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Insights to Improve Online Content and Language Integrated Learning (CLIL) Sessions on Biorefineries: A Case Study for University Students in Spain

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Abstract

The implementation of educational programs that tackle specific contents and promote English skills is convenient, especially in areas where English skills are not properly developed at universities, such as Spain. Indeed, some subjects are currently presented in English for this purpose. CLIL (Content and Language Integrated Learning), where students learn English as a part of specific subject goals of their degree, could be a suitable way to improve English skills while acquiring the corresponding competences. Moreover, online lessons are becoming important, especially during the COVID-19 outbreak, when it was an alternative for face-to-face teaching. The aim of this work was the implementation of an online CLIL course about biorefineries for chemistry, chemical engineering, and mechanical industrial engineering students. The course was a first approach presented as a specialization course that could be merged with related subjects in the future. The main objective of this session was the gradual introduction of English grammar and vocabulary (specific terms) and the promotion of students' participation on oral discussions. The results were successful, showing that the students got motivated and obtained good grades. As possible improvements, the introduction of terms should be less continuous, otherwise the students could lose track of the lesson.

Introduction

The English level of adults in Spain (and, especially, in Extremadura region) is considerably low compared to the rest of European countries. Indeed, a study carried out by Education First (EF) based on the results obtained in English tests for over 1.3 million adults in 88 different countries (including 76000 Spanish), allowed to compare the English level according to an EF EPI score, depending on the marks obtained in these tests. Figure 1 shows a Rank focused on European countries and comparing them with the situation of Extremadura region (belonging to Spain).

As it can be observed in this figure, the low English level observed in Spain puts it far behind countries like Portugal, Switzerland, Netherlands or Nordic countries. Similarly, Extremadura region, compared to the Spanish

average score, showed lower English levels in general.

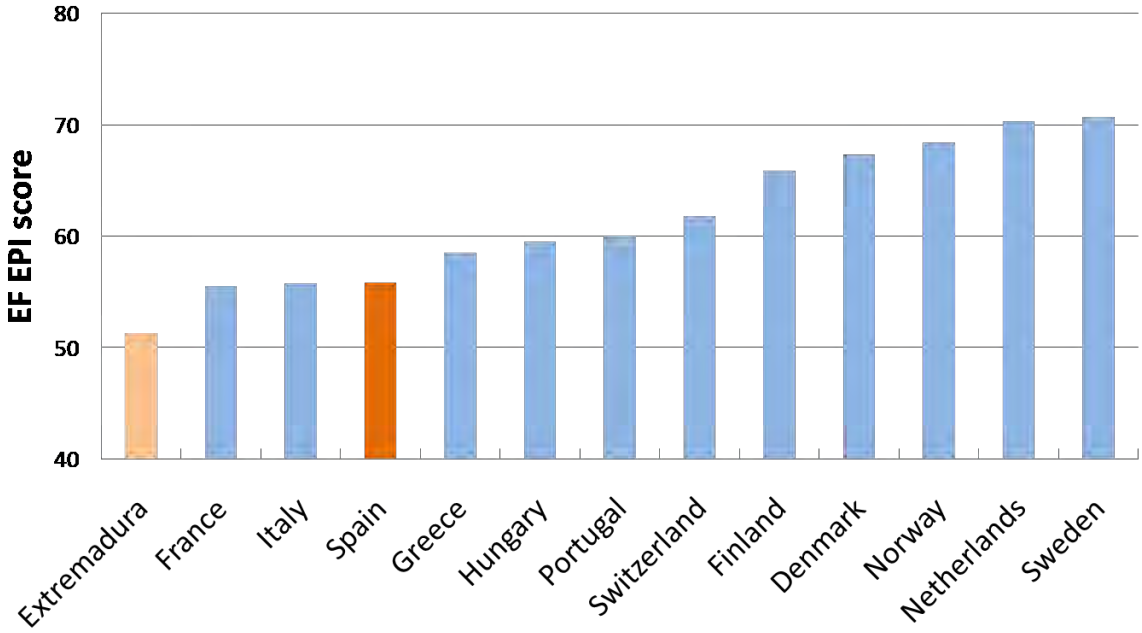

Figure 1. English Level in Extremadura Region and Spain compared to Other European Countries (according to EF-EPI ranking in 2018). Source: (EP, 2021).

