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Article

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Experimental teaching of Sciences in the English language (CLIL)

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Abstract

The implementation of experimental and creative practices and teaching methods in education, and in Foreign Language Teaching (FLT) in particular, is rendered significant due to the changes made in Curricula, the decisions taken by the Council of Europe, the emergence of the need for language learning and the development of multilingualism and multi-literacy, and finally, in the case of Greece, the decisions taken by the Ministry of Education (Law 3966) for the Model and Experimental Schools. In this context, Content and Language Integrated Learning (CLIL) was implemented at the 2nd Experimental Senior High School of Thessaloniki by the teachers of English, Chemistry and Physics, in the units of chemical compounds and reactions for Chemistry and Newton's Laws for Physics during the school year 2015-2016. The summative assessment and the questionnaire, structured on the 4 Cs of CLIL, show that the language does not hinder the understanding of the content; on the contrary it develops students' language skills.

Keywords: Content and Language Integrated Learning (CLIL), content, cognition, culture, communication language skills, assessment

1. Introduction

The constant changes in the Greek educational system as regards foreign languages teaching and learning, in accordance with the Directives of the Council of Europe (2006), encourage the development of key competences, such as communication in foreign languages, intercultural awareness and metacognitive skills (European Communities, 2007; PI, 2009). These competences arise from the needs in the modern world, such as the multicultural and multilingual European environment and the increased probability of young people working or living in multiple countries. In this context, the Unified Curriculum for foreign languages (2011) was reformed so as to cover the needs of a global citizen who will be able to communicate and mediate in various linguistic, social and cultural environments.
At the same time, the Model and Experimental Schools are invited to promote educational research in collaboration with University Departments and implement experimental practices and differentiated learning (Law 3966).
All the above developments and the growing trend of the CLIL approach in Europe (Eurydice, 2006) have given rise to Content and Language Integrated Learning (CLIL) in order to integrate the teaching of a foreign language and other subjects of the Curriculum, improve students' performance in the

foreign language (Lasagabaster, 2008) and create flexible and multifarious experiences at school (Coyle, 1999).

2. Content and Language Integrated Learning (CLIL)

Content and Language Integrated Learning was implemented at all levels of education under the umbrella of bilingual education in the 90s, after the successful implementation of immersion programs in Canada and Content-based Language Teaching in the United States (Cummins & Swain, 1986; Brinton et al., 1989), by supporting the teaching of curriculum subject matter in a foreign or second language, giving emphasis to both the content of the subject and the language (Perez-Vidal, 2007) and converting the class into a field of innovation and research (Craen et al., 2007; Perez-Vidal, 2007). So far various models, approaches and methods of CLIL, such as collaborative and experiential learning and integrated approach to language, have been implemented with the students working on a topic and developing thinking and study skills (Crandall, 1992, 1994). Whatever the models implemented and supported by researchers (Banegas, 2012; Calvino, 2012; Lasagabaster, 2008), CLIL is now a mainstream practice in Primary and Secondary Education in Europe (Eurydice, 2006) and converts the class into a non-typical class, as the medium of instruction is a foreign language (Katarzyna, 2011).

CLIL may serve the objectives of many countries educational systems, such as socio-economic, socio-cultural, linguistic and educational (Eurydice, 2006), but it also provides a practical approach of content and language learning, develops students' motivation and enhances intercultural awareness (Darn, 2006). Based on Coyle's triptych (2007), *language of learning* vocabulary and phrases to access the content, *language for learning* to enable students to perform the tasks *and language through learning,* namely language resulting from the cognitive process, CLIL gives students the opportunity to learn a language better, as it is assumed that one learns better when they get information through the foreign language (Richards & Rodgers, 2001; Larsen-Freeman, 2000, in Banegas, 2012).

CLIL presupposes a framework of four basic principles (4 Cs), according to Coyle (1999, 2002), in order to be successfully implemented: Content (subject matter, themes, cross-curricular approaches, the interrelationship between content), Communication (language for learning and learning of language use), Cognition (development of cognitive and thinking skills) and Culture (awareness of self and otherness) (Darn, 2006). It also demands teachers who will be able to use teaching strategies to teach the subject matter effectively, facilitate understanding by repetition, simplified speech, clarifications, visual material, and adapt to the students' needs, interests, abilities and learning styles (Perez-Vidal, 2007, adapted from Bermhardt, 1992).

