Je-LKS
Journal of e-Learning and Knowledge Society
The Italian e-Learning Association Journal
PEER REVIEWED PAPERS
EMBRACING LANGUAGE AWARENESS AND LANGUAGE DIVERSITY IN THE 21ST CENTURY
Vol. 15, n.1, 2019
ISSN: 1826-6223 | eISSN: 1971-8829

INNOVATIVE STEM LESSONS, CLIL AND ICT IN MULTICULTURAL CLASSES

Elisabetta Schietroma

I.I.S. Via delle Scienze, Colleferro (Rome), Italy

Keywords: CLIL, STEM, ICT, multicultural classes, lifelong learning

This article aims to describe a number of scientific activities carried out efficiently and effectively in English, French, Spanish and Italian in High Schools. Cooperative and constructive methodologies in multicultural classes, the learner's centrality, Information and Communications Technologies (ICTs) and laboratorial tasks are the core of these projects. Every student, regardless of their linguistic, conceptual and scientific background acquired and reorganized his/her knowledge learnt by doing in multilingual contexts. Working in pairs or small groups Italians and migrants were able to perform complex and demanding tasks and create valuable digital products. Integration and the acquisition of knowledge of STEM were promoted through the awareness of teenage and adult students' language competences, their conceptual and linguistic repertoire, their learning style and their type of intelligence. Content and Language Integrated Learning (CLIL) proved to be a suitable approach to increase motivation, develop the

for citations:
Schietroma E. (2019), *Innovative STEM lessons, CLIL and ICT in multicultural classes,* Journal of e-Learning and Knowledge Society, v.15, n.1, 183-193. ISSN: 1826-6223, e-ISSN:1971-8829
DOI: 10.20368/1971-8829/1587

key European competences and promote integration. A quadrilingual approach in teaching STEM was the first successful attempt to find a solution to some problems that usually arise in multicultural classes.

1 Introduction

Although CLIL "methodology" was officially introduced in Italy in 2010 (D.P.R. n.88/2010 and D.P.R. n.89/2010), highly motivated teachers have been dealing with non-linguistic subject lessons through a foreign language since 2000 (Langé *et al.* 2014, p. 13). In 2002, the European Council in Barcelona gave importance to "Life Sciences and Biotechnology" and underlined the importance "to improve the mastery of basic skills, in particular by teaching at least two foreign languages from very early age" and promoting the "development of digital literacy" and "the European dimension in education" (E.C., 2002, p. 19-20).

The Recommendation of the European Council of 2018 highlights the concept of language awareness in the multicultural classes and the importance of disseminating good practices. These aim to better language learning and promote multilingualism by developing an open mind towards cultural and linguistic diversity and the use of digital tools (E.C., 2018). As a result, teachers have been encouraged to organize activities to motivate students and to enhance their linguistic skills through various teaching methods and integrated approaches, including the content and language integrated learning (E.C., 2014). CLIL complies with the purpose of educating competent EU-citizens in speaking their mother tongue and in learning at least two other European languages through a "cross-curricula" approach and its benefits have been widely discussed since its introduction in Europe (Cinganotto, 2018). CLIL has been recommended as a suitable vehicle to promote language learning and linguistic diversity, because the teaching/learning of a non-linguistic discipline is carried out in a context in which a foreign language is a medium to learn contents (Coyle *et al*., 2010). The presence of foreign students in Italian schools has been a norm since the end of last century. On the one hand, migrants are seen as a resource and are appreciated as carriers of innovation and new cultural elements. Foreign and Italian students have been taught to take advantage of this diversity to widen their horizons and integrate in a multicultural society. Everyone can interact during the lessons speaking their mother tongue and foreign languages to improve their skills. On the other hand, in some contexts, diversity is considered a difficult problem to tackle, an obstacle to overcome, an element of distraction and destabilization. CLIL appears to be an effective tool to promote inclusion. "Communication skills and/or language awareness as transversal themes or competences" should be identified and implemented

through the effective cooperation between language and content-based subject teachers (Eurydice, 2019, p.136).

