and stored as verbal associations. It follows that if the presented numbers are not in a verbal format, the retrieval of arithmetic facts implies that firstly the numerical stimuli need to be transcoded in the verbal code. Therefore, the model predicts language effects on counting and simple calculations but not in other tasks that do not require verbal representations, such as magnitude comparison and approximate calculations. A third model is the Encoding Complex Model (Campbell, 1994) which assumes the existence of multiple codes for number processing (e.g., Arabic, auditory, written) which are specialized to do specific tasks but it also foresees a lot of interaction between the codes and the crucial roles played by the practice and the familiarity in a particular task-format combination in improving the retrieval efficiency. It follows also that language effects can be found in any tasks.

The studies that firstly investigated the specific role of language in the arithmetic facts retrieval have adopted a between-group design, comparing arithmetical performance between groups of monolingual and bilingual participants with the main aim of disentangling the issue whether the bilinguals have only one store (arithmeticon) for the arithmetic facts or two language-marked stores (Ellis, 1992; Geary, Cormier, Goggin, Estrada and Lunnhave, 1993). The results have been somehow controversial and not so straightforward. A second wave of studies have adopted a within-group design, comparing the performance of bilingual participants in arithmetic tasks carried

out both in their first language (L1) and in their second language (L2). These studies have employed production tasks (McClain & Shih Huang, 1982; Campbell, Kanz and Xuè, 1999; Campbell, 2004), verification tasks with single-digit additions and multiplications (Frenck-Mestre and Vaid, 1993; Bernardo, 2001) and the number matching task (Rusconi, Galfano, Rebonato and Umiltà, 2006). In order to disentangle the language specificity of the processes involved, in these studies the numbers have been presented both in Arabic digits and in words, in L1 and in L2.

Summing up the results, this line of research has underlined that, besides the effects related to the different formats in which the numbers are presented, associative confusion effects and interference effects are triggered also by written word numbers in L1 and L2. These results can be interpreted as an evidence of the presence of associative links between the representations of number words in different languages. This is a perspective that supports Dehaene's and Campbell's assumptions about the fact that the representations of arithmetic facts include a linguistic component. Moreover, the results show patterns of relative advantage for the performance in the different languages that are consistent with performance costs that are higher when associated with an unfamiliar numeral format than with a familiar one. Very interestingly, the results also show advantages in the performance not always related to the L1 but instead to the so called preferred language that is the language of formal instruction at school, namely the language used for learning and practicing arithmetic tasks, referred to as LoLA (Language of Learning Arithmetic).

3.2 Experimental Studies

The following experiments have been planned with Italian Primary school children in order to investigate:

a. the presence of interference effects in mental arithmetic as evidence for the automatic activation of the arithmetic facts

b. the presence of LoLA effects and LoLA influence in the automatic activation of the arithmetic facts when the language of acquisition is not the mother tongue but a foreign language.

3.2.1 Experiment 1

This study has been planned in order to investigate the activation of addition facts in a developmental perspective. If generally it can be assumed that children are in the process of developing knowledge and skills about the arithmetic facts, due to biological factors but more due to educational inputs (formal teaching and practice at school), it is also true that in children the network in which the arithmetic facts are stored might be not mature yet and the associative links not so strong. Since the results of previous studies about children are rather controversial (see the introduction of this chapter), this experiment investigates the presence of sum-based interference effect in Year 4 Italian children (9-10 year old), employing a number matching task in which the stimuli (Arabic digits) are visually presented. In this study, half of the classes of the sample are CLIL classes, in which children have been taught and trained in mathematics with English as the language of instruction since their first year of formal schooling.

Participants: Two classes of Italian Primary school children: Twenty-three Year 4, CLIL class pupils (12 males, mean age= 9:8 months (years:months), ranging from 8:6 to

10:5), nineteen Year 4, control class pupils (10 males, mean age= 9:8, ranging from 9:3 to 10:7).

The study was conducted in March.

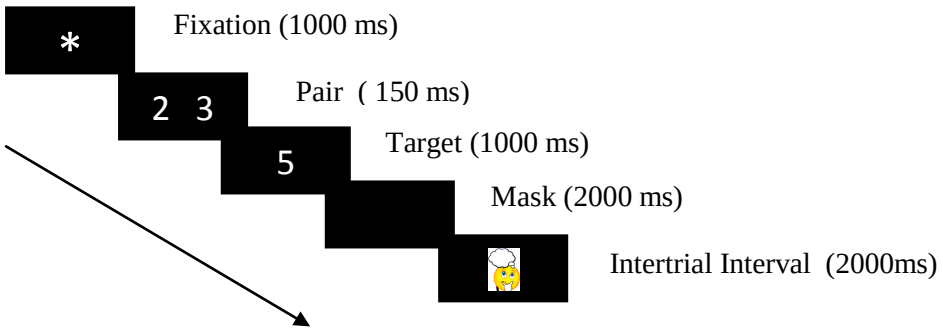
Materials: following LeFevre's paradigm, each trial consists of a pair of numbers followed by a target. Both the pairs and the targets are made of single-digit numbers and all the digits from 1 to 9 have been used. The participants are requested to press the "yes" button on the response box if the target is one of the numbers already seen in the pair (matching) or the "no" button otherwise (non-matching). Half of the trials are non-matching, the other half are matching. Twenty-four pairs have been created (a list of 12 pairs plus another list that is the reverse of the other, e.g., "6 3" and "3 6"), with the exclusion of ties (e.g., "3 3") because they have an easier access to the memory store than do other problems (Graham and Campbell, 1992). From these 24 pairs, one type of "yes" target (matching) and two types of "no" targets (non-matching) have been created. For the non-matching, there are two conditions: "the sum" and "the neutral" targets. For the sum, the target is the sum of the numbers in the pair (e.g., pair "2 3", sum target "5") , for the neutral the target is the sum ± 1 or ± 2 (e.g. pair "2 3", neutral target "4" or "7"). There are no targets that are the products of the pair. The distance between the target and the pair has been controlled for each non matching trial by calculating the average difference between each number in the pair and the target, resulting in 3.33 and 3.4 mean value of distance, respectively for the sum and the neutral trials. For the matching trials one half of the targets matches the digit on the right side of the pair and the other half the digit on the left side. For the second matching condition a new list of 24 pairs has been created in order to balance in the matching trials the range of digits used in the non matching trails. The order of the

stimuli has been pseudo-randomized with the following constraints: the same condition (sum vs. neutral vs. matching), the same response, the same position of a number in the pair do not appear more than twice in a row. The list of the trials is fixed within each block and the order of the blocks was counterbalanced across the participants.

All the 96 stimuli, divided in 4 blocks of 24 trials each, have been presented once with a SOA of 150ms. The decision regarding the use of only one SOA has been made based upon the results of some pilot experiments with 9 year old participants in which two SOAs (100ms and 150ms) were employed. Most of the children reported that they couldn't detect the pair presented for 100ms. The use of two SOAs heavily hampered their performance and the task in general resulted in being too long and too demanding.

Procedure: the sequence of events on each trial is shown in Figure 6.

Figure 6. The sequence of events on a single trial in Experiment 1.



Firstly a fixation point appears centered on the screen for 1000 ms. Then a pair of numbers is presented for 150 ms. After the pair offset, the target is presented, centered, lasting for 1000 ms. After this, a mask lasts for other 2000 ms, allowing a maximum of 3000 ms for responding. A centered picture then appears, lasting 2000ms, to signal the InterStimulus Interval. Half of the participants have to press the "yes" button that is the rightmost of the five buttons of the response box for the matching trials and the "no"

button that is the leftmost for the non matching trials. The other half performs the task with the reversed response assignment. Response times and accuracy are recorded. Before the experiment, each participant performs 12 practice trials with the researcher and 12 practice trials by him/herself. Practice trials include items that are similar to the experimental trails. The instructions stress both speed and accuracy.

Results and discussion

Data analyses were carried out only on non-matching targets, as the matching targets did not address our hypothesis. Correct RTs and percentages of correct responses were both analyzed. Errors comprise incorrect responses and the responses given beyond the deadline.

The data from one participant were not included in the analysis because the pupil had 80% errors.

Table 1 Overall and target type mean correct RTs in milliseconds, standard deviation (SD) and mean percentage (%) of correct responses in Experiment 1

	Overall			***Target type***					
				sum			***neutral***		
	RTs	*(SD)*	*%*	*RTs*	*(SD)*	*%*	*RTs*	*(SD)*	*%*
Exp. 1 (vis)									
CLIL	918	(246)	90.3	910	(238)	89.6	925	(257)	91.1
Control	993	(249)	90.2	979	(241)	91	1008	(265)	89.4

Percentage of correct responses and mean correct RTs (see Table 1) were analyzed in a 2 (target type: sum, neutral) x 2 (class: CLIL, control) repeated-measure analysis of variance (ANOVA). Target type was a within factor and class a between factor. The main effect of target type and of class did not reach significance neither for accuracy ($F<1$) nor for RTs ($F(1,39)=2.24$, $p=.14$). The interaction between target type and class was not significant both for accuracy ($F(1,39)=2.14$, $p=.15$) and for RTs ($F<1$).

If sums are subject to automatic activation, the response time to sum targets would be longer than those to neutral targets. Therefore, latencies were expected to be longer for sum targets than for neutral targets. The result of this study does not provide evidence that simple addition facts are subject to automatic activation in fourth-graders when they perform a non-arithmetic task in only-visual modality. On the contrary, as it is shown in Table 1, sum targets were rejected somewhat more quickly than the neutral targets in both classes (CLIL class 910 vs. 925; control class 979 vs. 1008). Even though the difference is not statistically significant, it shows a direction of the interference effect that is opposite than the expected one. The reversal of the effect was found in latencies also in LeFevre et al. (1991) and in Lemaire et al. (1994) for most of the sum vs. neutral targets at SOAs different from 120ms. As in the above mentioned studies, as a possible explanation for this finding, we might consider that the pupils' representations of arithmetic facts at this age are still not adequately developed to support a sum-based inference effect as it was found in adults.

3.2.2 Experiment 2, 3 and 4

The following experiments have been designed with the aim of detecting the specific contribution of LoLA effects in the automatic activation of addition facts. With the specific aim of disentangling the issue about LoLA effects in the automatic activation of addition facts, a manipulation has been set up in the number matching task of the Study 1. Specifically, in Experiments 2, 3 and 4 the targets are presented in the auditory modality, namely the targets are Italian spoken numbers in Experiment 2, English spoken numbers in Experiment 3 and German spoken numbers in Experiment 4.

While written number words have been used in studies with adults, we feel they are not appropriate for Primary school children, since firstly it would represent a very unusual and unfamiliar format and secondly it may create possible confounds with automaticity in the reading processes, especially for the English number words. Moreover, spoken numbers are the most used inputs in practicing and training mental arithmetic and definitely the number format to which children are mostly accustomed to for arithmetic facts.

Regarding LoLA effects, it is important to underline that basically none of the results and conclusions of research on mental arithmetic on bilinguals can be considered as a reference point. First of all, the results of these studies are almost impossible to be compared due to the difficulty in sharing a univocal definition of bilingual and to the adoption across the studies of different criteria for including the participants as bilinguals. Moreover, the specific issue related to the language of acquisition has never been considered in isolation.

In our sample, the CLIL class had English as only language of instruction for Mathematics since their first year of formal schooling, the control class had formal instruction in English as a foreign language as it is foreseen by the Italian national curriculum for the Primary School. Both classes had the same amount of formal instruction in German as a second foreign language. The fact that no previous findings can really fit the specific feature that characterized half of the classes participating to our experiments makes predictions not straightforward. In the case of results showing a sum-based interference effect in any of the cross-modality experiments, it would be possible to disentangle the issue about language-specific influence and effect. Cross comparisons between the performance of the classes in the three different languages

could lead, or not, to an evidence-based proof that there is a preferred language. If there is, it should be possible to identify which is which for the CLIL class and for the control classes and finally draw some conclusions whether LoLA really makes a difference in the automatic activation of arithmetic facts.