As a consequence, taking into account that language skills are vital for the development of professional careers in this changing society and labour market, improving the English level in this context is necessary and owing to this fact, action has been taken in the last years in order to increase the load of English lessons at early educational levels in Spain, as it can be seen in Table 1.

Table 1. Percentage of Students studying English at Different Educational Levels in 2018. Source: Ministerio de Educación y Formación Profesional and Ministerio de Universidades, 2020 (MEFP, 2020; MICINN, 2020).

Educational level	Students attending English courses (%)
Childhood education	84.0
Primary education	99.1
Secondary education	98.2
High school	97.1

Thus, the highest percentage of students attending English courses (over 99 %), corresponds to primary education, whereas a slight decrease is found at higher educational levels. This way, and depending on the quality of English programs, a great effort has been made in order to promote English learning in future generations. However, at university level, and possibly due to the difficulty of academic degrees, English learning is usually disregarded by university students at this stage, implying serious drawbacks regarding their professional future.

That is the reason why our university will promote English programs in order to teach at least 80 subjects (included

in 25 different degrees) completely in English (UNEX, 2020). In addition, a minimum English level is required so that students can obtain the corresponding degree (B1 international accreditation). This way, there is a clear transition towards active language learning (especially concerning English). One of the main issues at this point is the implementation of this kind of subjects. As in the case of other universities in our country and around the world, the implementation of CLIL (content and language integrated learning) is considered to be a key point for foreign language learning, although some challenges had to be faced such as the use of clear and specific guidelines to develop coherent CLIL programs that address the language needs for students and also for university lecturers (Arnó-Macià et al., 2015; Banegas et al., 2020; Borzova et al., 2019).

In this context, the possible use of CLIL sessions (regardless the degree field of knowledge) could be a useful way to keep or improve the English level of students during their university stage (Coyle et al., 2010). Indeed, by definition, CLIL students use English to study subjects that were originally taught in the native language at earlier stages (Eisenstein Ebsworth et al., 2019; Klimova, 2012). Many researchers have studied the influence of CLIL at different educational levels: from primary or secondary school (Llinares et al., 2013; Pérez et al., 2015; Piesche et al., 2016; Pladevall-Ballester et al., 2016) to higher education or universities (Arnó-Macià et al., 2015; Chostelidou et al., 2014), presenting some advantages like better receptive skills, comprehension, content knowledge and specially vocabulary (Agustín-Llach et al., 2016; Castellano-Risco et al., 2020), and providing an extra motivation to students and an appropriate learning environment to enhance their autonomy (Ángel, 2015). However, some authors have questioned the effectiveness of CLIL, showing some pros and cons, and have pointed out a thorough consideration about its implementation (especially taking into account the context of teachers and students), possibly affecting foreign language teaching (Bruton, 2011, 2013) or implying a lack of knowledge acquisition by the students.

Among other fields, CLIL has been studied in scientific subjects, by exploring the potential of hands-on tasks in CLIL chemistry and physics lessons (Nikula, 2015). As in other cases, there was a potential to add more explicit language focus. Nevertheless, in certain cases studied in the literature (such as secondary education learners), some linguistic gains were observed compared to formal instruction, especially concerning grammar (Pérez-Vidal et al., 2015).

