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Using Active Learning Methodologies in Physical Chemistry in CLIL Contexts

Recatalá, David

Department of Physical and Analytical Chemistry, Jaume I University
Avda. de Vicent Sos Baynat, s/n. 12071 Castelló (Spain)
e-mail: drecatal@uji.es; Tel. (+34) 964 728094

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Abstract
One of the main objectives of the European Higher Education Area (EHEA) is to promote a change toward a student-centred education model. This fact has led to the implementation of novel methodologies based on active learning, aimed at engaging students' interest. This implementation has been usually accompanied by significant changes in both the teaching and learning processes in European universities. Furthermore, teaching a subject through the medium of a foreign language has also been gaining attention over the past few years. More specifically, this approach commonly known as Content and Language Integrated Learning (CLIL) has been employed for the simultaneous learning of content and English in a number of European countries. In this contribution we report on the active learning methods implemented in a Physical Chemistry course, as well as the efforts devoted to Content and English Language Integration in this subject. This research analyses a series of factors that can contribute to the global learning and teaching experience when both active learning and CLIL are implemented in the Physical Chemistry classroom. Some examples of them include changes in attitudes towards the subject, engagement and motivation during the course, perception of English learning, and in general, students' satisfaction with the learning process.

Keywords
Active learning methods; teaching methodologies; European Higher Education Area; Content and Language Integrated Learning

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1. Introduction

The European Higher Education Area (EHEA), also known as Bologna process, emerged in 2010 as a new educational area, conceived to promote a shift from a teacher-centred to a student-focused educational model (EHEA, 2010). The creation of the EHEA has been accompanied by the introduction of the European Credit Transfer System (ECTS), which takes into consideration the total time that students employ in order to reach the learning objectives (European Communities, 2009). In contrast, before the implementation of the EHEA, only the time spent in lectures was taken into account to define the duration of a higher education course.

The implementation of the Bologna process has led to dramatic changes in teaching methodologies, with the aim of promoting students' participation in the classroom, as well as engaging their interest towards learning. In this context, the term "Active Learning" has gained a growing interest over the past few years. This concept involves the combination of teacher lectures with other student-centred activities, which engage students in the learning process during the time they spend in the classroom (Prince, 2004).

Collaborative learning is another form of active learning in which students work together in small groups to achieve a specific aim. This methodology lies emphasis on the interaction between students, in contrast to the traditional individualistic approach. In this context, Google Docs has been recently explored as a tool for promoting collaborative learning in laboratory courses (Spaeth et al., 2012). Cooperative learning is a variant of collaborative learning, in which each member of the group is assigned a particular task, although all of them pursue the same goal. This methodology was satisfactorily applied in an undergraduate laboratory course, in which each member of the group was asked to prepare a particular part of the experiment (Smith et al., 1991). Both collaborative and cooperative learning methods have been successfully employed to increase the overall marks of an Organic Chemistry course by over 20 – 30 %, as compared to the traditional course based exclusively on teacher lectures (Paulson, 1999).

Problem-based learning (PBL) is another active learning methodology in which students are provided with interesting and challenging problems, and they are therefore actively involved in the search for the solution. The effectiveness of this approach in a Physical Chemistry laboratory course was investigated (Gürses et al., 2007), and the results indicate that the PBL approach highly promotes students' problem-solving skills.

Content and Language Integrated Learning (CLIL) represents "a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language" (Marsh et al., 2011). The implementation of CLIL throughout Europe varies greatly from one country to another. In the particular case of Spain, the interest in this approach has grown significantly over the past few years, and its implementation in bilingual communities, such as Valencia, fosters multilingualism (Frigols, 2007).

Different types of CLIL programmes can be found, ranging from full immersion to partial immersion (Eurydice, 2006). Research shows that CLIL presents a number of benefits for students, and that its success strongly depends on the context in which this approach is introduced (Cambridge ESOL, 2010). Teaching a subject through the medium of the English language has attracted a great deal of interest in Spain due to its multiple benefits, since CLIL is supposed to improve students' fluency in English, and can hence contribute to better prepare them for their future career.