It is a within group design since the same participants perform the task in Italian, in English and in German in three separate experimental sessions.

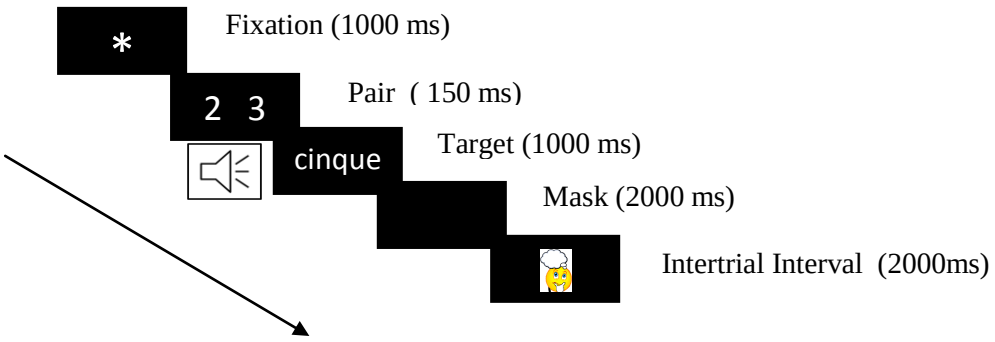
Participants: the same as in Experiment 1. Experiment 2 and 3 were conducted in the Spring, Experiment 4 was conducted in October and the pupils were fifth-graders.

Materials: the same as in Experiment 1.

Procedure: the same as in Experiment 1 with the crucial difference that the targets are presented in the auditory modality, respectively Italian spoken numbers in Experiment 2, English spoken numbers in Experiment 3 and German spoken number in Experiment 4.

The sequence of events on each trial in Experiment 2 is shown in Figure 7.

Figure 7. The sequence of events on a single trial in Experiment 2.



The recordings of the numbers keep consistency with the gender of the speaker and of the teacher at school. The length of the audio files ranges from 0.68s to 0.71s for the English numbers, from 0.72s to 0.75s for the Italian numbers, from 0.67s to 0.69s for the German numbers. The CLIL class performs first the experiment with English

spoken numbers and in a following experimental session the one with Italian spoken numbers. The control class does the opposite. Before the experiments, participants perform 12 practice trials and are instructed as in Experiment 1. If the participant feels uncomfortable or not confident enough with the response procedure, another set of 12 practice trials is performed.

Results and discussion

Data analyses were carried out only on non-matching targets, as the matching targets did not address our hypothesis. Correct RTs and percentages of correct responses were both analyzed. Regarding accuracy, errors comprise incorrect responses and the responses given beyond the deadline.

The data from two English bilingual participants were not included in the analysis of the Experiment 3 as well as the data of two German bilingual participants in the analysis of Experiment 4, plus an additional pupil that had 61% error rate.

Table 2 Overall and target type mean correct RTs in milliseconds, standard deviation (SD) and mean percentage (%) of correct responses in the experiments with spoken targets

	Overall			***Target type***					
				sum			***neutral***		
	RTs	*(SD)*	*%*	*RTs*	*(SD)*	*%*	*RTs*	*(SD)*	*%*
Exp.2 (Ita)									
CLIL	1011	(273)	95.3	1025	(286)	95.3	997	(264)	95.3
Control	1154	(256)	94.6	1136	(226)	95	1172	(285)	94.3
Exp.3 (Eng)									
CLIL	1018	(278)	95	1031	(325)	95	1004	(239)	95
Control	1159	(291)	92.1	1164	(280)	91.4	1155	(312)	92.8
Exp.4 (Ger)									
CLIL	1072	(355)	92.9	1059	(353)	93.7	1085	(360)	92.3
Control	1158	(239)	93	1149	(225)	92.8	1167	(258)	93.4

Firstly, separate analyses of variance (ANOVA) were conducted on each of the three experiments. Percentage of correct responses and mean correct RTs (see Table 2) were analyzed in a 2 (target type: sum, neutral) x 2 (class: CLIL, control) repeated-measure ANOVA. Target type was a within factor and class a between factor. The main effect of target type and of class did not reach significance neither for accuracy ($F<1$ for all the experiments) nor for RTs (Exp.2: $F(1,40)=<1$; Exp.3: $F(1,38)=1.70$, $p=.19$; Exp.4: $F(1,37)=1.76$, $p=.19$).

However, the interaction between target type and class was significant ($F(1,40)=4.58$, $p=.03$) for RTs but only in Experiment 2. In fact, in the experiment with Italian spoken targets the reversal effect, namely sum targets rejected more quickly than neutral targets occurs in the control class but not in the CLIL class (CLIL class 1025 vs. 997; control class 1136 vs. 1172), leading to a significantly different pattern of behavior between the two classes. In the other experiments with spoken targets, the reverse direction of the interference effect shows up in both classes in the experiment with German spoken targets (CLIL class 1059 vs. 1085; control class 1164 vs. 1155), even though the difference is not statistically significant, as in Experiment 1. It does not in the experiment with English spoken targets (CLIL class 1031 vs. 1004; control class 1164 vs. 1155) in none of the classes.

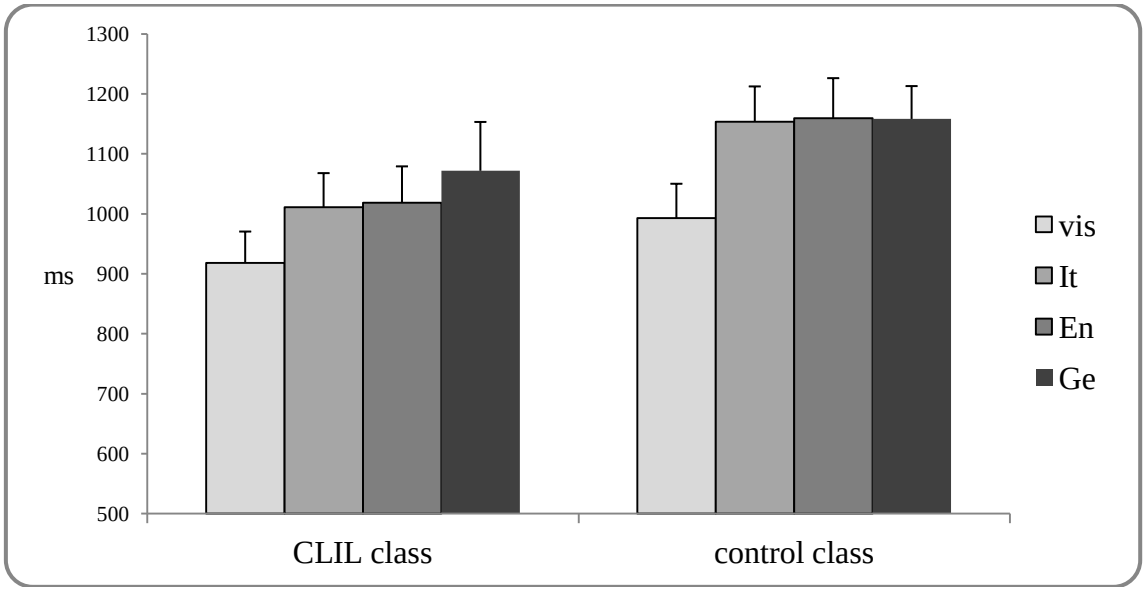
Longer latencies to sum targets than those to neutral targets would have accounted for a sum-based interference effect. The results of the three experiments with spoken targets do not provide evidence that simple addition facts are automatically activated when Year 4 pupils perform a non-arithmetic task in cross-modality (visual-audio presentation respectively of pairs and targets).

Secondly, we considered the performances of the two classes in the four experiments. Experiment and class were entered as factors in a two-way repeated-measures ANOVA on percentages of correct responses and on mean correct RTs. A main effect of experiment was significant for both accuracy ($F(3,99)=5.07$, $p<.001$) and RTs ($F(3,99)=3.05$, $p=.03$). The main effect of class was not significant neither for accuracy ($F=2.57$, $p=.11$), nor for RTs ($F=3.18$, $p=.08$). The interaction did not reach significance either (accuracy $F<1$; RTs $F<1$).

Appropriate comparison of means have shown that Experiment 1 differs significantly from the other experiments both for accuracy (Experiment 2: $p<.001$; Experiment 3: $p=.04$; Experiment 4: $p=.04$; all ps were adjusted with fdr) and for RTs (Experiment 2: $p=.03$; Experiment 3: $p=.02$; Experiment 4: $p=.02$; all ps were adjusted with fdr). The experiments with spoken targets did not differ significantly from each other. On the one hand, the main effect of the experiment in RTs could be accounted for the difference between the encoding speed of only-visual stimuli in Experiment 1 and the encoding speed of audio-visual stimuli in the experiments with spoken targets. On the other hand, the significantly higher error rate in Experiment 1 could be accounted for the fact that the experiment in the only-visual modality resulted in being more demanding in terms of participants' attention and concentration.

Mean correct RTs as a function of class in the four experiments are shown in Figure 8.

Figure 8. Mean correct RTs in milliseconds as a function of class in Experiment 1 (vis), Experiment 2 (It), Experiment 3 (En) and Experiment 4 (Ge).



3.3 Conclusions

In this study, we firstly aimed at finding evidence for obligatory activation of simple addition facts in Year 4 (9-10 year old) Primary school children. Whereas at this age children are generally able to retrieve arithmetic facts in ordinary arithmetic tasks at school, it is controversial (LeFevre et al., 1994; Lemaire et al., 1991) whether the associative links in the network of the arithmetic facts are strong enough to produce obligatory activation when arithmetical calculations are not required and not relevant for performing the task.

Adopting a number matching task as non-arithmetic task in which the stimuli (single-digit numbers for pairs and targets) are visually presented, Experiment 1 can be considered a replication of the LeFevre's study (1994) but with the removal of the plus sign between the two numbers of the pair.

In addition, the issue related to the language of acquisition for arithmetic has been considered. In particular, the specific contribution of LoLA effects in the automatic activation of addition facts has been explored in Experiment 2, 3 and 4. The manipulation of the number matching task of Experiment 1 has set up a cross-modal presentation of the stimuli, being the pairs always visually presented and the targets being Italian spoken numbers in Experiment 2, English spoken numbers in Experiment 3 and German spoken numbers in Experiment 4.

The study was aimed at detecting possible differences in performing the task across the three experiments and between the control class and the CLIL class that had English as the only language of instruction for Mathematics since the first year of formal schooling.

The results do not show a sum-based interference effect at Year 4, neither in the only-visual modality experiment nor in the cross-modality (visual-audio) experiments. This may be accounted for by assuming that at this age arithmetic associations are still developing. Alternatively, it may be that our test was not sensitive enough to detect such automatic arithmetic associations. At present, we favor the first alternative, and propose that, without questioning the children competence in retrieving arithmetic facts in ordinary arithmetic tasks, these patterns of results show that connections and associative links are not yet strong enough to produce obligatory activation in a non-arithmetic task. It might be argued as well that the number matching paradigm as a non-arithmetical task is too "sophisticated" and not appropriate for children. It might be the case that the task is perceived by the children as being rather unnatural and odd.

Given the fact that in none of the experiments no evidence for obligatory activation of simple addition facts was found, it is consequently not possible to

disentangle the issue about a language-specific influence in the automatic activation of the arithmetic facts.

Nevertheless, the experiments with spoken targets in the three different languages can be considered as number recognition tasks. Probably, the most interesting results come from the comparisons between the performances of each class across the experiments with spoken targets. In this perspective, regarding the LoLA effect and considering the overall mean RTs (see Figure 8) in the experiments with Italian, English and German spoken targets (CLIL class: Ita 1011 vs. Eng 1018 vs. Ger 1072; control class: Ita 1154 vs. Eng 1159 vs. Ger 1158) the use of a foreign language in teaching and learning arithmetic does not hamper or negatively affect the performance of the CLIL class.