According to studies (Lasagabaster, 2008; Calvino, 2012; Smit & Dalton-Puffer, 2007), CLIL presents many advantages for both students and teachers. In particular, it prepares students for further studies and work in the globalized environment, increases motivation for language learning, helps students learn terminology, develops their intercultural communication skills and a positive attitude to what students can do in the foreign language (can do statements) (CEFR, 2001), improves the communication between students and between students and teachers. As regards teachers, the advantages include the development of best practices, the use of innovative methods and tools, and opportunities for networking and professional mobility (Calvino, 2012).

Possible problems may arise from the customization of the teaching materials of the subject matter in the Curriculum, the culture of the school environment and the country in which CLIL is implemented, and the range of knowledge of the teachers involved in the instruction of the foreign language and the subject matter (Calvino, 2012). These problems can be overcome by persistence, teachers' collaboration and diversification of learning so as to achieve the best outcome for students.

3. The research methodology

The present research was conducted at the 2nd Experimental Senior High School of Thessaloniki in the school year 2015-2016. The lessons lasted for about three weeks for the two classes of the first grade. One class was taught Chemistry by the teachers of Chemistry and English, and the other was taught Physics by the teachers of Physics and English.
In the Physics class there were more boys, while in the Chemistry class there were more girls (fig. 1).

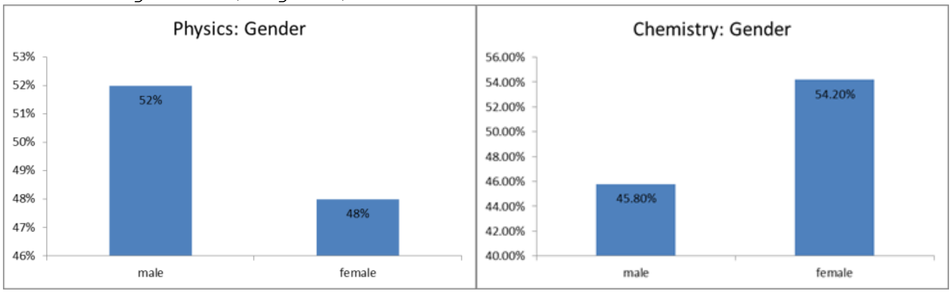

Fig. 1

The units chosen from the Curriculum were the chemical compounds and chemical reactions for Chemistry, and Newton's Laws for Physics. The whole practice had been approved at the beginning of the school year by the School Scientific and Guiding Board, since there was a previous experience of teaching 1/3 of the subject matter of Physics in English the previous school year. The specific units were selected by certain criteria, such as students' motivation, attractiveness of the content, learning of key terms, relatedness to everyday life, and enrichment by a variety of techniques and methods, such as demonstrations, experiments, videos etc. More specifically, in Physics we used the International Baccalaureate (IB) teaching material Physics for the IB Diploma (Tsokos, 2008), while in Chemistry we used authentic material from English instructional sites adapted by the teachers (see. references).
Our ambition was to offer students a bilingual and real experience, since they had to study the material to cope with the activities and the final test, just as they would do in their native language. The objectives were related to knowledge, skills and attitudes. For example, knowledge objectives included to learn and apply the laws; skills objectives included to perform simple experiments, connect the existing knowledge to the new one, apply knowledge to everyday life, develop language and learning skills; attitudes objectives included to adapt students to being taught in the English language and to demystify the difficulty of the subjects of Sciences. Thus, before the implementation of the practice, the students were extensively taught the Latin and English names of the chemical elements of IA, IIA, VIIA and VIIIA groups of the Periodic Table and the types of chemical compounds so as to smoothly move to the English terms in Chemistry.
In order to achieve the above objectives, but also to increase students' motivation as it is the driving force of learning in general, and language teaching and learning in particular (Katarzyna, 2011; Masgoret & Gardner, 2003), we used a range of activities, techniques and methods, such as PowerPoint presentations, experimental demonstrations, videos, brainstorming, worksheets, pair and group work, etc. Moreover, in Chemistry, we did three laboratory exercises and worksheets on the comparison of Cu-Fe activity, the identification of ions Cl^{-1} - I^{-1}, and double substitution reactions.
The involved teachers' collaboration was exemplary throughout the course from the preparation stage to the implementation and evaluation ones, while

the students' level of English (B2-C2) helped do the practice smoothly throughout. In particular, about half of the students were B2-level learners in both classes, and two out of ten C2-level learners in Physics and four out of ten in Chemistry (Fig. 2).