Teaching a non-language school subject (e.g. Natural Science) through the second language, mainly English, using up-to-date technology and including tailored and catch-up lessons for support, increases motivation, prevents school truancy and segregation and enhances the school's success. In CLIL education, the Science teacher is not necessarily a native speaker of the language used to teach a non-language subject. The CLIL lessons increase the students' exposure to the foreign languages "without claiming an excessive share of the school timetable" (Eurydice, 2017, p. 55). The communication vehicles and the discipline contents should not be reduced or simplified while they are taught in a foreign language. English, German, French, Spanish and Italian for the migrants can become the languages of the entire Science lesson, even if it would sometimes be preferred to interact in the students' mother tongue and to acquire contents through a frequent switching. Authentic written and oral texts are often adapted to the students' needs following useful frameworks. Handling realia in a STEM laboratory or in a Museum as well as using images and virtual materials is more efficient and effective than translating into students' mother tongue. In addition, students express their knowledge, discuss and interact in English while they are cooperatively learning in "social and real-life contexts" (Eurydice, 2011, p. 64). From the perspective of the foreign students, who represent the linguistic minority and are competent in their own languages, the subjects are taught in the official language of the school and often according to "Hard" CLIL programmes (Ball *et al.*, 2015, p. 26-28). The education occurs in a situation of "submersion" where the Science expert, native speaker teacher's target is to help migrants to develop skills in the language and to acquire non-language contents (E.C., 2014, *op.cit.,* p. 3). Language functions and cognitive processes are used to fulfil the purposes of the teaching subject. Language awareness is promoted. Students develop their identity as Europeans and as citizens of a globalized world, overcome the perception of diversity, reflect on some common cultural aspects and benefit from the differences as resources. Giving opportunities to Italians and migrants to share culture and language with their classmates stimulates interest in other languages, countries and cultures, develops multilingual competences, contributes to mutual understanding and ensures that all citizens overcome the barriers that prevent them from integrating and mastering basic skills according to the European key competences (EC, 2018, *op. cit.*). Working in groups, all students can use creativity to plan and carry out projects, transform their innovative ideas into action, to take risks and use their skills to reach the objectives they set. They can experience the utility of turning ideas into practice and in bi- and three-dimensional objects (cultural awareness and expression). Therefore, they can develop scientific,

technological, digital, social and civic competences.

2 Teaching and learning STEM through CLIL

The first attempt to teach Genetics and Molecular Biology through authentic English scientific materials was made by the author between 2002 and 2004 in 2nd classes of the Industrial Technical Institute (I.T.I.S.) at Lonato del Garda (BS). In the context of two granted projects,[1] teenagers were introduced to complex concepts about "Life Sciences and Biotechnology" and modelling. The project plans relied on constructivist theories and aimed to promote the scientific acquisition of the contents, to develop students' lab skills and remove misconceptions**,** linguistic obstacles, cultural and emotional barriers, which prevent the literacy in Science (Eurydice, 2011, *op. cit.*). "Inquiry methods, dialogues, discussions, verbalisation of problems, collaborative and independent working and the use of ICT" (*Ibidem*, p. 70) have played an important role in the author's STEM lessons since her first experiences. In addition, in multilingual and multicultural classes, specific activities in English were introduced to help the migrants reach the STEM aims. The input was rich and comprehensible (Meyer, 2010) and students' linguistic competences were attentively considered. Materials were adapted for the context. All students became actors in the learning process and built their own knowledge giving valuable contributions in carrying out practical group tasks. They learnt cooperatively and performed experiments in a well-equipped Chemistry laboratory following the instructions of Italian and English protocols. They observed, bred and cultivated model organisms (bacteria, yeast, a nematode and fruit flies), following their development through more generations in order to understand the transmission and the expression of sets of genetic characteristics. They prepared and observed chromosomes, extracted DNA and built models, which they orally described in a video. The students' lab reports, concept maps and multimedia products, including the pictures taken during the experiments and the visit to the laboratories of the "Carabinieri's" Scientific Investigation Unit (RIS) of Parma documented all their activities. Forensic Chemistry and Biology were taught through a team teaching "cross-curricula" approach. Additionally, students learnt using the molecular biologists and genetic researchers' most innovative techniques and instruments. The efficiency and effectiveness of this project were assessed by the evaluation of their digital outcomes, their portfolios, visual and material manufactured cell, chromosome and DNA models, produced using their creativity and sense of initiative and