Moreover, there are no differences both in accuracy and mean RTs in the experiments with spoken targets both in the CLIL class and in the control class. It might be that these patterns of results could be dependent on the use of only single-digit numbers as targets that might be easily recognized in any of the three languages used. Nevertheless, this finding can reasonably lead to the conclusion that, limited to this specific task, the language seems to be irrelevant and that there is not an evidence-based proof of a preferred language.

APPENDIX 1

Pairs of numbers and targets used in Experiment 1, 2, 3 and 4

Pair	Target	Pair	Target
9 6	9	1 4	4
7 1	6	1 8	7
1 8	9	7 2	9
7 2	7	1 7	8
3 4	6	1 6	1
1 6	8	2 3	5
4 3	4	6 9	6
6 1	6	4 5	8
8 3	8	4 7	7
3 6	7	6 3	8
1 4	5	9 5	9
7 3	7	5 7	7
4 1	1	6 1	9
3 5	8	8 5	8
4 1	3	5 4	7
8 7	8	6 2	8
2 4	6	2 3	7
6 3	6	8 4	8
8 5	8	7 5	7
4 3	7	5 4	9
6 2	2	8 1	1
3 2	7	3 2	5
8 1	9	6 7	7
2 6	8	7 5	7
7 1	1	6 9	6
8 1	7	3 5	9
3 5	3	6 2	7
4 2	6	4 2	4
8 9	9	3 6	9
5 4	5	2 4	2
7 9	7	8 6	8
5 3	6	4 1	5
3 4	7	2 3	3
7 6	6	9 7	9
3 4	3	2 7	8
3 7	7	4 5	5

1 4	3	6 3	9
4 9	9	4 3	8
3 6	3	2 7	2
6 1	7	5 3	8
2 6	9	2 6	6
3 2	2	4 5	9
1 7	9	1 6	7
4 2	5	5 3	3
1 7	7	2 7	9
5 3	5	1 8	8
7 1	8	5 4	4
2 4	7	7 2	8

Arithmetic Facts in Primary School Children: Does the Language of Acquisition Really Matter?

Chapter 4

Canavesio M. L., Sulpizio S., Job R. (in preparation), Arithmetic Facts in Primary School Children: Does the Language of Acquisition Really Matter?

4.1 Introduction

The pattern of results from the previous set of experiments has led to the assumption that connections and associative links are not yet mature enough to produce obligatory activation of the arithmetic facts in Year 4 school children. Taking into account the fact that for this set of experiments a non-arithmetic task such as the number matching was employed, the conclusions drawn from the experiments calls into question the issue related to the type of task. As mentioned before, it might be that our test was not sensitive enough to detect such automatic arithmetic associations or, more likely, it might be that the number matching task was not so appropriate and not able to trigger arithmetic associations in children as it did in adults (LeFevre et al., 1988; Thibodeau et al., 1996).

Given this result, we decided to continue the investigation of the obligatory activation of arithmetic facts in Primary school children, using this time a different task, the verification task. This is a direct arithmetic task in which the participants are asked

to judge the correctness of arithmetic problems. According to some studies (e.g. Rusconi et al., 2007), the verification task activates in itself an arithmetic "mode" and therefore it seems not fully appropriate to test the automaticity because it does not fulfill all the automaticity criterions, namely the autonomy and the lack of intention because the participants are explicitly required to perform arithmetic calculations. Nevertheless, taking into account the results of our experiments employing the number matching task with children, we have considered that the verification task might be more appropriate for children to detect developmental changes in arithmetic associations, also due to the fact that it can be perceived as a more natural task compared to the number matching.

Previous studies (Zbrodoff and Logan, 1986; Lemaire et al., 1994) employing the verification task with adults found both in addition and multiplication problems an interference cross-operational effect that shows up with latencies for false problems significantly slower for confusion targets (e.g., the target is the product of the two operands of an addition problem) than for non-associative targets.

On the other hand, the development of associative effects in Primary school children has been always a controversial issue. Zbrodoff (1979) using a verification task found an associative confusion effect detected in latencies as evidence that both sum and product activations occur in Primary school children. On the contrary, Hamann and Aschcraft (1985) and Koshmider and Ashcraft (1991) found associative interference effects only rather late, suggesting that simple arithmetic processes can be defined firstly as partially autonomous and that there are evidence of associative-based obligatory activation only after nine-ten years of formal instruction at school. While from a descriptive perspective Miller and Paredes (1990) based the interference effect on the fact that the introduction of the multiplication acts as a temporary disruption of

the addition skills worsening the performance of Year 3 school children in solving addition problems, Lemaire et al. (1991) found an associative-based confusion effects between sum and product targets in Year 4 and 5 school children, using a verification task. Slower latencies were detected when children had to reject targets that would have been correct if a different operation (e.g, multiplication instead of addition) were performed. The conclusion of the latter study argued against the Ashcraft and colleagues' interpretation (1985, 1991) but it left the door open to deeper investigation of the extent to which the observed effects may be dependent on the specific feature of the task and/or on the type of stimuli (e.g., interference effect as a function of the size of the numbers or of the distance between the target and the numbers of the problem). In a follow-up study (Lemaire et al., 1994, experiment 3) employing the verification task, an addition-multiplication associative confusion effect was detected in Year 3, 4 and 5 school children. Firstly, the sum activation proved to be more robust than the product activation that emerged later. In fact, the sum-based interference effect was detected in Year 3, 4 and 5 pupils. This finding can be accounted for by considering that multiplication facts are taught and practiced in school later than the addition facts. However, the effect presented some degree of variability depending on the age of the pupils and on the size of the numbers. The latter in particular was proven to be the most important and critical factor. In fact, the automatic activation of the sum resulted in a significant interference effect in Year 3 only with small numbers, namely when both the operands were less than five, and with small and medium size numbers in Year 4 and 5. It was never detected with large numbers, namely when both operands were greater than five. This finding leads to the necessity of taking seriously into account the role played by the size of the numbers and its interaction with the interference effect.

Some findings of the relatively small amount of research conducted on bilinguals' arithmetical skills in the two languages have reported a first-language advantage when the bilinguals performed the task in the two languages at the same time (Marsh and Maki, 1976) under mixed-language conditions. However, the first-language advantage disappeared under blocked-language conditions (McClain and Huang, 1982). Other studies (Ellis and Hennelly, 1980; Ellis, 1992) revealed that in bilinguals the language advantage depends on the length of the number words in the two languages. At this point, it is important to underline that in these studies participants were required to mentally perform multi-digit arithmetic problems with word numbers. In this case, the difference in calculation speed between the two languages can be affected and at least partially explained by the different length of the number names in the two languages and by the different degree of practice in the second language (Magiste, 1982).

But if we consider only simple arithmetic calculations such as addition sums with single-digit operands and time table multiplications whose results are supposed to be retrieved directly from the long-term memory store, the role of language in affecting the speed of the arithmetic facts retrieval might be considered less direct and crucial.

Regarding the issue about the influence and the effect of the language on arithmetic facts, the Frenk-Mestre and Vaid's study (1993) appears to be of a particular relevance. The first experiment employed a verification task in which bilingual participants were asked to mentally verify the correctness of single-digit additions with the stimuli in three different formats (digits, number words in the first language and number words in the second language). Firstly, a main effect of format was found both in latencies and in error rate, being the participants faster and more accurate in digit than in word format, and in the first than in the second language. Secondly, a facilitation

effect was found with latencies significantly faster for true problems (sum targets) than for false problems (unrelated targets) but, interestingly enough, the effect was found in the digit and in the first language format but not in the second language one. In the second experiment an associative confusion effect between addition and multiplication was firstly investigated in adults employing a verification task and the digit format of the numbers. The effect showed up with latencies for false problems significantly slower when the target was associatively related to the operands of the problem (respectively, the sum of the operands in the multiplication problems and the product of the operands in the addition problems) compared to the latencies for unrelated targets. Moreover, the same task was then performed by a group of bilinguals with word numbers both in their mother tongue and in L2. In general, the participants were slower and less accurate in their second language then in their first language. Very interestingly again, the confusion effect was detected only with word numbers in the mother tongue and only in latencies with a very low percentage of error rate. On the contrary, with word numbers in the second language no effect in latencies was detected but a drop in error rate, especially for correct responses. The different pattern of results observed in the second language format might suggest that perhaps effects that can be explained on the base of associative links in the network of the arithmetic facts are restricted to the first language. At the same time, the assumption that the retrieval of arithmetic facts and their obligatory activation are at least language-sensitive, if not language-dependent, might be drawn. However, it is important to underline that in this study the participants have been defined as late and low skilled bilinguals. This detail leads to the already mentioned difficulty in defining bilinguals in a univocal way and the consequent

impossibility of comparing the results of diverse studies when different criteria for including the participants as bilingual are adopted.

Bernardo (2001) focused on how the language may affect the retrieval of addition facts. The study involved a group of High School students with Filipino as their first language attending a bilingual educational program with English as medium of instruction for mathematics since their first year of formal schooling. The replication of the Frenck-Mestre and Vaid's (1993) first experiment with the above mentioned group of bilinguals led to the same pattern of results with the crucial difference that this time the facilitation effect was found with the numbers in digit and with word numbers in English and not with word numbers in their first language, leading to the conclusion that English, being the second language of this specific group of subjects but also the language of instruction for mathematics, can be considered their preferred language rather than their first. In order to test the strength of activation of the different formats, a second experiment foresaw the manipulation of the formats of the numbers and used mix-format stimuli (digits, word numbers in Filipino and word numbers in English) involving both the addends and the targets at the same time. The result showed a decreasing efficiency from the digit to the verbal formats, supporting the assumption that the formats differ in strength and efficacy. Even though the results showed associative-based interference effects, these seemed to be weaker with word numbers in Filipino, leading to the conclusion that the stronger verbal format is not always the first language but, as in this specific context, the language used for learning arithmetic (LoLA) at school, suggesting that the strength of activation of the format depends also on the amount of experience and practice in the task using that format.

4.2 Experimental Studies

The following experiments have been planned with Year 4 and Year 5 Italian Primary School children in order to investigate:

c. the presence of sum-based interference effects in mental arithmetic as evidence for the obligatory activation of addition facts

d. the presence of an associative confusion effect between addition and multiplication as evidence for the obligatory activation of arithmetic facts

e. the presence of LoLA effects and LoLA influence in the automatic activation of the arithmetic facts when the language of acquisition for mathematics is not the mother tongue but a foreign language.

4.2.1 Experiment 5 and 6

This study has been planned in order to investigate the activation of addition facts and the presence of an associative confusion effect between addition and multiplication in a developmental perspective. Since from the results of the previous set of experiments (see experiment 1, 2, 3, 4 in Chapter 3) no evidence for obligatory activation of simple addition facts was found in Year 4 Primary School children employing a non arithmetic task, such as the number matching task, these experiments investigate the presence of sum-based interference effects and of an associative confusion effect between addition and multiplication in Year 4 (9-10 year old) and Year 5 (10-11 year old) Italian children, employing a verification task. Moreover, the following experiments have been designed with the aim of detecting the specific contribution of LoLA effects in the obligatory activation of the arithmetic facts. In order to disentangle the issue about LoLA effects and specifically the role of the language in

the retrieval of the arithmetic facts, while the addition problems to be verified consist of only single-digit addends visually presented, the targets, that are single and two-digit numbers, are presented in the auditory modality, namely the targets are Italian spoken numbers in Experiment 1 and English spoken numbers in Experiment 2.

While studies with adults (LeFevre et al., 1988; Frenck-Mestre and Vaid, 1993; Campbell at al., 1999; Bernardo, 2001; Rusconi et al., 2006) always used word numbers, as already mentioned in the previous set of experiments, we feel they are not appropriate for Primary School children, since firstly it would represent a very unusual and unfamiliar format and secondly it may create possible confounds with automaticity in the reading processes, especially for the English word numbers. Moreover, spoken numbers are the most used inputs in practicing and training mental arithmetic and definitely the number format to which children are mostly accustomed to for arithmetic facts.