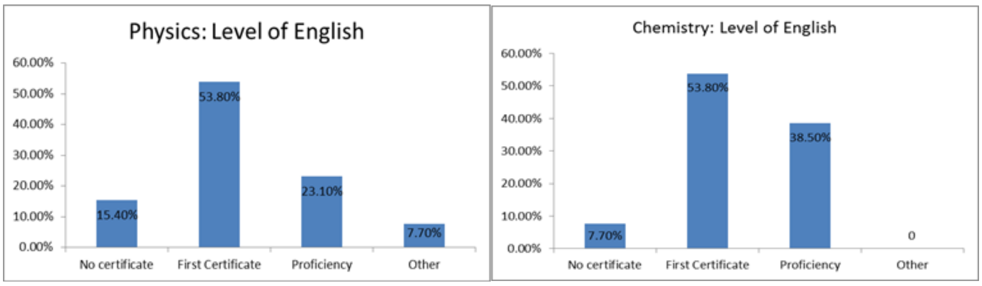

Fig. 2

The specific students did not have a similar experience before; they mostly use the English language for fun and communication (Fig. 3).

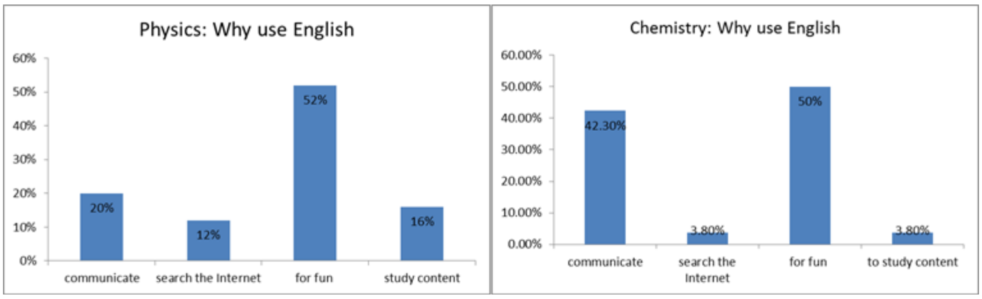

Fig. 3

It is worth mentioning that the cognitive level of the students' parents in both classes is very high, since about half of them are University graduates, and some (about 2 out of 10) are post-graduate or PhD holders (Fig. 4 & 5). This probably explains the positive attitude of parents to the implementation of the specific practice.

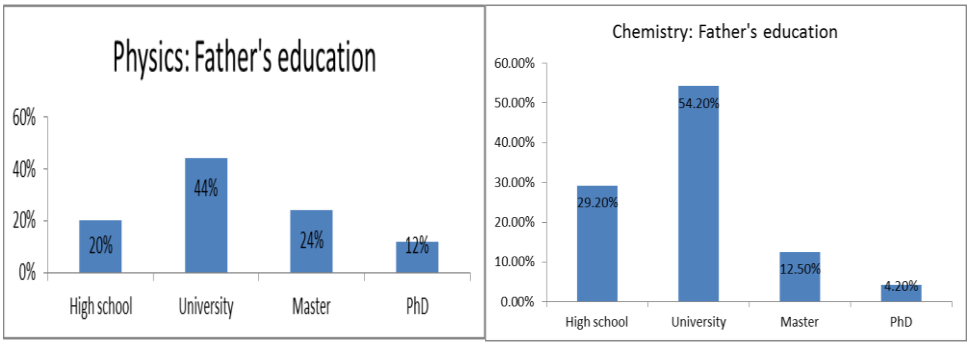

Fig. 4

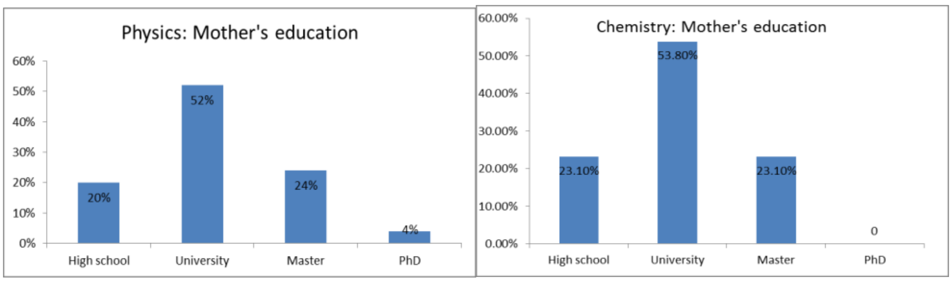

Fig. 5

At the end of the CLIL practice, besides the summative tests, a 5 Likert scale questionnaire, structured on the 4 Cs of CLIL was given out to students. The statistical program SPSS was used to test the reliability of the questionnaire which, as shown in the figure below (Fig. 6), was very high for both the questionnaires used for Physics and Chemistry.