On the other hand, online lessons have gained an important role recently, especially due to the COVID-19 outbreak, when many educational centers had to resort to this resource in order to replace face-to-face lessons. In this way, online lessons could be a complementary aid for traditional courses, and many specific studies have been carried out during this hard period (Bao, 2020; Mahmood, 2020; Mishra et al., 2020; Moorhouse, 2020). Thus, the irruption of this pandemic has underlined that educational institutions should be prepared to abrupt changes, whose learning methodological adaptations can be based on technological or society evolution, among other factors.

Concerning the research interest, CLIL and online lessons have been widely studied in educational fields. Indeed, these subjects have considerably gained interest for researchers in recent years, as it can be seen in Figure 2 (Martin et al., 2020).

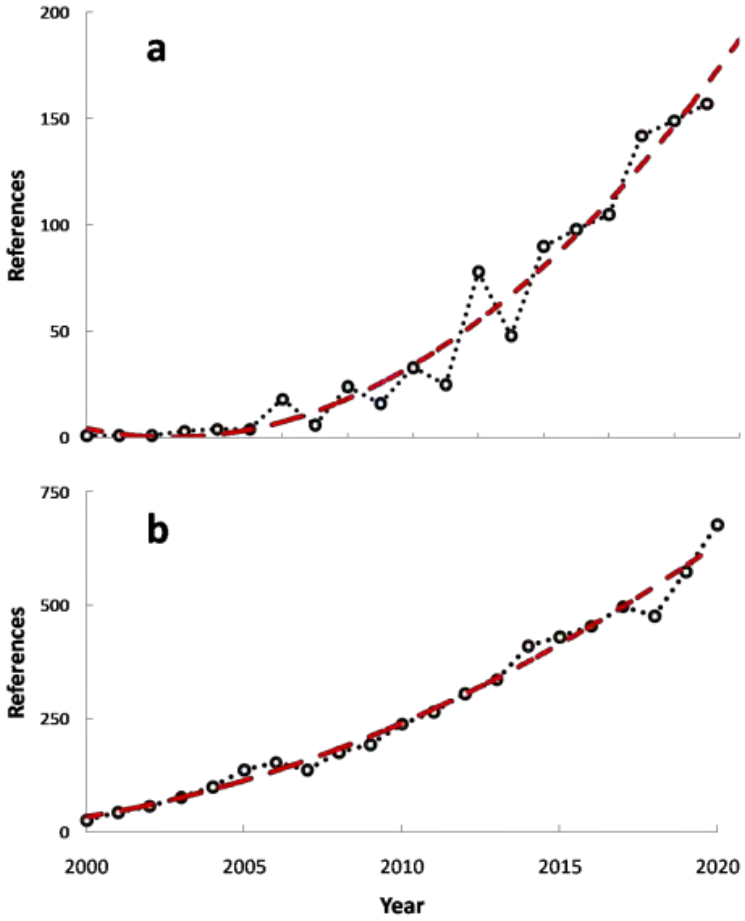

Figure 2. Scientific References per Year about: a) CLIL and b) Online Lessons. Source:(SCOPUS, 2023).

According to this figure, the scientific references about CLIL and online lessons have continuously increased since 2000. In the case of articles about CLIL, the number of research articles increased from 2005, showing an exponential trend. Regarding online lessons, this increase was steady, with more articles in comparison to CLIL. As a consequence, these are, currently, interesting fields in educational research.

In the light of the above-mentioned considerations, the aim of this work was the implementation of an introductory online CLIL course about biorefineries for chemistry, chemical engineering and industrial technical engineering students, paying special attention to the design, performance and feedback obtained from the students through their direct participation and carrying out a final test and a satisfaction survey.