It is a within group design since the same participants perform the task in Italian and in English in two separate experimental sessions.

In this study, all the schoolchildren have Italian as the first language but half of the classes of the sample are CLIL classes, in which children have been taught and trained in Mathematics with English as the language of instruction since their first year of formal schooling.

Participants: Four classes of Italian Primary school children: Twenty-two Year 5, CLIL class pupils (11 males, mean age= 10:8 months (year:months), ranging from 10:6 to 11:5), nineteen Year 5, control class pupils (10 males, mean age= 10:7, ranging from 10:3 to 11:2), eighteen Year 4, CLIL class pupils (10 males, mean age= 9.7, ranging

from 9.4 to 10.5), nineteen Year 4, control class pupils (9 males, mean age=9.8, ranging from 9.3 to 10.2).

The experimental sections were conducted in March, April and May.

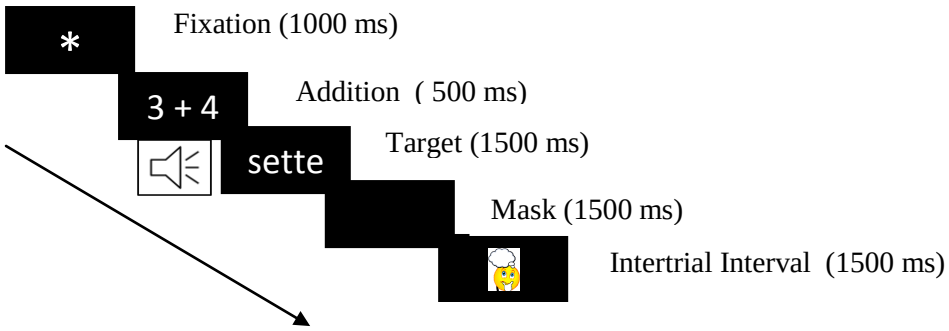
Materials: each trial consists of two numbers (or addends) separated by a plus sign (e.g., 3 + 4), followed by the target (e.g., 7). The addends are single-digit numbers from 1 to 9. The participants' task is to decide whether the target is the sum of the addends. Participants are requested to press the "yes" button on the response box if the target is the correct sum of the two addends (positive response) or the "no" button otherwise (negative response). Half of the trials are positive responses, the other half are negative. Twenty addition problems have been created, with the exclusion of ties (e.g., 4 + 4) because they have an easier access to the memory store than do other problems (Graham and Campbell, 1992). For the same reason the digit five does not appear as addend. Not more than two addition problems share the same sum. From these 20 problems, three experimental conditions (target type) have been created: the "sum", the "product" and the "neutral" targets. For the sum, the target is the sum of the addends, for the product the target is the product of the addends, for the neutral the target is the sum ± 1 (small split) or the sum ± 4 (large split). Small and large split targets have been used in order to control and balance the distance between the correct response and the neutral targets. Other twenty addition problems and targets that are always the correct sums of the addends (control sum condition) have been added in order to equal the number of positive and negative responses. In addition, these filler stimuli have been chosen in order to balance the number of times in which the single-digit numbers (including the number five) appear as addends. The data from these control trials are not to be analyzed. Moreover, the entire list of addition problems has been created taking into

account the size of the addends so that in half of the trials both the addends are digits less than five (small size) and in the other half of the trials one addend is less than five and the other addend is greater than five (medium size). In half of the problems the greater digit is the left addend, in the other half is the right one. The order of the stimuli has been pseudo-randomized with the following constraints: the same condition (sum vs. neutral vs. product), the same position of the addends in the problem, the same target do not appear more than twice in a row and the same response is not required more than three times in a row. The list of the trials is fixed within each block and the order of the blocks is counterbalanced across the participants.

All the 80 stimuli, divided in 4 blocks of 20 trials each, have been presented once with a SOA of 500ms.

Procedure: the sequence of events on each trial is shown in Figure 9.

Figure 9. The sequence of events on a single trial in Experiment 1.



Firstly a fixation point appears centered on the screen for 1000 ms. Then an addition problem is presented for 500 ms. After the problem offset, the target is presented in the auditory modality, respectively Italian spoken numbers in Experiment 5 and English spoken numbers in Experiment 6. The recordings of the numbers keep consistency with the gender of the speaker and of the teacher at school. The length of the audio files

ranges from 0.90s for the single-digit numbers to 1s for the two-digit numbers both for the Italian and the English targets. After this, a mask lasts for other 1500 ms, allowing a maximum of 3000 ms for responding. A centered picture then appears, lasting 1500 ms, to signal the InterStimulus Interval. Half of the participants have to press the "yes" button that is the rightmost of the five buttons of the response box for the positive response and the "no" button that is the leftmost for the negative response. The other half performs the task with the reversed response assignment. Response times and accuracy are recorded. The classes perform firstly the experiment with Italian spoken numbers and in a following experimental session the one with English spoken numbers. Before the experiments, participants perform 10 practice trials including items that are similar to the experimental trails. If the participant feels uncomfortable or not confident enough with the response procedure, another set of 10 practice trials is performed. The instructions stress both velocity and accuracy.

Results and discussion

Correct response times and percentages of correct responses were both analyzed. Errors comprise incorrect responses and the responses given beyond the deadline. Data from the control sum condition were not analyzed as they are considered as fillers.

Year 5

The data from two English bilingual participants were not included in the analysis of the Experiment 6 as well as the data of a pupil that had 56.6% accuracy percentage in Experiment 5. Percentage of correct responses (table 3) and mean correct RTs (table 4) were analyzed in a 3 (target type: sum, unrelated, product) x 2 (class: CLIL, control) x 2 (addend size: small size, medium size) repeated-measure analysis of variance (ANOVA). Target type and addend size were within factors and class a between factor.

Accuracy data

Table 3 Year 5 target type mean percentage (%) and standard deviation (SD) of correct responses in function of target type, addend size (ss= small size; ms= medium size) and class in Experiment 5 and 6

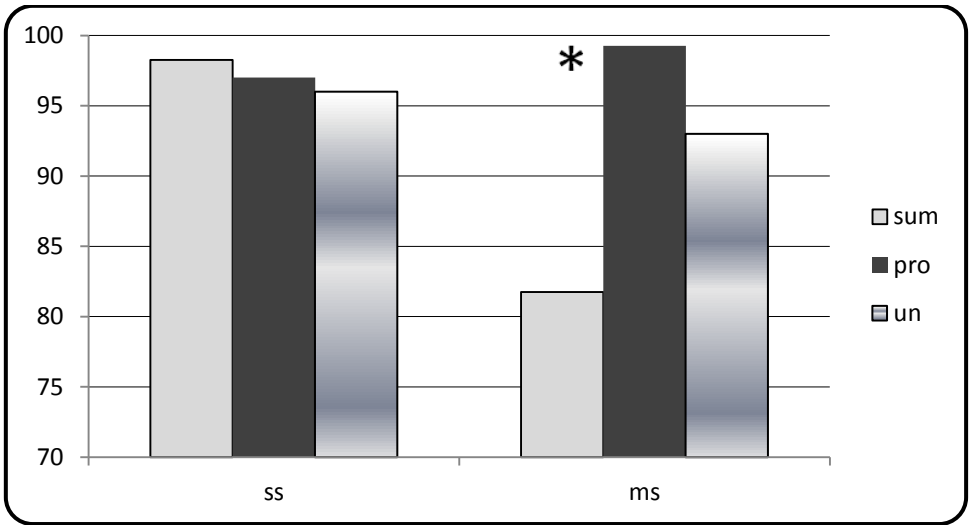
	Target type					
	sum		***unrelated***		***product***	
Addend size	ss (SD)	ms (SD)	ss (SD)	ms (SD)	ss (SD)	sm (SD)
Exp. 5 (Ita)						
CLIL	98.5 (3.5)	84.7 (8.7)	97.1 (5.6)	95.7 (6.7)	98.5 (3.5)	99 (3)
Control	97.8 (4.1)	78.4 (10.6)	94.7 (6.1)	90 (10)	95.2 (5.1)	99.4 (2.2)
Exp. 6 (Eng)						
CLIL	96.3 (7.6)	85.7 (14.6)	97.8 (6.3)	95.2 (9.6)	98.9 (3.1)	97.3 (9.3)
Control	92.6 (7.3)	74.2 (16)	92.6 (8.7)	88.4 (12.1)	93.1 (8.8)	93.1 (9.4)

Experiment 5. The main effects of class ($F(1,38)=7.01$, $p=.001$) was significant, being the CLIL class significantly more accurate in responding than the control class. Additionally, the main effect of target type ($F(2,76)=32.42$, $p<.001$) and addend size ($F(1,38)=58.55$, $p<.001$) were significant. Neither the interaction between target type and class ($F<1$) nor the interaction between addend size and class ($F<1$) reached significance. Target type, addend size and class interacted in a significant way ($F(2,76)=4.89$, $p=.01$), such as target type and addend size ($F(2,76)=76.77$, $p<.001$).

Higher error rate in responses for product targets than those for sum targets would account for a confusion effect. However, appropriate comparison of percentage of correct responses in function of target type, addend size and class showed no evidence of confusion effect in both classes. On the contrary, considering the interaction between target type and addend size, the comparisons between accuracy for sum and product targets showed the reverse direction of the confusion effect with medium size addends,

occurring with a significant lower percentage of error rate for product targets than those for sum targets (p adjusted fdr <.001), as shown in Figure 10.

Figure 10. Mean percentage of correct responses as a function of target type (sum, product, unrelated) and addend size (ss=small size; ms=medium size). The asterisk (*) indicates the significant difference between sum targets and product targets in the medium size addend condition.



Generally, a different pattern in error rate between the two addend size conditions can be detected. Particularly, whereas with small size addends the accuracy percentage showed a ceiling effect in the three different target types, with medium size addends a drop in error rate for sum targets can be detected.

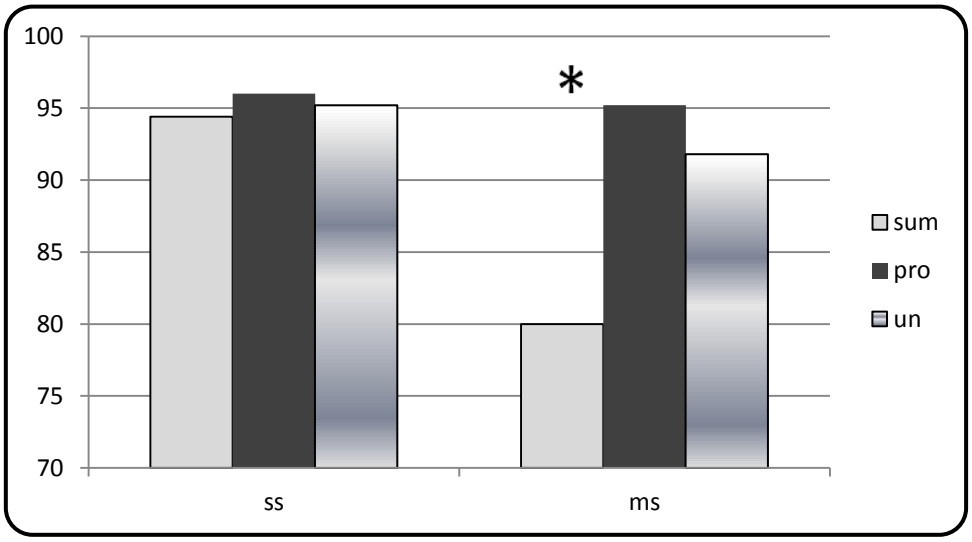
To explain this finding, we can consider the fact that the sum targets of medium size addend problems are bigger in size than the sums of small size problems (e.g., 6 as sum of the small size addend problem 4+2; 13 as sum of the medium size addend problem 9+4). Consequently, we can assume the use of an estimation-driven strategy based on which children tend to reject big numbers. Even more, this hypothesis would hold also for the product targets, accounting for the ceiling effect of the product accuracy. On one hand, this hypothesis is consistent with the fact that no evidence was found for obligatory activation of multiplication facts. On the other hand, we can assume the residual presence of an estimation strategy. Whereas a conflict of strategies as an

explanation for the drop in accuracy for sum targets can be hypothesized limited to the medium size addend condition, it seems that this is not the case for the small size addend condition in which the conflict might be already solved in favour of the obligatory activation of the addition facts.