[1] The "Direzione Scolastica Regionale della Lombardia" granted these projects, carried out in collaboration with the University of Pavia (S.I.L.S.I.S), G. Cenci (Sapienza University of Rome), EMBO (Heidelberg), A. Croce and M. Bianchi (IFOM-FIRC Institute of Milan).

entrepreneurship. Their capability to work in groups during the laboratory experiments and their skills to use the ICTs was also assessed. Moreover, the students' mental representations were analysed before the beginning and after this module according to constructivists' methodologies (Berdardini Mosconi *et al.*, 2003; Giordan *et al.*, 2007). Their initial and final answers were compared in order for the teacher to be aware of the students' ability to overcome their misconceptions, to acquire meaningful knowledge and to connect the new concepts with their correct pre-knowledge and other structured concepts. These students' performance and answers were compared with those of a control class, that was following a more traditional teaching method. The final scores were higher in the experimental classes than in the later.

The author has continued to develop the basic European key competences in Italian High Schools, promoting "conceptual change in the context of science education" (Eurydice, 2011, *op. cit.*), adopting innovative methodologies based on lab experiences, the ICT and CLIL. This approach improved since those years and new frameworks were developed (Barbero, 2005; Coyle *et al.*, *op. cit.*; Langé *et al*., *op. cit.*; Meyer *op. cit.*). In the Science teacher's first experiences, carried out in Lombardy, CLIL activities relied on the framework introduced in Italy in those years (Serraggiotto, 2003). The colleague, who taught English, was involved to develop language skills through the contents of Biology. Discussions about contemporary social and ethical issues, such as cloning, were introduced through authentic scientific texts. Students' receptive skills (watching and reading in English the contents of authentic multimedia scientific sources) improved during the Science lessons to learn STEM contents.

Communicating in a foreign language involved more migrants than Italian students. Some support ("scaffolding") was necessary to allow students to understand contents. Digital materials about Molecular Biology and Biotechnologies, which were not compulsory subjects in Italian High Schools at that time, were used in this project. Produced in the four main European languages and freely distributed on CD roms to teachers selected to take part in international STEM courses, they compensated for the lack of multimedia and interactive tools in Italian. These digital products were full of images and animations with easy to understand captions, videos and interactive virtual experiments that students virtually performed on the computer following simple instructions in English. The input was comprehensible, multimodal and multilingual in order to comply with the different learning styles and to allow foreign students to learn through the language they understood better. Appropriate "scaffolding" was given during the lessons, so that students could tackle scientific language and solve the problems they encountered while carrying out the designed tasks working in groups, communicating and interacting in their first language. Moreover, great emphasis was given to the

ICTs, to the centrality of students, to cognitive and metacognitive aspects and to the interpersonal skills. Communication, content, cognition and culture (Coyle *et al.*, *op. cit.*) were introduced systematically in Science lessons. The foreign students learnt Natural Science in Italian through a "Hard" CLIL approach based on the "submersion" (E.C. 2014, p. 3) and were assessed (Ball *et al., op. cit.*). Migrants could also use their mother tongue during the tests. Learning by manipulating organic materials and by observing the results of their experiments in an interactive environment, such as a laboratory or a virtual world, allowed students to acquire and elaborate difficult biological concepts and processes. They accessed Lower and Higher Order Thinking Skills (HOTs) to reach the aims of the discipline.