Physics: Reliability Statistics

Cronbach's Alpha	N of Items
.951	55

Chemistry: Reliability Statistics

Cronbach's Alpha	N of Items
.983	55

Fig. 6

Having discussed the demographic questions of the questionnaires, we now proceed to the analysis of the four parts of the questionnaires and the test results.

4. The research results

As mentioned above, the questionnaire was structured on the 4 Cs of CLIL, namely: Content, Communication, Cognition and Culture.
The data show that, with regard to the content of the Physics subject matter (17 questions) (Fig. 7), CLIL helped students at a percentage of 50%-80% understand the content of Newton's laws better by worksheets, relate images and drawings to the 3 laws of motion, capitalize videos to raise misconceptions, capitalize demonstrations to comprehend how the 3 laws of motion apply, solve problems of equilibrium, find the net force on a body by vector addition, draw the forces on the body of interest and apply Newton's 2nd law, recognize that the net force on a body is in the same direction as the acceleration of that body, memorise key vocabulary, and perform activities better. In Chemistry, there are lower results, but more than half of the students believe that they understood the use of symbols, folmulae and chemical equations, they can recognise an element, a compound and the type of a written reaction (synthesis, decomposition etc.), they learnt the names of elements in the Periodic Table, learnt key vocabulary and phrases, and can deal with more complex information in the target language.

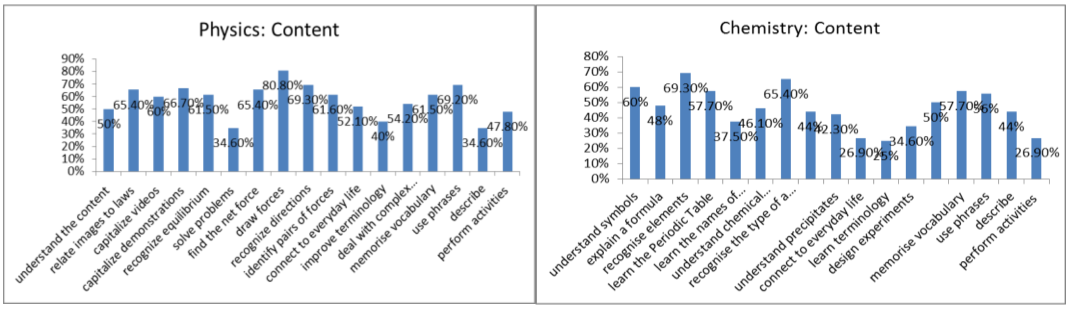

Fig. 7

As regards communication (16 questions) (fig. 8), 7-8 students in Physics and 6-7 out of 10 students in Chemistry believe that the English language helped them significantly improve all language skills (listening, reading, speaking and writing) and their vocabulary, and about 5 -7 out of 10 students believe that it helped them improve fluency and pronunciation, describe graphs, give explanations, understand presentations, ask questions and communicate with their teachers, but not with their classmates.

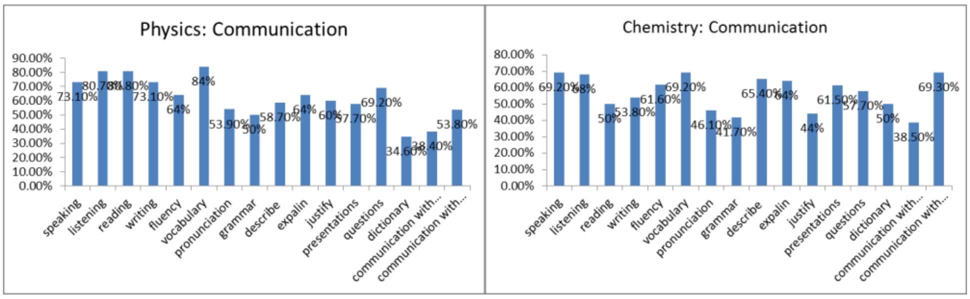

Fig. 8

As far as cognition is concerned (16 questions) (Fig. 9), about 5-6 out of 10 students think that CLIL helped them understand concepts and apply them (not so much in Chemistry), make informed choices, make decisions and justify with reasons, do independent research and transfer knowledge and key vocabulary (more in Physics), cooperate, think critically (8/10 students in Physics), be creative, and develop motivation and a positive attitude to the English language and Chemistry.