In this contribution, we report on the results obtained upon application of active learning methodologies in a Physical Chemistry course within the Degree in Chemistry at Jaume I University (Castelló, Spain). The main topic of this course is spectroscopy, and the contents are those covered by a standard textbook, such as *Physical Chemistry* by R. A. Alberty and R. J. Silbey. The students had already some notions of Physical Chemistry, as they were in the third course of the Degree in Chemistry. In addition, we decided to integrate the English language into this subject by following a partial integration approach in a group of bilingual speakers (Spanish / Catalan). This choice was motivated by the

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multiple benefits of CLIL. The students' satisfaction with the changes introduced in the subject were analysed by means of a Likert-type questionnaire.

2. Methodology

Active learning methodologies and Content and Language Integrated Learning have been implemented in 29 bilingual Chemistry students (Spanish / Catalan), which were divided into two groups of 14 and 15 students, respectively. The methods employed in each case are detailed herein.

2.1. Active Learning Methodologies

A series of active learning methodologies have been implemented in a Physical Chemistry course over the past few years. As already stated in the Introduction, this course, in which Spectroscopy is the main topic, corresponds to the third year (second semester) of the Degree in Chemistry at Jaume I University (Castelló, Spain), and corresponds to 6 ECTS credits. The students taking this course are supposed to have passed three previous Physical Chemistry subjects, which cover Chemical Thermodynamics (first year), Kinetics (second year), and Quantum Chemistry (third year, first semester). Nevertheless, having passed these subjects is not a prerequisite to enrol the Spectroscopy course. In this Spectroscopy course, the lectures sessions are combined with computer-based workshops in which the students have to solve problems. These sessions involve spreadsheets calculations, graphical analysis of data, as well as the use of Web-based simulation packages to facilitate a better understanding of the theoretical concepts.

The students attend a three-hour workshop approximately on alternate weeks. Prior to the workshop, they are encouraged to do a series of activities at home, which serve as a reminder of the theoretical concepts that they are going to use. Students have to hand in these activities to the teacher just before the beginning of the workshop in order to prove

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that they have understood the concepts. In the workshop sessions, each student uses a computer provided with a spreadsheet program. Each student is provided with a set of problems that has to solve individually by using a computer. At the beginning of the workshop, teachers give a brief explanation of what has to be done during the session. This explanation is followed by the individual work of students, who are encouraged to finish all the activities during the session (approximately 3 hours). Having finished all the activities, the students have to answer a quiz through the Moodle platform that we usually employ for uploading content related to the subject. The marks obtained by the students in these workshops represent the 20 % of the total marks of the subject. Students are required to complete the quiz and to hand in a definitive version of the spreadsheet in one week.

2.2. Content and Language Integrated Learning (CLIL)

With the aim of teaching Physical Chemistry through the medium of a foreign language, we decided to integrate the English language in a partial integration fashion. In this approach, the written materials were provided in English, whereas the oral language was Catalan. This choice of foreign language was motivated by the multiple benefits of being fluent in English (Frigols, 2007), and in general by the benefits of learning foreign languages (Merritt, 2013; Kruschewsky, 2014).

2.3. Analysis of Students' Satisfaction

The factors than can contribute to a better global learning and teaching experience when both active learning and CLIL are implemented in the Physical Chemistry classroom were assessed by means of a Likert-scale questionnaire, for which an integer value from 1 to 5 was assigned to each item (1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree). This questionnaire was comprised of 20 items that can be classified into four different groups according to their nature, that is:

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1) Quality and adequacy of the learning resources.
2) Satisfaction with the methodology employed.
3) Satisfaction with CLIL.
4) Overall satisfaction with the course.

The questionnaire is provided in Table 1 for illustrative purposes. The main aim of the items included in this questionnaire was to evaluate changes in students' attitudes towards the subject as a result of the implementation of active learning methods, their perception of English learning in the CLIL context, and in general, students' satisfaction with the learning process. In addition, students were asked to make at least one positive and one negative comment about the methodology employed in the computer-based workshops.

Table 1. Likert-scale questionnaire. Note that the items can be rated from 1 to 5 (1 = strongly disagree; 5 = strongly agree)

QUALITY AND ADEQUACY OF THE LEARNING RESOURCES

1.	The workshops are synchronised with the theory.	
2.	The workload is adequate.	
3.	Recalling the theoretical concepts before each session is useful for me.	
4.	Solving problems promotes a better understanding of the theoretical concepts.	
5.	The time allotted for each session is adequate.	