Although in 2004 EC promoted "Language Learning and Linguistic Diversity" through an Action Plan, and CLIL was expected to make an important contribution to reach the EU's language learning objectives, only few schools understood the importance of this approach. The Institute of Superior Instruction (IIS) in Via Asmara, in Rome, was one of the High Schools where Language and Science teachers were ready to cooperate and promote integrated learning of content and language. In the school years 2007-2008 and 2008-2009 in Via Asmara and in the near Scientific High School "Avogadro", the author carried out projects about model organisms, cells, chromosomes and genes and taught Earth Science and Chemistry through the CLIL approach in English, French and Spanish. Experts were also invited at school as recommended by Eurydice 2011 (*op. cit.*). Some classes were multilingual and multicultural. Teenagers and adults who attended evening classes in the Professional School of Villa Paganini were also involved. In some classes CLIL lessons were performed in French and English in co-teaching per one hour per week. The CLIL activities, based on the 4Cs framework, focused on content and language and were performed and assessed by holistic evaluation rubrics.

3 Multilingual CLIL activities

The CLIL 4-Cs framework (Coyle *et al.*, *op. cit.*) supported the projects carried out from 2007 to 2009 and 2018. Constructivism (Giordan, *op. cit.*), activism and the most innovative scientific approaches and methods were applied during the Chemistry, Earth Science and Geography lessons (Eurydice, 2011, *op. cit.*). Contents were taught through Spanish, French and English. Students were at the centre of CLIL lessons and built concepts learning cooperatively, performing problem solving activities and lab experiments. The marks were assigned in all classes through open and closed paper-and-pencil tests, taking into account their individual and group products and their portfolios following evaluation rubrics (Ball *et al.*, *op. cit.*). Their answers

to the initial and final constructivist questionnaires contributed to the mark on their report in 2007-09. Mohan and Bloom's taxonomies were taken into account (Langé *et al*, p. 51-52, *op. cit.*; Anderson *et al.*, 2001). The CLIL lessons were carried out during half of the school yearly timetable. Students were required to communicate orally and to write in foreign languages during the tests, individual and group tasks.

3.1 CLIL in chemistry

Chemistry was taught mainly through experiments, group work, project based learning approach (PBL). Creative activities (inventing and performing experiments) and pair work (reading, listening, speaking and writing) were taken into account. English and French were the vehicular languages in a 3rd class in Rome in 2008-09, whereas English was used in the school year 2018-19 for 22 hours in a 2nd class of the Linguistic (2^ML) and for 11 hours in a 4th class of the Scientific High School (4^ES) at Colleferro (Roma). The framework was based on the 4Cs (Coyle *et al.*, *op.cit.*), Meyer's pyramid (Meyer, *op. cit.*) and on the most modern methods to develop STEM and language competences (Eurydice, 2011; Langé *et al.*, *op. cit.*; and E.C. 2018, *op. cit.*). Great emphasis was placed on ICT. Students used computers, tablets and mobiles to play games, to interact online in formal and informal ways, to produce webpages, an e-glossary and other digital tools. The positive results (Table 1) increased the motivation and developed a very positive attitude towards Chemistry, a subject that students found complicated and boring before starting CLIL. In the two control classes (2^LL and 2^NL), the same Chemistry contents were taught in Italian in a more traditional way. These students neither produced multimedia products nor benefited from extra hours in the lab or from the virtual and flipped classroom.

3.2 Trilingual CLIL

One of the most innovative projects was carried out in school year 2007-2008 in a 5th multicultural class (5^AL) of the Linguistic High School of Via Asmara. The language of the CLIL lessons was English during half of the school yearly timetable During the trimester (September-January), Astronomy was taught in Italian, English and in French. During the pentamester (January-June), Italian was used for one third, Spanish for another third and French for the last third of half the scheduled curriculum. Students learnt through authentic texts and videos in the three main European foreign languages. The framework, the approaches, the contents, the assessment methods and the holistic rubrics have been described (Schietroma, 2008, p. 254-255; p. 266-269).

During the pentamester, students were required to write in French, English and Spanish to be evaluated. Sometimes, they also had to translate from a foreign language into Italian without a dictionary. Only an oral and a written test were taken in Italian. Students proved their ability to use the foreign languages to think, translate, summarize, organize concept maps, write lab reports and interact during the group works. Migrants obtained positive marks (Table 1) and contributed to the group production and tasks.