Experiment 6. The main effects of class ($F(1,36)=9.02$, $p<.001$) was significant, being the CLIL class significantly more accurate in responding than the control class. The main effect of target type ($F(2,72)=18.05$, $p<.001$) and addend size ($F(1,36)=30.14$, $p<.001$) were significant. Additionally, the interaction between target type and addend size reached significance ($F(2,72)=15.76$, $p<.001$) but no other interactions did (target type x class: $F<1$; addend size x class: $F(1,36)=1.34$, $p=.25$; target type x addend size x class: $F(2,72)=1.73$, $p=.18$). A confusion effect between addition and multiplication would be accounted by a higher error rate in responses for product targets than those for sum targets. However, appropriate comparison of percentage of correct responses showed no evidence of confusion effect.

Such as in Experiment 5, considering the interaction between target type and addend size, the comparisons between accuracy for sum and product targets showed the reverse direction of the confusion effect, occurring with a significant (p adjusted fdr=.001) lower percentage of error rate for product targets than those for sum targets with medium size addends, as shown in Figure 11. Moreover, whereas the accuracy percentage showed a ceiling effect in the three different target types in the small size addend condition, in the medium size condition a drop in accuracy for sum targets can be detected, leading again to a different pattern in error rate between the two addend size conditions, consistently with Experiment 5.

Figure 11. Mean percentage of correct responses as a function of target type (sum, product, unrelated) and addend size (ss=small size; ms=medium size) in Year 5. The asterisk (*) indicates the significant difference between sum targets and product targets in the medium size addend condition.



RT data

Table 4 Year 5 target type mean correct response time in milliseconds and standard deviation (SD) in function of target type, addend size (ss= small size; ms= medium size) and class in Experiment 5 and 6

	Target type					
	sum		***unrelated***		***product***	
Addend size	ss (SD)	ms (SD)	ss (SD)	ms (SD)	ss (SD)	ms (SD)
Exp. 5 (Ita)						
CLIL	997 (230)	1134 (283)	1123 (243)	1225 (247)	1117 (260)	1189 (235)
Control	1202 (185)	1481 (292)	1303 (235)	1509 (300)	1279 (170)	1386 (232)
Exp. 6(Eng)						
CLIL	1007 (255)	1233 (278)	1082 (237)	1240 (298)	1101 (232)	1244 (316)
Control	1270 (221)	1525 (310)	1357 (233)	1517 (342)	1302 (253)	1461 (287)

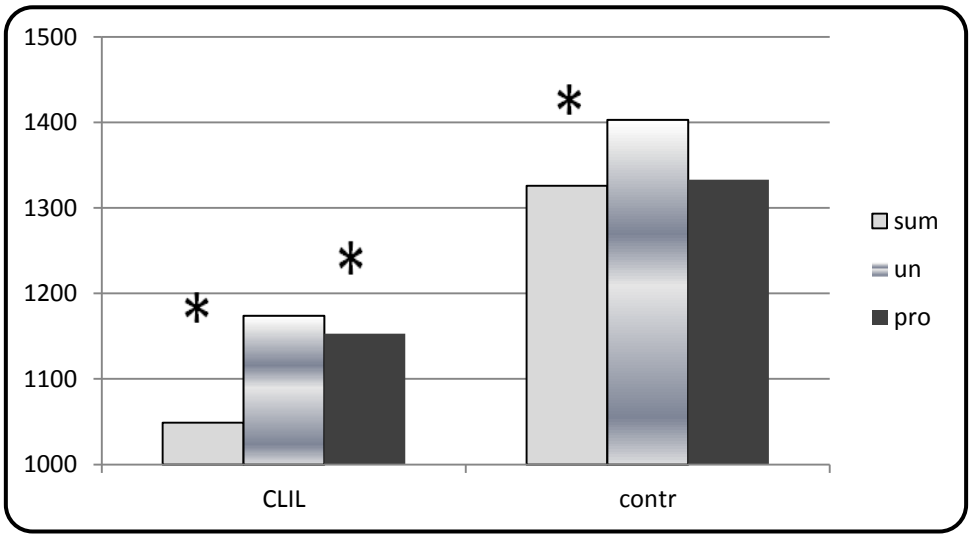
Experiment 5. The main effects of class ($F(1,38)=11.47$, $p=.001$) was significant, being the CLIL class significantly faster in response times than the control class. The main effect of target type ($F(2,76)=9.49$, $p<.001$) and addend size ($F(1,38)=53.10$, $p<.001$) were significant. The interaction between target type and addend size reached significance ($F(2,76)=8.79$, $p<.001$) as well as the interaction between target type and

class (F(2,76)=3.66, p=.03). On the contrary, the interaction between addend size and class was not significant (F<1) and so that the interaction between target type, addend size and class (F<1), leading to the conclusion that the addend size had the same relevance for both classes.

Appropriate comparison of means of correct RTs in function of target type and addend size showed a significant difference in RTs between the small and medium addend size only with unrelated targets (p adjusted with fdr=.04).

Shorter response times to sum targets than those to unrelated targets would account for an interference effect as evidence of the occurred obligatory activation of the addition facts. Considering the interaction between target type and class, appropriate comparison of means of correct RTs showed a sum-based interference effect with latencies significantly faster for sum targets than for unrelated targets (CLIL: sum 1049 vs. unrelated 1174, control: sum 1326 vs. unrelated 1403) in both classes (CLIL p=<.001, control p=.03; all ps were adjusted with fdr), as shown in Figure 12.

Figure 12. Mean RTs of correct responses as a function of target type (sum, unrelated, product) and class (CLIL and control). The asterisks (*) indicate the significant difference between sum and unrelated targets in both classes, and the significant difference between sum targets and products targets in the CLIL class.



Moreover, the analysis showed also significantly faster RTs for sum targets than for product targets (sum 1049 vs. product 1153) but only in the CLIL class (p adjusted with fdr=.03). This finding can be interpreted as a further confirmation of the sum-based interference effect, leading to the hypothesis that the effect might be considered somehow stronger in the CLIL class than in the control class.

Slower negative response times for product targets than for unrelated targets would account for a confusion effect. However, appropriate comparison of means of correct response showed no evidence of confusion effect.

Experiment 6. The main effect of class ($F(1,36)=11.2$, $p=.001$) was significant, being the CLIL class significantly faster in response times than the control class. The main effect of addend size ($F(1,36)=82.54$, $p<.001$) was significant with response times for the small size addend condition significantly faster than response times for the medium size condition. The main effect of target type approached significance ($F(2,72)=2.6$, $p=.08$). No interaction reached significance (addend size x class: $F<1$; target type x class: $F(2,72)=1.03$, $p=.36$; target type x addend size: $F(2,72)=2.88$, $p=.06$; target type x class x addend size: $F<1$). These pattern of results do not provide evidence of sum-based facilitation effect and confusion effect between sum and multiplication in both classes.

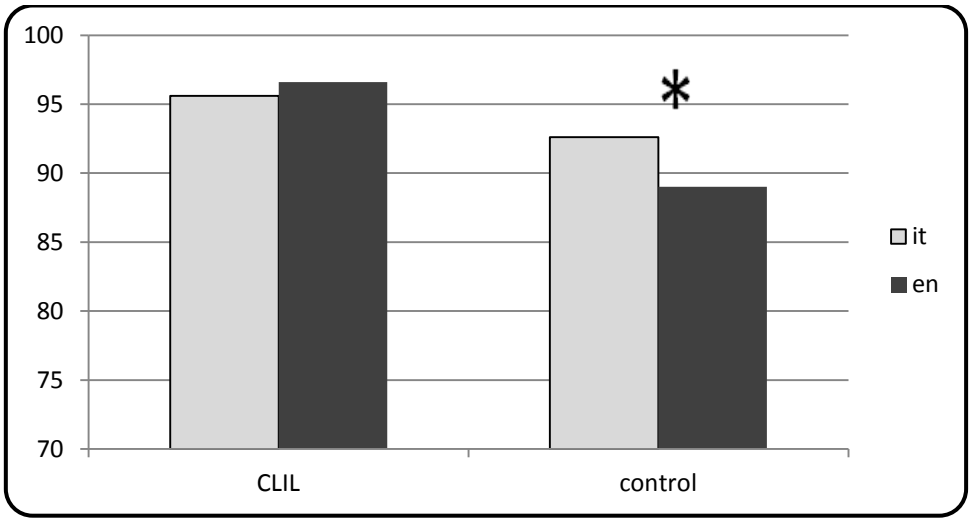
Finally, we considered the performances of the two Year 5 classes in the two experiments. Experiment and class were entered as factors in a two-way repeated-measures ANOVA on percentages of correct responses and on mean correct RTs.

Accuracy data

The main effect of class was significant ($F(1,35)=19.64$, $p<.001$) with the CLIL class significantly more accurate than the control class. The main effect of experiment was approaching significance ($F(1,35)=3.18$, $p=.056$). The interaction between class and experiment was significant ($F(1,35)=11.33$. $p=.001$).

Appropriate comparison of means have shown that the control class error rate differs in the two experiments, being significantly less accurate (p adjusted fdr<.001) in the experiment with English spoken targets while the CLIL class was not, as shown in Figure 13.

Figure 13. Mean percentage of correct responses as a function of experiment (it=Italian spoken targets, en=English spoken targets) and class (CLIL and control). The asterisk (*) indicates the significant difference in the control class between the experiment with Italian spoken numbers and the one with English spoken targets.



The significantly higher error rate in Experiment 6 for the control class could be accounted for by the fact that the experiment with English targets resulted in being more difficult.

RT data

The main effect of class was significant ($F(3,99)=3.05$, $p<.001$) with the CLIL class significantly faster than the control class. The main effect of experiment was not significant ($F(1,35)=2.34$, $p=.13$), as well as the interaction between experiment and class ($F(1,35)=1.77$, $p=.19$).

Year 4

Due to the low percentage of accuracy (68.3%) the data from a participant were not included in the analysis of Experiment 5 and the data of two pupils (68% and 66% accuracy percentage) were not included in the analysis of Experiment 6. Percentage of correct responses (Table 5) and mean correct RTs (Table 6) were analyzed in a 3 (target type: sum, unrelated, product) x 2 (class: CLIL, control) x 2 (addend size: small size, medium size) repeated-measure analysis of variance (ANOVA). Target type and addend size were within factors and class a between factor.

Accuracy data

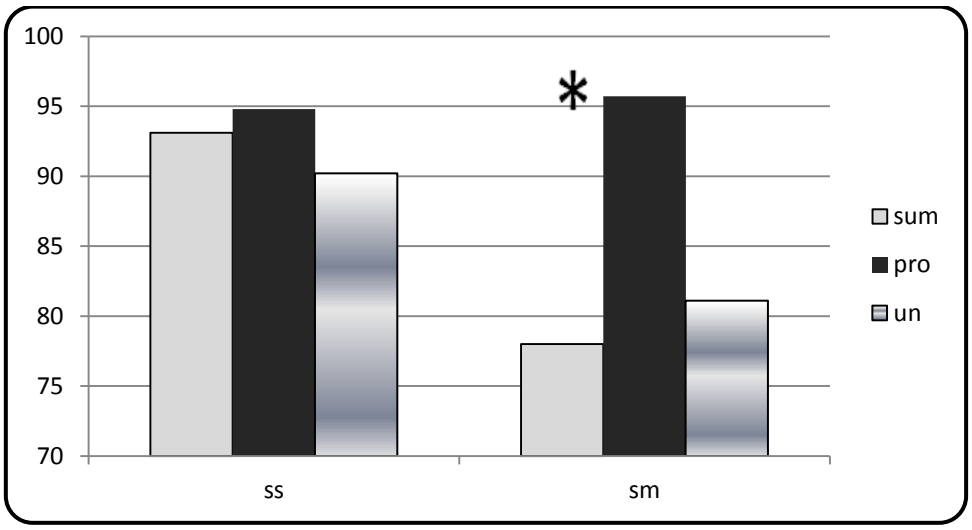
Table 5 Year 4 target type mean percentage (%) and standard deviation (SD) of correct responses in function of target type, addend size (ss= small size; ms= medium size) and class in Experiment 5 and 6.