SATISFACTION WITH THE METHODOLOGY EMPLOYED

6.	There is no difference between solving problems by using computers and solving them by traditional methods.	
7.	I find it attractive and motivating to solve problems by using computers.	
8.	The quizzes via the Moodle Platform are useful for the learning process.	
9.	The difficulty of the problems is appropriate.	
10.	In general, these computer-based workshops are interesting.	
11.	The proposed activities are clear and adequate.	

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SATISFACTION WITH CLIL

12.	By using English, I am gaining fluency in this language.	
13.	I would like that this subject be taught entirely in English.	
14.	The fact that the written materials are in English is an added difficulty to the subject.	
15.	My English level is adequate to follow this course.	
16.	My English level would be adequate to follow and participate in the classroom if this subject would be taught entirely in English.	

OVERALL SATISFACTION WITH THE COURSE

17.	My attitude toward Physical Chemistry has positively changed throughout this course.	
18.	In general, I am satisfied with the course and with the methodology employed.	
19.	I feel that I am learning quickly.	
20.	I find multimedia resources rather scarce.	

So far, we have presented the state-of-the-art methodologies that are being applied within the framework of the European Higher Education Area, as well as our approach to teaching Physical Chemistry in this context. The results obtained in the questionnaire in Table 1, and also the analysis of these data are presented in the following Section.

3. Results and Discussion

The questionnaire was anonymously answered by the 29 students (gender: 52 % males and 48 % females). Relevant data are listed in Table 2. The average values of the points given by the students to each group of items are mentioned herein:

1) Quality and adequacy of the learning resources (items 1 – 5): 3.92 ± 0.81
2) Satisfaction with the methodology employed (items 6 – 11): 3.39 ± 0.81
3) Satisfaction with CLIL (items 12 – 16): 2.68 ± 1.22
4) Overall satisfaction with the course (items 17 – 20): 3.29 ± 0.90

Table 2. Relevant data for the satisfaction survey. Note that the items of the questionnaire are listed in Table 1. SD stands for Standard Deviation.

Item	Average	Median	Mode	SD for the average
1	4.45	4.00	5.00	0.57
2	3.72	4.00	4.00	0.84
3	3.69	4.00	4.00	1.14
4	4.17	4.00	4.00	0.76
5	3.55	4.00	4.00	0.74
6	2.21	2.00	3.00	0.98
7	3.48	4.00	4.00	1.09
8	3.14	3.00	4.00	0.88
9	3.97	4.00	4.00	0.57
10	3.79	4.00	4.00	0.73
11	3.72	4.00	4.00	0.65
12	2.93	3.00	4.00	1.31
13	1.90	1.00	1.00	1.11
14	3.45	4.00	4.00	1.21
15	3.00	4.00	4.00	1.31
16	2.10	2.00	1.00	1.18
17	3.45	4.00	4.00	1.02
18	3.86	4.00	4.00	0.83
19	3.21	3.00	4.00	1.08
20	2.66	3.00	3.00	0.67

In view of the latter results, the highest satisfaction level corresponds to "Quality and adequacy of the learning resources", whereas the lowest average satisfaction level corresponds to "Satisfaction with CLIL". It is also noteworthy that the highest rated item is Item 1 (The workshops are synchronised with the theory), with 4.45 ± 0.57 points, while the lowest rated item is Item 13 (I would like that this subject be taught entirely in English) with 1.90 ± 1.11 points. The latter result is in agreement with a negative attitude toward English language amongst higher education students (Tsuda, 2003). Interestingly, the items with the highest standard deviation are Items 12 and 15 (SD = 1.31), which means that there are striking differences in the English level of the students.

The relative frequencies of the points obtained for each group of items are represented in Figures 1 and 2. In both charts in Figure 1, the maximum relative frequencies correspond to 4 points, which indicates that in general students are satisfied with the quality and adequacy of the learning resources and with the methodology employed. It is also noteworthy that in Figure 1a, the sum of the relative frequencies corresponding to 4 and 5 points represent 73 % of the total. This percentage is significantly lower in Figure 1b, for which this sum represents 56 %.