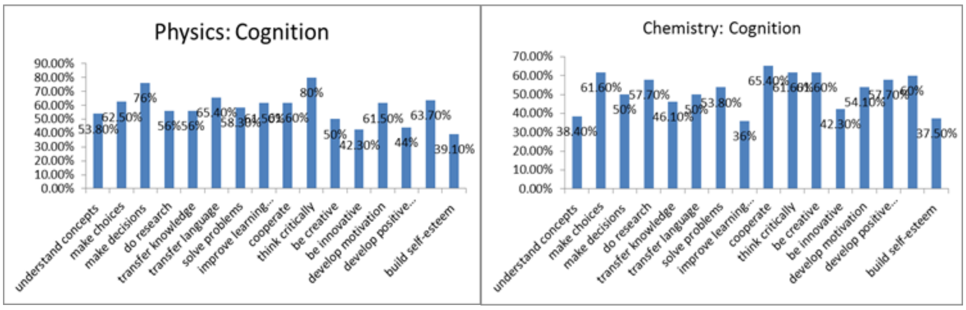

Fig. 9

Finally, as regards culture (6 questions) (fig. 10), similar results are exhibited: the students believe that CLIL enables them to understand authentic material (symbols, formulae, etc.) in the foreign language, do a project with students from other countries, do a post-graduate course in English (mostly in Physics), and study or work abroad (both in Physics and Chemistry).

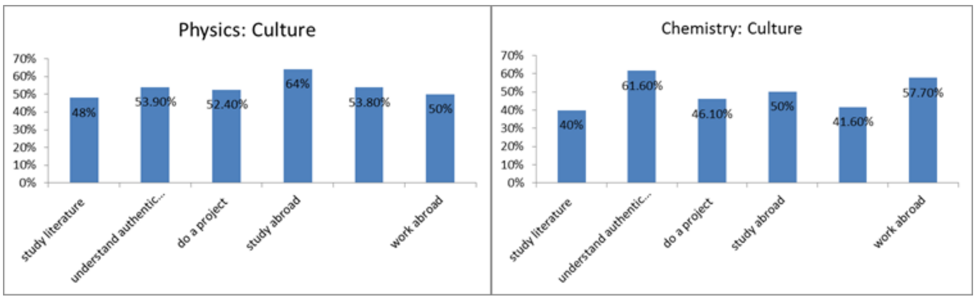

Fig. 10

The data collected from the questionnaires show that the students were more benefited in Physics than in Chemistry. This is also evident in the test scores. In the Physics class, the mean of the language test was 18.5 out of 20, and of the Physics test 15.5. This grade in the Physics test is an intermediate of the students' grades in previous physics tests in their mother tongue (16.6, 16.1, 14.0, 17.6). In the Chemistry class, the mean of the language test was 15, and of the Chemistry one was 14. Similar scores appeared in the Chemistry test in the mother tongue, which enhances the Chemistry teacher's view that it takes students a long time to familiarize

with the content of the subject matter of Chemistry, which is particularly difficult and of a higher cognitive level, as compared to that of the Lower High school, even in their mother tongue.
The results usually depend on the students' cognitive level, their motivation, their willingness to cooperate, their cognitive, interpersonal and other skills, the context of the class, and other factors. Thus the students' responses to the questionnaire and the test scores could be the springboard for future planning and implementation of similar practices in Senior High School.

5. Conclusion

The above research makes clear that CLIL does not hinder the understanding of the content of the subject matter in the foreign language. On the contrary, by applying FLT methodology and by using a range of methods and techniques, CLIL helps students understand the content of the subject matter, improve communication and language skills, develop 21st century skills, such as problem solving, critical thinking, etc., and enables them to study and work abroad, since it develops their intercultural awareness. Moreover, CLIL is known to place the language and the content on a continuum, without one dominating the other (Holmes, 2005, in Coyle, 2006). Consequently, if CLIL is repeatedly implemented as a parallel programme, data are analysed and conclusions are drawn, we could hope for the introduction of CLIL in the Greek educational system.

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