	Target type					
	sum		***unrelated***		***product***	
Addend size	ss (SD)	ms (SD)	ss (SD)	ms (SD)	ss (SD)	sm (SD)
Exp. 5 (Ita)						
CLIL	92.3 (9.7)	74.1 (15)	89.4 (8.9)	80 (18.3)	94.7 (6.2)	93.5 (7.8)
Control	93.8 (9.1)	81.6 (10.6)	91.1 (9)	82.2 (15.1)	95 (5.1)	97.7 (5.4)
Exp. 6 (Eng)						
CLIL	85.7 (12.6)	71.1 (14)	91.1 (8.5)	82.9 (18.9)	91.1 (8.5)	91.1 (10.5)
Control	89.4 (8.2)	74.1 (12.7)	90 (9.3)	80.5 (17.8)	92.3 (8.3)	84.7 (12.3)

Experiment 5. The main effects of target type ($F(2,66)=25.02$, $p<.001$) and addend size ($F(1,33)=35.56$, $p<.001$) were significant, whereas the main effect of class was not ($p=.2$). The interaction between target type and addend size reached significance ($F(2,66)=22.77$, $p<.001$). No other interactions was significant (target type x class: $F<1$; addend size x class: $F(1,33)=1,7$, $p=.2$: target type x addend size x class: $F<1$).

Higher error rate in responses for product targets than for sum targets would account for a confusion effect. However, appropriate comparison of means of percentage of correct responses in function of target types and addend sizes showed no evidence of the confusion effect. On the contrary, the comparisons between accuracy for sum and product targets showed the reverse direction of the confusion effect, occurring with a significant (p adjusted fdr <.001) lower percentage of error rate for product targets than those for sum targets with medium size addends (product 95.7 vs. sum 78), as shown in Figure 14.

Figure 14. Mean percentage of correct responses as a function of target type (sum, product, unrelated) and addend size (ss=small size; ms=medium size) in Year 4. The asterisk (*) show the significant difference between sum targets and product targets in the medium size condition.



Additionally, a different pattern in error rate between the two addend size conditions can be detected. Particularly, whereas with small size addends the accuracy percentage showed a ceiling effect in the three different target types, with medium size addends there is a drop in error rate for sum targets, consistently with the result of Year 5.

Experiment 6. The analysis showed that neither main effects nor interactions reached significance. Only the main effects of addend size (p=.059) and the interaction between target type and addend size (p=.059) approached significance.

RT data

Table 6 Year 4 target type mean correct response time in milliseconds and standard deviation (SD) in function of target type, addend size (ss= small size; ms= medium size) and class in Experiment 5 and 6

	Target type					
	sum		***neutral***		***product***	
Addend size	ss (SD)	ms (SD)	ss (SD)	ms (SD)	ss (SD)	ms (SD)
Exp. 5 (Ita)						
CLIL	1150 (283)	1475 (418)	1281 (286)	1462 (413)	1339 (342)	1384 (343)
Control	1285 (241)	1605 (281)	1470 (212)	1713 (235)	1471 (243)	1551 (254)
Exp. 6(Eng)						
CLIL	1182 (277)	1398 (373)	1279 (321)	1488 (406)	1282 (305)	1396 (394)
Control	1404 (255)	1668 (306)	1464 (226)	1676 (236)	1507 (229)	1673 (287)

Experiment 5. The main effect of target type ($F(2,76)=9.49$, $p<.001$) and addend size ($F(1,38)=53.10$, $p<.001$) were significant, whereas the main effect of class was not (p=.1). Only the interaction between target type and addend size reached significance ($F(2,76)=8.79$, $p<.001$).

Appropriate comparison of means of correct RTs in function of target type and addend size showed a significant difference in RTs between the small and medium size addends both for unrelated (p adjusted fdr<.001) and product targets (p adjusted with fdr=.04).

Faster response times for sum targets than those for unrelated targets would account for a sum-based interference effect. No evidence was found.

Slower negative response times for product targets than for unrelated targets would account for a confusion effect. However, appropriate comparison of RTs means showed no evidence of confusion effect. Additionally, post-hoc analysis showed approaching significance (p adjusted fdr=.058) faster RTs for sum than for product targets with small size addends but the reverse direction of the pattern with medium size addends that shows significantly faster RTs for product than for sum targets (p adjusted fdr=.02) and also for unrelated targets (p adjusted fdr<.001).

Experiment 6. The analysis showed that neither main effects nor interactions reached significance. Only addend size approached significance (p=.08).

Finally, we considered the performances of Year 4 classes in the two experiments. Experiment and class were entered as factors in a two-way repeated-measures ANOVA on percentages of correct responses and on mean correct RTs.

Accuracy data

A main effect of experiment was significant for accuracy ($F(1,31)=10.86$, $p<.001$) and experiment and class interacted in a significant way ($F(1,31)=4.8$, $p=.03$). Appropriate comparison of means showed that the control class error rate differs in the two experiments, being significantly less accurate (p adjusted fdr<.001) in the experiment with English spoken targets while the CLIL class did not. The significantly higher error rate in Experiment 6 for the control class could be accounted for by the fact that the experiment with English targets resulted in being more difficult.

RT data

A main effect of class was significant for RTs ($F(1,31)=6.36$, $p=.01$) with the CLIL class significantly faster than the control class. Neither the main effect of experiment reached significance nor did the interaction between experiment and class .

4.2.2 Conclusions

In this study, we aimed at finding evidence for obligatory activation of addition and multiplication facts in Year 4 (9-10 year old) and Year 5 (10-11 year old) Italian Primary school children. In fact, previous studies investigating the presence of associative effects (e.g., sum-based interference effect and confusion effect between addition and multiplication) as evidence for obligatory activation of the arithmetic facts has led to rather controversial results and some open issues (Zbrodoff, 1979; Hamann and Aschcraft, 1985; Koshmider and Ashcraft, 1991; Lemaire et al., 1991). The latter mostly concern the extent to which the findings might depend on the specific task adopted, on the type of stimuli and/or on the influence of other factors, such as the age of the pupils, the problem size and the distance between the numbers of the problems and the target.

At the same time, we explored the influence of the language in retrieving arithmetic facts, and particularly the presence of LoLA effects in the obligatory activation of the arithmetic facts when at school the language of instruction for arithmetic is not the mother tongue but a foreign language. Specifically, the study was aimed at detecting possible differences across the two experiments and between the control classes and the CLIL classes that had English as the only language of instruction

for Mathematics since the first year of formal schooling. The two within-group design experiments employed a verification task in which the participants were asked to judge the correctness of simple addition problems consisting of single-digit addends visually presented. In order to disentangle the specific role of the language, the targets to be verified, which can be single or two-digit numbers, were presented in the auditory modality, namely the targets were Italian spoken numbers in Experiment 5 and English spoken numbers in Experiment 6.

The results show a sum-based interference effect at Year 5, confirming the fact that evidence for obligatory activation of addition facts can be detected in 10-11 year old school children. The effect was found in latencies, only in the experiment with Italian spoken targets and not in the one with English spoken targets . On one hand, the CLIL class seems not hampered or negatively affected by having English as the language of instruction for Mathematics. On the other hand, our finding suggests that the obligatory activation is triggered in both classes only by mother-tongue spoken targets. Given this, it might be assumed that the strength of activation of the format is at least language-sensitive. Concerning specifically the CLIL class, our finding argues against the assumption that after five years of formal teaching and practicing at school the language of instruction can act as the mother tongue or even as the preferred language in performing arithmetic tasks.

No evidence of sum-based interference effect was found in Year 4 classes. This finding may be accounted for by assuming that at this age the associative links in addition facts are still developing and not yet strong and strengthened enough to produce obligatory activation.

In none of the experiments, the results show a confusion effect between addition and multiplication, neither in Year 5 nor in Year 4 classes. This result suggests that multiplication facts might be not activated automatically in Primary school children. This finding confirms the result of previous studies (Lemaire et al., 1994), according to which, in a developmental perspective, the product activation emerges later; as a further explanation, we can also consider the fact that multiplications are taught and practiced in school later than additions.

Additionally, the results showed that, overall, the children were more accurate and faster in responding to small size than medium size addend problems, confirming the size effect being reliable and consistent in all classes, regardless of the language.

Moreover, the comparison between the performance of each class across the experiments showed that the control classes were both significantly less accurate in the experiment with English targets than in the experiment with Italian targets. On the contrary, the CLIL classes in the experiment with English targets were as accurate as in the one with Italian targets. However, considering the response times, the same comparison led to a different pattern of results. In fact, in each class there were no differences in RTs in the two experiments and this is consistent with the findings of Experiment 2, 3 and 4. Nonetheless, differently from the previous experiments, this time also two-digit numbers have been used as targets and it is more likely that not all of them might be easily recognized in both languages. Hence, our hypothesis would predict slower response times in the experiment with English targets, at least for the control classes. However, this finding argues against our previous assumption, leading to the conclusion that in performing simple arithmetic problems the language seems not to be that relevant in terms of speed. We might even state that this pattern of results can

rule out the hypothesis about a preliminary ”translation” of the English target into the mother tongue preceding the cognitive processing.

In conclusion, the results reported in this study are of particular relevance in that they show the presence of an interference effect in Year 5 school children as an evidence of the obligatory activation of addition facts. Equally relevant, no evidence of automatic activation of simple multiplication facts was found, leading to the conclusion that connections and associative links in the arithmetic facts domain are still developing, as confirmed also by the results from Year 4 classes.

Regarding the LoLA effect, if for the CLIL classes a higher accuracy can be detected in performing the experiment with English numbers, overall, there is no evidence-based proof of a preferred language.

APPENDIX 2

Additions and targets used in Experiment 5 and 6

Addition	Target	Addition	Target
9 + 3	27	4 + 9	13
5 + 7	12	3 + 2	6
3 + 8	24	1 + 3	8
8 + 4	12	9 + 3	12
3 + 1	4	2 + 8	16
1 + 3	3	4 + 7	28
4 + 9	36	1 + 2	3
8 + 7	15	3 + 1	5
2 + 1	4	2 + 6	8
7 + 8	15	3 + 8	15
4 + 2	8	8 + 4	32
9 + 4	13	8 + 6	14
1 + 2	2	6 + 4	24
3 + 4	7	9 + 7	16
7 + 2	14	3 + 2	1
4 + 3	12	2 + 8	10
5 + 1	6	8 + 5	13
3 + 4	12	1 + 2	7
9 + 5	14	3 + 8	11
6 + 7	13	5 + 5	10
9 + 4	12	2 + 1	3
2 + 8	11	4 + 2	5
7 + 5	12	9 + 1	10
1 + 4	4	6 + 9	15
7 + 9	16	4 + 3	6
1 + 4	5	2 + 4	8
3 + 1	3	4 + 7	11
3 + 4	8	3 + 6	9
4 + 3	7	8 + 4	8
2 + 3	5	1 + 3	4
4 + 9	12	2 + 4	2
3 + 2	5	5 + 8	13
6 + 4	9	3 + 6	18
9 + 3	16	6 + 4	10
4 + 2	6	4 + 7	7

9 + 4	36	6 + 8	14
7 + 2	9	2 + 1	2
5 + 6	11	7 + 2	10
1 + 4	1	3 + 6	13
9 + 6	15	2 + 4	6

Summary and Conclusions

The research reported in this thesis focused on bilingual education in the Primary School and more specifically on how and to which extent the processes of teaching and learning are affected when most of the school subjects are taught using a foreign language (FL) as a medium of instruction, such as in the *Classi bilingui* pilot programme.