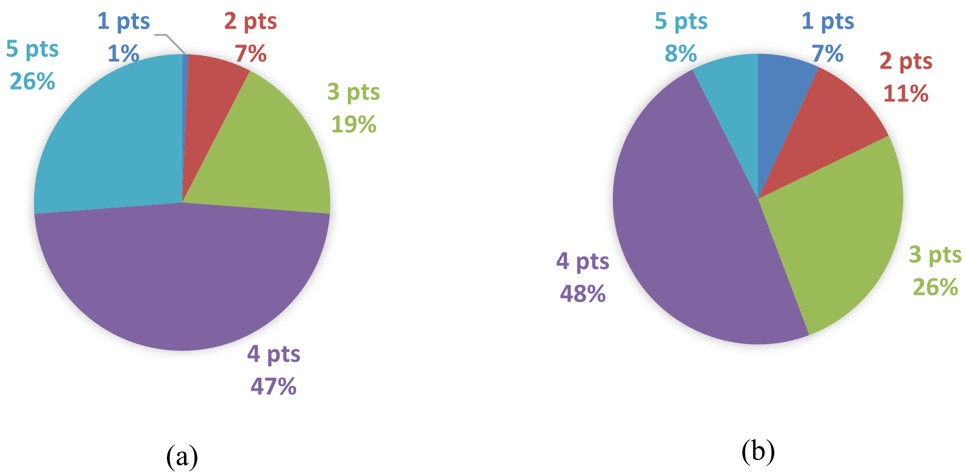

Figure 1. Relative frequency in "Quality and adequacy of the learning resources" (Fig. 1a; items 1 – 5) and in "Satisfaction with the methodology employed" (Fig. 1b; items 6 – 11). Note that "pts" stands for points.

In Figures 2a and 2b, the sum of the relative frequencies corresponding to 4 and 5 points represent in both cases less than 50 %, being this sum lower in Fig. 2a (33 %) than in Fig. 2b (43 %). The extremely low value obtained from the data in the group "Satisfaction with CLIL" reveals the negative attitude of our group of students towards the English language.

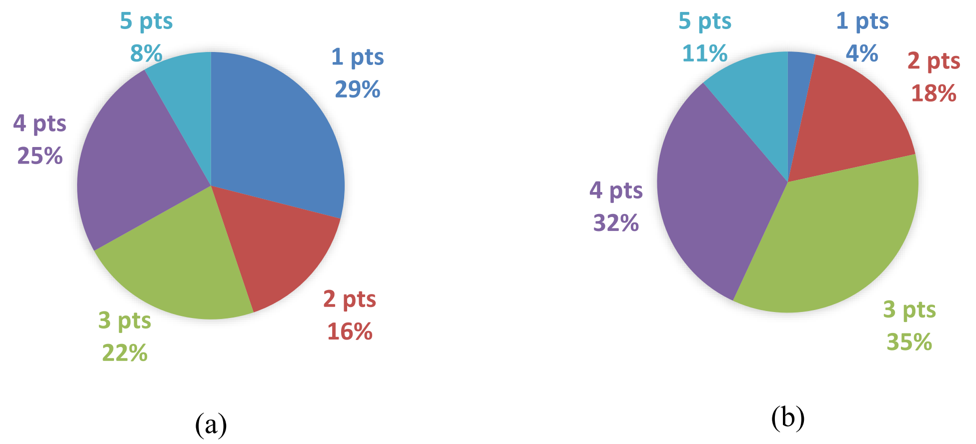

Figure 2. Relative frequency in "Satisfaction with CLIL" (Fig. 2a; items 12 – 16) and in "Overall satisfaction with the course" (Fig. 2b; items 17 – 20). Note that "pts" stands for points.

As previously mentioned, the survey was undertaken by two groups of students (15 and 14, respectively). The standard deviation for the average values of the items in both groups of students differ by less than 0.50 points. The maximum difference in the standard deviation values is observed in Item 13 (0.44 points), while the minimum corresponds to Item 6 (0.01 points). In addition to the Likert-type items, both groups of students (N = 29) were encouraged to make both a positive and a negative comment about the workshop sessions. Approximately 62 % of the students contributed with valuable comments that may become extremely convenient to improve the course methodology in the near future. The average score for the questionnaire (3.32 ± 0.93 points) indicates the students' overall satisfaction with the course.