3.3 CLIL approach with adults of the "Istituto Professinale di Stato per i Servizi Sociali" (I.P.S.S.S.)

Without doubt, the most challenging and innovative project involved adults. They appreciated and benefited from learning by doing, working in groups and acquiring Earth Science in the 1st class (1^eP) through English and their own mother tongues (Spanish or French for migrants). The CLIL framework, the methods, the activities and the assessment modality were the same used for the other classes, as described at beginning of paragraph 3. The adults attending the evening courses came mainly from South America, Poland, Philippine, Africa, and Republic of Moldova and tended to attend only the lessons they were interested in. As CLIL activities in English started, their motivation increased. All students attended theoretical and practical lessons in English and Italian. Moreover, Spanish was used with South Americans and French with the Africans. A Philippine student who had found it difficult to integrate in the class and to learn subjects in Italian overcame his linguistic obstacle and reached the highest score (10) in the English STEM test. In Asia, he studied scientific subjects in this language. He collaborated actively during the group works helping his classmates. Migrants benefited in learning some contents through Italian, their mother languages and English. Adults were highly motivated, succeeded in Science and performed better than teenagers of the 1st diurnal class of the Professional Institute (1^BdP), who learnt Earth Science and English during the one-hour per week co-teaching CLIL lessons (Table 1).

3.4 A synthesis of the results

Table 1 summarizes and compares data collected during the trimester (T) and the pentamester (P). All students answered open and closed questions. The 2^ML and the 4^ES performed the same activities in the lab and took the same test. They also described their projects in English. A multilingual test was taken in the 5^AL. The means of the marks on the school reports also included activities performed and evaluated in Italian.

Table 1
STUDENTS' MARKS

MARKS	Chemistry in 2^LL and 2^NL (Trimester)		Chemistry in 2^ML and 4^ES (Trimester)		Geography in 5^AL		Earth Science 1^eP 2008-09		Earth Science 1^BdP 2008-09	
	2^L	2^N	2^M	4^E	T	P	T	P	T	P
STUDENTS' NUMBER	23	24	23	21	23	23	20	23	10	15
STUDENTS' MEANS CLIL WRITTEN TEST			6.5	7.62		8.5		6.6		7.6
MEANS ON THE SCHOOL REPORT	6.5	6.04	7.3	7.43	7.04	7.78	6.6	7.0	5.78	6.62
Standard Deviation	1.3	1.43	1.27	1.12	0.77	1.09	1.26	1.51	1.08	1.20
INSUFFICIENT STUDENTS	4	7	1	0	1	0	3	3	6	1

These results show that all classes involved in CLIL activities in 2008-2009 during the pentamester performed better than in the trimester. The results obtained in CLIL tests positively influenced the final marks. In 2018-19, Chemistry was taught in English in the 2^M class of "Liceo Linguistico" and in the 4^E class of the "Liceo Scientifico" without switching to Italian. 2^M performed better than the control classes (2^L and 2^N) and worse than the 4^E, however, their interest and motivation toward Chemistry boosted. The hypothesis that students can learn a difficult subject such as Chemistry efficiently and effectively through English before the 5th class was proved. The innovative methodologies actively involved the classes, made Chemistry accessible to students and increased their motivation.

Conclusions

In these projects, teenage and adult foreign students had the opportunity to learn by doing in groups with the Italians. All students took advantage of using laboratory equipment, and actively participating in innovative Science lessons instead of listening to face-to-face lessons and passively studying from paper books. Moreover, they structured concept maps, produced work and became more motivated in learning Natural Science. The results proved the effectiveness of the adopted methodologies.

These studies highlighted the feasibility of CLIL activities before the 5th year of the High School. Students acquired contents and developed STEM, digital and linguistic skills in multicultural contexts. Literacy and the integration of migrants were promoted. Italians and foreign students took advantage of CLIL lessons, lab activities and group projects. In some contexts, they used their

mother tongue to learn and express their knowledge. Africans could use Arabic in their written production and interact in English or French. South Americans benefited from material and activities in Spanish. All acquired scientific terms and were considered a linguistic and cultural resource for their classmates. Using the Higher Order Thinking skills, they developed cognitive competences in authentic and simulated situations. Students interacted in foreign and native languages to form their own knowledge and create their own multimedia products. Their motivation and interest toward STEM was boosted while they learnt by doing through a foreign language. They became aware of other languages, use and culture and developed the new literacy in the 21st Century.