Chapter 1 draws a picture of CLIL and its implementation in the European context. As an "umbrella" term that can be applied to any dual-focused educational experience in which a language other than the learners' first language is used as a medium of instruction for non-language content, CLIL has been seen as an effective way for encouraging and fostering the development of multilingual skills among the European population. Following social and cultural needs linked to the processes of internationalization and of increasing mobility, studies and guidelines of the European Union have stressed the importance of the multilingualism as an essential element of the identity and citizenship of Europe and for the integration and cohabitation in a multi-cultural society (White Paper, 1995). To sum up, according to the general framework in which CLIL is positioned by the European policy, it can be said that CLIL is seen as an approach effective both in bridging the delivery gap existing between what is provided as FL education and the outcomes of the learners performance and also in favouring the development of intercultural competences.

After roughly twenty years of implementation throughout Europe, CLIL exists in nearly all countries at primary and secondary levels even though it is certainly not yet widespread. Its most distinctive feature is undeniably the great degree of variability that characterized the CLIL provision all over Europe which makes CLIL experiences very difficult, if not impossible, to compare. This variability is mainly due to the strong differences between the national educational systems and the considerable degree of autonomy of the single schools. The variability ranges from the number of the subjects involved in CLIL and their combination to the percentage of CLIL in the curricula, from the average and/or minimum amount of weekly CLIL lesson time to the starting class, from continuity or discontinuity among the school levels, from the presence or absence of admission criteria and of centralized or school-based CLIL measures to the teachers' professional requirements and training. Nevertheless, in the very heterogeneous landscape of CLIL implemented through a myriad of different and diverse experiences and organizational models, a common point can be found in the almost complete lack of monitoring and evaluation of CLIL, both at the school and at the national level, with just a few exceptions, such as Estonia and The Netherlands.

Along this line, the implementation of CLIL in Italy shares most of the distinctive features of the CLIL provision in Europe. In particular, Italy stands out for the total lack of centralized planning and guidelines for CLIL introduction and implementation. There is no surprise that CLIL has developed in the last fifteen years as a grassroots movement with CLIL experiences undertaken by schools and group of teachers practically on individual basis. Only few regional and provincial educational institutions in the north of Italy promoted CLIL-related projects and actions, usually providing pre- and in-service professional development courses for language teachers and non-linguistic

subject teachers. To sum up, the lack of a systematic survey at the national level has made it almost impossible to get a complete map of the availability of CLIL programmes but it can be assumed that CLIL provision is still very limited and implemented mostly through the activation of short modules based on a team-teaching approach. It is worth noticing though that recently the law concerning the last school reform (L.169/2008), effective for the Secondary school in 2010 (DPR n.89/2010), has provided a new curriculum with the introduction of a mandatory non-linguistic subject taught through a foreign language, starting from the students on the "language" pathway (Liceo Linguistico) and after involving the other Lyceums and Technical Institutes. The gradual introduction of CLIL in Secondary education at the national level has started in the a.y. 2012-2013 in Year 3 of Liceo Linguistico and should be implemented in Year 5 in all of the different types of Secondary school from the academic year 2014-2015, even though regulations and conditions are still to be clarified.

Even though inserted in the Italian context, the CLIL implementation in the Autonomous Province of Trento has its own peculiarity, given the fact that the promotion of multilingualism has been for some years now an element on which a relevant amount of attention has been paid by the provincial educational institutions and that strongly characterises the school system in Trentino.

Since the academic year 2005-2006, the PAT has implemented a project integrating the progressive diffusion of educational programmes in which is foreseen the use of English and/or German as a means for teaching the curriculum. These pilot programmes have had impact on all the school levels, from nursery to secondary education, with an increasing involvement especially within Primary schools. All these programmes have referred to CLIL as the recognised methodology of teaching and learning where a

language other than the pupils' mother tongue is used as a medium of instruction and interaction in teaching non-linguistic contents.

On one hand, the CLIL implementation in Trentino presents a considerable degree of variability, concerning different degrees of diffusion of CLIL among the different schools, in terms of the number of CLIL classes and the percentage of CLIL in the curriculum. In this respect, the Trentino's CLIL experience is by all means inserted in the heterogeneous picture of the CLIL provision in Europe.

On the other hand, according to the figures released by PAT, from a quantitative perspective, the degree of diffusion and the weight of CLIL in relation to the small size of the school system put Trentino's CLIL experience in an interesting position certainly in the Italian and probably also in the European context.

Given the fact that CLIL has spread out as a grassroots movement driven by the initiative of interested and motivated teachers and schools, it is natural that CLIL practice has largely preceded research and research in CLIL is still moving its first steps. If the first discussions focused mainly on the methodological aspects of CLIL, once that they were framed, at least at a very general level, research on CLIL has developed in two directions. The first encompasses action-research studies in CLIL classes focused on language competence and attitude towards the FL that showed extremely positive results in the students' attitude and attainment of receptive skills in the FL. However, far less positive results have been found for the productive skills, especially speaking and also for grammar competence and vocabulary knowledge. These elements have triggered a large amount of research, especially in the North America area, with the aim of addressing these weaknesses and of making a strong point in stressing the need and importance of a systematic focus on language objectives,

form, metalinguistic awareness and opportunities for production practice. The second group of studies focused on good and effective teaching practices and class materials, on the investigation of students', parents' and teachers' perceptions on CLIL through qualitative research paradigm and on the identification of indicators of an effective CLIL pedagogy.

However, despite the growing body of literature about CLIL, outcome-oriented research and empirical studies are rare, leading to state that the development of substantial evidence-based studies can be considered nowadays the main challenge to be addressed. Moreover, besides the need of empirical studies based on research design that can be mixed, combining both quantitative and qualitative research methods, and that can favor a longitudinal perspective, future studies need also to tackle areas that so far have been almost completely neglected, and particularly the subject-specific pedagogy and the acquisition of subjects' competences in the CLIL-specific case of contents for which a FL is used as the medium of instructions.

Chapter 2 reported the monitoring conducted on the *Classi bilingui* semi-immersion programme, characterized by a high intensity of tuition in English. Since no evaluation or assessment have been carried out by the local education institutions during the five years of the programme implementation, the timing of this investigation has resulted in being particularly appropriate.

Firstly, the study presents a context analysis that aims at surveying and shading a light on teachers' and parents' motivation, perceptions, needs and attitude towards this specific educational context. According to previous studies (e.g., Mehisto and Asser, 2007), these aspects are very relevant in pointing out the factors that have been

fundamental at the initial stage of the programme and in providing additional insights for the effective and successful development of the programme in the future.

Based upon data from teachers' and parents' questionnaires and from the content analysis of interviews and field notes of observations of several teachers' meetings, the analysis provided a rich description of the educational context. It revealed an extremely positive relational environment characterized by very good relationships between teachers and families. The latter expressed a high degree of appreciation towards the programme, the quality assured and towards the educational experience overall. A high degree of motivation, collaboration and undertaking of responsibility emerged as well as a distinctive feature of the *Classi bilingui* context. The teachers' perceptions on the programme revealed a high degree of motivation and satisfaction but also the awareness of the challenges and the high amount of extra personal effort and time the programme implies. The importance of the colleagues' collaboration, of the coordinator's support and of the teachers' group meetings emerged as the factors that mostly contributed in supporting the teachers both in growing and fostering their professional expertise and in building their identity as a group totally in charge and responsible for the programme implementation and development.

Secondly, a curriculum study was conducted with the aim of investigating the impact of the programme on the curriculum. From the methodological point of view, the Van de Akker's (2003) framework for curriculum development and evaluation have been taken into account. This framework describes the different levels in which a curriculum can be represented: the intended curriculum, the implemented curriculum and the attained curriculum, providing a practical and effective comprehensive framework for identifying and investigating the different curriculum components and a

guideline for their specific and detailed description. Moreover, it helps in paying attention to the specific intentions expressed at the intended curriculum level and on how they are then translated by the teachers at the operational level.

The study is based upon the analysis of different school documents (e.g., the *Classi bilingui* official document, the Plans of study, annual and two-month class planning, etc.), observations of the teachers' meetings especially dedicated to the writing of the Plans of study and on data of the outcomes of the students' standardized tests. The descriptive analysis of the diverse elements at the different levels of the curriculum representation highlighted the fact that, in general, the curriculum implementation has triggered the setting up and the development of a shared educational project which has played also a relevant role in fostering the identity of the teachers' as a group of professionals. The specific linguistic feature of the programme foresees a great amount of exposure to the FL and most of the subjects taught from Year 1 entirely using English as the medium of instruction. Hence, a CLIL programme with such a degree of intensity has required a careful consideration and a systematic and continuous reflection on the challenges the programme implies, both at the content and at methodological level.

At the intended curriculum level, the pedagogical framework has incorporated both the reference to the Cognitivist and Sociocultural learning theories and the main issues and principles of the bilingual education, namely the linguistic interdependence and the concept of additive bilingual learning. The latter has led to extensive discussions about the need of defining precise guidelines for the role of the two languages and the level of linguistic competence that the pupils are expected to achieve. Staying at the intended curriculum level, the Plans of study are the formal, written curriculum and represent an

essential part of it. On one hand, they reflected the urge of identifying the list of skills and knowledge for each subject, taking firstly into account the guidelines and the competences provided by the Provincial Plans of study which are the first point of reference. On the other hand, the relevant amount of group work needed for the writing of the *Classi bilingui* curriculum became the trigger for an extensive reflection on the educational curriculum implemented in the very first years of the programme, on the methodological choices and on how and to what extent the methodological aspects needed to be improved, developed, shared and framed. The writing of the Plans automatically led to the necessity of a deeper methodological reflection on the core-issue of the relationship between language and content and on the "how" the content can be effectively delivered in any of the language used as medium of instruction. In this respect, deeply rooted in a language-sensitive approach, an integrated cross-subject and cross-content language pedagogy is proposed. Its key principles are explicitly mentioned and taken into account at the curriculum implementation level, both in the methodological introductions to the subjects and in the lesson plans of each class.

At the attained curriculum level, the decision of administering standardized tests for Italian (reading comprehension and orthography accuracy) and Mathematics (numeracy and problem solving limited to Year 3, 4, 5) is to be seen as a first, partial attempt of answering to the question about the level of competence achieved by the *Classi bilingui* pupils and especially to the need of a better understanding concerning the effect on the pupils' performance of the massive use of English and the parallel reduction of the use of the mother tongue. The analysis of the outcomes indicates a positive picture that does not reveal any critical situation and an average degree of variability in the score distribution. In general, no delays or drawbacks both in Italian and in Mathematics have

been found. Hence, it seems reasonable to state that the use of English for more than 50% of the school time and in particular as the language of instruction for Maths does not have negative effects on the learning outcomes in Italian and Mathematics.

Finally, the study sketches the factors that have mainly contributed to the success of the programme, the necessary conditions for its sustainability and some suggestions about measure and actions to be undertaken in the next future in order to improve and consolidate the programme.

Moving to the experimental research, *Chapter 3* and *Chapter 4* reported six experiments aimed at investigating in Italian Primary school children 1) the presence of interference effects in mental arithmetic as evidence for the obligatory activation of the arithmetic facts and 2) the presence of LoLA (Language of Learning Arithmetic) effect in the obligatory activation of the arithmetic facts when the language of acquisition is not the mother tongue but a FL. In fact, half of the classes of the sample under investigation were CLIL classes, in which children have been taught and trained in Mathematics with English as a medium of instruction since their first year of formal schooling.