4. Conclusions

An active learning method based on workshops in which Physical Chemistry students have to solve problems by using computers has been reported. In addition, our efforts devoted to teaching Physical Chemistry through the medium of English language have been presented herein. Students' satisfaction with both the active learning methodology and

CLIL has been assessed by means of a 20-item Likert-scale questionnaire. The highest satisfaction level corresponds to "Quality and adequacy of the learning resources", with 3.92 ± 0.81 points, whereas the lowest average satisfaction level corresponds to "Satisfaction with CLIL" (2.68 ± 1.22). The average score for the questionnaire has been 3.32 ± 0.93. The low score obtained in "Satisfaction with CLIL" suggests that a great deal of effort has to be devoted to the efficient integration of English with Physical Chemistry, and also to raise students' awareness toward the English language.

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6. References

Cambridge ESOL (2010). Teaching Knowledge Test (TKT). Content and Language Integrated Learning (CLIL). Handbook for Teachers. Retrieved March 9, 2015 from http://www.cambridgeenglish.org/images/tkt-clil-handbook.pdf

European Communities (2009). ECTS Users' Guide. Retrieved March 9, 2015 from http://ec.europa.eu/education/tools/docs/ects-guide_en.pdf

European Higher Education Area (2010). Retrieved March 9, 2015 from http://www.ehea.info

Eurydice (2006). Content and Language Integrated Learning (CLIL) at School in Europe. Retrieved March 9, 2015 from http://www.indire.it/lucabas/lkmw_file/eurydice/CLIL_EN.pdf

Frigols, M. J. (2007). CLIL Implementation in Spain: An Approach to Different Models. Retrieved March 9, 2015 from http://arca.unive.it/bitstream/10278/1013/1/13Frigols.pdf

Gürses, A., Açıkyıldız, M., Doğar, Ç. and Sözbilir, M. (2007). An investigation into the effectiveness of problem-based learning in a physical chemistry laboratory course. Research in Science & Technological Education, 25(1), 99 – 113. DOI:10.1080/02635140601053641

Kruschewsky, G. (2014). 6 Multilingual Benefits That You Only Get If You Speak Another Language. The Huffington Post. Retrieved March 9, 2015 from http://www.huffingtonpost.com/2014/06/02/multilingual-benefits_n_5399980.html

Marsh, D., Mehisto, P., Wolff, D. and Frigols, M. J. (2011). European Framework for CLIL Teacher Education. Retrieved March 9, 2015 from http://www.ecml.at/tabid/277/PublicationID/62/Default.aspx

Merritt, A. (2013). Why Learn a Foreign Language? Benefits of Bilingualism. The Telegraph. Retrieved March 9, 2015 from http://www.telegraph.co.uk/education/educationopinion/10126883/Why-learn-a-foreign-language-Benefits-of-bilingualism.html

Paulson D. R. (1999). Active Learning and Cooperative Learning in the Organic Chemistry Lecture Class. Journal of Chemical Education, 76 (8), 1136 – 1140. DOI: 10.1021/ed076p1136

Prince M. (2004). Does Active Learning Work? A Review of the Research. Journal of Engineering Education, 93(3), 223 – 231

Smith M. E., Hinckley, C. C. and Volk, G. L. (1991). Cooperative learning in the undergraduate laboratory. Journal of Chemical Education, 68 (5), 413 – 415. DOI: 10.1021/ed068p413

Spaeth A. D. and Black R. S. (2012), Google Docs as a Form of Collaborative Learning. Journal of Chemical Education, 2012, 89 (8), pp 1078–1079. DOI: 10.1021/ed200708p

http://dx.doi.org/10.4995/muse.2016.3696
EISSN: 2341-2593

Tsuda S. (2003). Attitudes toward English Language Learning in Higher Education in Japan (2): Raising Awareness of the Notion of Global English. Intercultural Communication Studies XII-3, 61 – 75. Retrieved March 10, 2015 from http://www.uri.edu/iaics/content/2003v12n3/06%20Sanae%20Tsuda.pdf