To sum up, CLIL is without doubt one of the best approaches to promote a positive attitude towards STEM, acquire knowledge, embrace language awareness and acceptance of migrants, promote the discovery of other cultures and the comparison with other mentalities. The future of general and STEM education in Europe is quadrilingual and involves teenagers and adults in a lifelong learning multicultural and multilingual perspective.

REFERENCES

Anderson L. W., Kratewohl, D. R. (a cura di) (2001), *A taxonomy for learning, teaching and assessing: a revision of Bloom's Taxonomy of educational objective*, New York, Longman.

Ball P., Kelly K., Clegg, J. (2015), *Putting CLIL into Practice*, Oxford, Oxford Univ. Press.

Barbero T., Clegg J. (2005), *Programmare percorsi CLIL*, Roma, Carocci Faber.

Berdardini Mosconi P., Gagliardi R.P. (2003), *Capire dove si vive per capire il mondo. Il modello territoriale per l'educazione ambientale*, Roma, Armando Editore.

Cinganotto L. (2018), *Apprendimento CLIL e interazione in classe*, Roma, Aracne editrice.

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

D.P.R. 88/ 2010 and D.P.R. 89/2010 URL:http://www.gazzettaufficiale.it/eli/gu/2010/06/15/137/so/128/sg/pdf (accessed on 21st January 2019).

European Council (2002), *Presidency conclusions, Barcelona,* 15 and 16 March 2002, URL:http://ec.europa.eu/invest-in-research/pdf/download_en/barcelona_european_council.pdf (accessed on 21st January 2019).

European Commission (2014), *Improving the effectiveness of language learning: CLIL and computer assisted language learning*. Education and Training URL: https://www.ecml.at/Portals/1/resources/Articles%20and%20publications%20on%20the%20ECML/CLIL%20and%20CALL%20report_July.2014.pdf?ver=2017-07-11-151504-977 (accessed on 15th November 2018).

European Commission (2018), *Recommendation on Key Competences for Lifelong Learning*, URL:https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018H0604(01)&rid=7(accessed on 21st January 2019).

Eurydice (2011), *L'insegnamento delle scienze in Europa: politiche nazionali, pratiche e ricerca*, URL: http://eurydice.indire.it/wp-content/uploads/2017/06/Science_IT.pdf (accessed on 21st January 2019).

Eurydice (2017), *Key Data on Teaching Language at School in Europe*
URL: http://eurydice.indire.it/wp-content/uploads/2017/05/Key-Data-on-Teaching-Languages-2017-Full-report_EN.pdf (accessed on 21st January 2019).

European Commission/EACEA/Eurydice (2019), *Integrating Students from Migrant Backgrounds into Schools in Europe: National Policies and Measures*. URL: https://eacea.ec.europa.eu/national-policies/eurydice/sites/eurydice/files/integrating_students_from_migrant_backgrounds_into_schools_in_europe_national_policies_and_measures.pdf (accessed on 21st Jan. 2019).

Giordan A., Saltet, J. (2007), Apprendre à apprendre, Paris, E.J.L.

Langé G., Cinganotto, L. (2014), *E-CLIL per una didattica innovativa*, I quaderni della ricerca, n. 18. Loescher.

Meyer O., (2010), *Towards quality CLIL: successful planning and teaching strategies*, Pubs, 33, 11-29.

Schietroma, E. (2008), *Strategie didattiche per l'insegnamento delle Scienze della Terra, a.a. 2007-2008*, Relatore Prof.ssa Paola Fredi, Roma, Sapienza Università di Roma (unpublished dissertation).

Serraggiotto, G. (2003), *C.L.I.L. Apprendere insieme una lingua e contenuti non linguistici*, Perugina, Edizioni Guerra-SOLEIL.