Previous studies investigated the role of retrieval processes in basic mental arithmetic in children and the question whether and when associative links and connections in the network of the arithmetic facts stored in the long term memory are strong enough to lead to the automatic activation of the arithmetic facts, namely the results of additions with single-digit operands and of multiplications of the timetables. Most of these studies employed a verification task that is a direct arithmetic task in which the participants are asked to judge the correctness of basic arithmetic problems. While Zbrodoff (1979) and Lemaire and colleagues (1991) found associative-based

interference effects as evidence that both sum and product activations occurred in Primary school children, on the contrary Ashcraft and colleagues (1985, 1991) found associative interference effects rather late and only after nine, ten years of formal schooling.

As far as we know, no study has investigated language-specific effects on the obligatory activation of the arithmetic facts in Primary school children. Moreover, the specific issue related to the language of acquisition have never been considered in isolation. Only very few studies investigated the influence of the second language in bilingual adults, defined as late and low skilled bilinguals (Frenck-Mestre and Vaid's, 1993), and in High school students (Bernardo, 2001) in verification task experiments using three different formats for the stimuli: digits, word numbers in the first language and word numbers in the second language. Different patterns of results were detected in both studies in the two different language conditions. For the low skilled bilingual adults interference effects were found only with word numbers in the mother tongue leading to the conclusion that the associative links in the network of the arithmetic facts seem to be restricted to the first language and to the assumption that the retrieval of the arithmetic fact is at least language-sensitive if not language-dependent. Regarding the High school students, interference effects were detected with word number in English and not with word numbers in their first language, leading to the conclusion that English, being the second language of this specific group of subjects but also the language of instruction for mathematics, can be considered their preferred language rather than their native language.

The role of retrieval processing in basic mental arithmetic and the underlying cognitive processes have been also investigated in the experiments that used an indirect

arithmetic task such as the number matching task (LeFevre et al., 1988). This task neither implies any arithmetical knowledge nor requires any calculation competence as the participants are only required to match digits. Moreover, the number matching task seems to better fulfilled the automaticity criterions (Zbrodoff and Logan, 1986) and particularly the autonomy and the lack of intention, since the participants are not required to perform arithmetic calculations. Number matching experiments with adult participants are reported by several studies (LeFevre et al., 1988; Lemaire et al., 1991, Thibodeau et al., 1996; Galfano et al., 2003; Rusconi et al., 2004) that found both sum-based and multiplication-based interference effects. Interestingly, the results of some of these studies showed that the effects are not influenced by the format of the numbers. In fact, the above mentioned effects are detected when the numbers appeared both as digits and as word numbers.

Only two studies (LeFevre et al., 1991; Lemaire et al., 1994) employed the number matching task in experiments with Primary school children. The results are rather controversial, showing a weak and unstable sum-based interference effect found only in accuracy (LeFevre et al., 1991) or in latencies (Lemaire et al., 1994).

The four experiments reported in *Chapter 3* have been designed in order to investigate the activation of addition facts in Primary school children and the specific contribution of the language of acquisition in the same domain.

Experiment 1 aimed at finding the presence of sum-based interference effect as evidence for obligatory activation of the addition facts in Year 4 Italian children, employing a number matching task in which the stimuli (Arabic digits) are visually presented. It can be considered as a replication of the above mentioned two last studies,

even though a particular attention has been paid in setting up the list of stimuli in order to avoid some methodological issues arisen from the previous two studies.

Experiment 2, *Experiment 3* and *Experiment 4* have been designed with the aim of detecting LoLa effect in the automatic activation of addition facts. In order to do this, a manipulation has been set up in the number matching task of Experiment 1, employing a cross-modal presentation of the stimuli. Specifically, being the pairs always visually presented, the targets are Italian spoken numbers in Experiment 2, English spoken numbers in Experiment 3 and German spoken numbers in Experiment 4. The reasons for adopting this novel cross visual-auditory modality are twofold. While written number words have been extensively used in studies with adults, we feel they are not appropriate for Primary school children, since firstly it would represent a very unusual and unfamiliar format and secondly it may create possible confounds with automaticity in the reading processes, especially for the English number words. Moreover, spoken numbers are the most used inputs in practicing and training mental arithmetic and definitely the number format to which children are mostly accustomed to for arithmetic facts.

The results do not show a sum-based interference effect at Year 4, neither in the only-visual modality experiment nor in the cross-modality (visual-audio) experiments. This may be accounted for by assuming that at this age arithmetic associations are still developing. Without questioning the children competence in retrieving arithmetic facts in ordinary arithmetic tasks, these patterns of results show that connections and associative links are not yet strong enough to produce obligatory activation in a non-arithmetic task. It might be argued as well that the number matching paradigm as a non-

arithmetical task is too “sophisticated” and not appropriate for children. It might be the case that the task is perceived by the children as being rather unnatural and odd.

Given the fact that in none of the experiments there was any evidence for obligatory activation of simple addition facts, it is consequently not possible to disentangle the issue about a language-specific influence in the automatic activation of the arithmetic facts. Nevertheless, the experiments with spoken targets in the three different languages can be considered as number recognition tasks. Probably, the most interesting results come from the comparisons between the performances of each class across the experiments with spoken targets. In this perspective, regarding the LoLA effect and considering the overall mean RTs in the experiments with Italian, English and German spoken targets the use of a foreign language in teaching and learning arithmetic does not hamper or negatively affect the performance of the CLIL class.

Moreover, there are no differences both in accuracy and mean RTs in the experiments with spoken targets both in the CLIL class and in the control class. It might be that these patterns of results could be dependent on the use of only single-digit numbers as targets that might be easily recognized in any of the three languages used.

Nevertheless, this finding can reasonably lead to the conclusion that, limited to this specific task, the language seems to be irrelevant and that there is not an evidence-based proof of a preferred language.

The two experiments reported in *Chapter 4* have been planned in order to investigate the activation of addition facts and the presence of an associative confusion effect between addition and multiplication in Year 4 and Year 5 Italian Primary School children. Specifically, the study aimed at finding the presence of sum-based interference effects in mental arithmetic as evidence for the obligatory activation of addition facts,

the presence of an associative confusion effect between addition and multiplication as evidence for the obligatory activation of arithmetic facts and the specific contribution of LoLA effects in the arithmetic facts domain. A verification task has been employed that is a direct arithmetic task in which the participants are asked to judge the correctness of addition sums. In order to disentangle the issue about LoLA effects and specifically the role of the language in the retrieval of the arithmetic facts, in the addition problems to be verified the targets are presented in the auditory modality, namely the targets are Italian spoken numbers in Experiment 1 and English spoken numbers in Experiment 2. Again, half of the classes of the sample are CLIL classes, in which children have been taught and trained in Mathematics with English as the language of instruction since their first year of formal schooling.

The results show a sum-based interference effect at Year 5, confirming the fact that evidence for obligatory activation of addition facts can be detected in 10-11 year old school children. The effect was found in latencies, only in the experiment with Italian spoken targets and not in the one with English spoken targets. On one hand, the CLIL class seems not hampered or negatively affected by having English as the language of instruction for Mathematics. On the other hand, our finding suggests that the obligatory activation is triggered in both classes only by mother-tongue spoken targets. Given this, it might be assumed that the strength of activation of the format is at least language-sensitive if not language-dependent. Concerning specifically the CLIL class, our finding argues against the assumption that after five years of formal teaching and practicing at school the language of instruction can act as the mother tongue or even as the preferred language in performing arithmetic tasks.

No evidence of sum-based interference effect was found in Year 4 classes. This finding may be accounted for by assuming that at this age the associative links in addition facts are still developing and not yet strong enough to produce obligatory activation.

In none of the experiments, the results show a confusion effect between addition and multiplication, neither in Year 5 nor in Year 4 classes. This result suggests that multiplication facts might not be activated automatically in Primary school children. This finding confirms the result of previous studies (Lemaire et al., 1994), according to which, from a developmental perspective, the product activation emerges later; as further explanation, we can also consider the fact that multiplications are taught and practiced in school later than additions.

Moreover, the comparison between the performance of each class across the experiments showed that the control classes were both significantly less accurate in the experiment with English targets than in the experiment with Italian targets. On the contrary, the CLIL classes in the experiment with English targets were as accurate as in the one with Italian targets. However, considering the response times, the same comparison led to a different pattern of results. In fact, in each class there were no differences in RTs in the two experiments and this is consistent with the results of Experiment 2, 3 and 4. This finding supports the assumption that in performing simple arithmetic problems the language seems not to be that relevant in terms of speed. We might even state that this pattern of results can rule out the hypothesis about a preliminary ”translation” of the English target into the mother tongue preceding the cognitive processing.

Regarding the LoLA effect, if for the CLIL classes an advantage in accuracy can be detected in performing the experiment with English numbers, overall, there is no evidence-based proof of a preferred language.

In conclusion, despite the small scale of the research, the effort to integrate qualitative and quantitative approaches has uncovered some of the major issues and questions that are likely to emerge in any CLIL implementation programme.

From a descriptive point of view, the research has highlighted how the teachers' extensive and collective reflection on what the programme implies, both at the content and at the methodological level, has led to the gradual building and development of an innovative, shared and at the same time deeply context-rooted educational course. The careful consideration of the complex nature of establishing a bilingual programme has prioritized the need of adding to the school's general pedagogical perspective a conceptual methodological framework for the integration of language and content. The integration is based upon the adoption of a comprehensive, integrated, cross-subjects, cross-contents and language-sensitive approach as well as some clear teaching and practical guidance as results of precise teachers' methodological choices. The use of common instructional practises, procedures and templates for setting-up, planning, material development, assessment and self-evaluation could be considered as tools through which the school can ensure quality teaching and learning and a successful CLIL implementation.

The investigation of the obligatory activation of the arithmetic facts in Primary school children can be considered as a partial and limited attempt of uncovering in a developmental perspective the cognitive processes underlying basic calculations and, at

the same time, the possible role that the language of acquisition can play in this specific domain. It is worth underlining that, as far as we know, the latter issue has never been taken into account in isolation.

The results of the experimental studies reported in this research are relevant in that they show the presence of a sum-based interference effect in Year 5 Primary school children as evidence for the automatic activation of addition facts. The effect was not detected in Year 4 school children. Equally relevant, no evidence of automatic activation of simple multiplication facts was found, neither in Year 5 nor in Year 4, leading to the conclusion that at this age connections and associative links in the arithmetic facts domain are still developing.

Additionally, the adoption in both studies of a visual-audio modality for presenting the stimuli has proved to be particularly fruitful and effective in allowing the consideration of the language issue in isolation. On one hand converging findings have revealed that the CLIL classes are not hampered by having Mathematics taught and practiced in a language which is not the mother tongue. On the other hand evidence for obligatory activation of the addition facts were found only with Italian numbers, leading to the assumption that, at that age, automaticity is triggered only by mother-tongue spoken numbers, regardless of the language of instruction. If we might assume that the strength of activation is at least language-sensitive if not language-dependent, at the same time we can reasonably state that, after five years of language of instruction for Mathematics at school, the foreign language does not play the role or acts as the mother tongue or even as the preferred language in performing arithmetic problems.

As suggestion for future research we think that it would be interesting to further explore the automaticity in arithmetic, in terms of development and strengthening of the

network of the arithmetic facts and of the underlying cognitive processes. It is reasonable to assume that interference effects might be more evident and distinguishable later in age and probably Middle school students (11-14 year old) would represent a very interesting sample for this kind of investigation. At the same time, in presence of a longer use of English, some changes in the pattern of results could be hypothesized also with respect to the influence and effect of the language of instruction.

Finally, it would be interesting to compare the findings of our studies with the results that can be obtain in the same experimental setting with a sample of adults with a good competence in English. The main aim would be the investigation of possible differences in terms of accuracy and speed in performing arithmetic problems in connection with the use of the mother tongue and of the foreign language.

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