Method

Context and course design

Our department, specifically the laboratory devoted to biodiesel and biolubricant production, had previous experience on research in educational science. Thus, we have covered other similar courses, like exhibition sessions for any kind of audience, both at university, primary, secondary or high school levels (Nogales-Delgado et al., 2019). Moreover, a safety course was carried out for the students who develop their work in our laboratory

(Nogales Delgado et al., 2020), apart from a teaching guide for final degree students in scientific and technical degrees (Nogales-Delgado et al., 2022). Finally, due to the COVID-19 outbreak, some interesting conclusions were obtained from this hard experience concerning final degree projects (Nogales-Delgado et al., 2020). Based on that, this CLIL course was initially designed as a face-to-face lecture, but due to the circumstances related to the confinement that took place in Spain (especially between March and May 2020), the CLIL session was finally carried out online, supported by software tools previously implemented in our university. The course was designed following the constructivist approach. The constructivism theory states that learning is an active process where students construct knowledge based on their experiences, being considered essential in effective education design and having a great impact in science education (Alsharif, 2014; Sejzi et al., 2012). This way, the correct implementation by teachers is very important in order to improve the learning process of students by giving them opportunities to discuss, negotiate or reflect their own ideas, among others (Alsharif, 2014). In other words, learners' new knowledge is created through their own experiences (and also through active and collaborative learning), and teachers should act as facilitators, guiding their students in the teaching and learning process (Ahmad et al., 2015; Gunduz et al., 2015). The aim of this course was the implementation of new knowledge (about English language and scientific content about biorefineries) based on the previous language and academic level of the audience. Basically, it can be compared to the construction of a building (see Figure 3), where its foundations, that is, the previous English and academic level of the student, are the basis of the construction of the house by adding bricks, like new concepts or further knowledge.

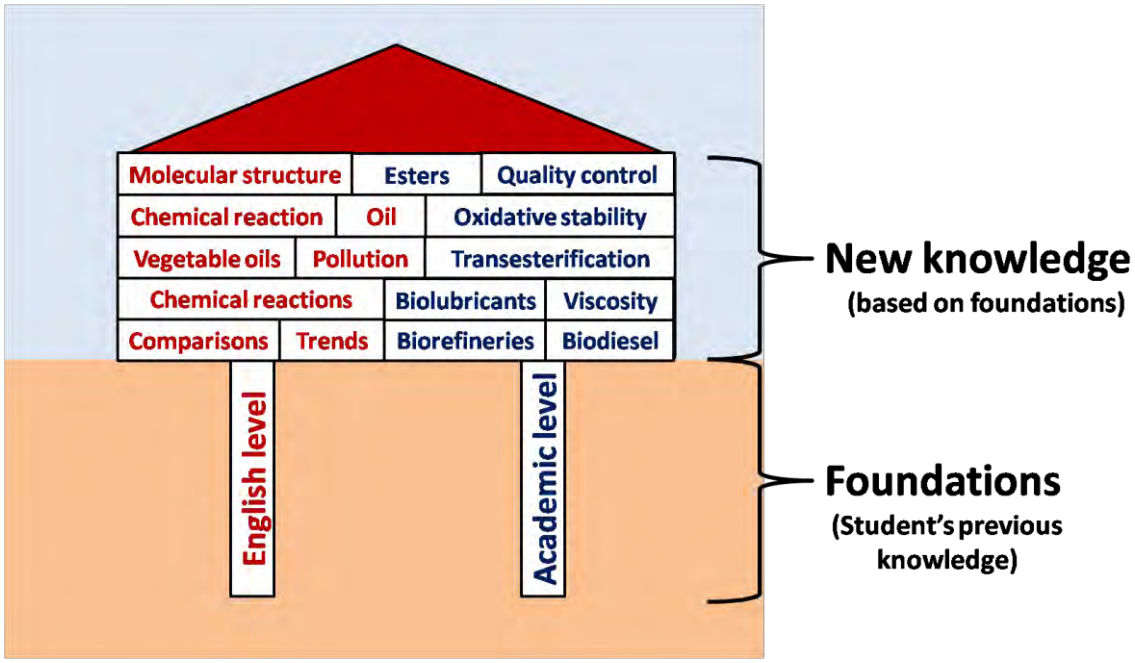

Figure 3. Teaching Procedure for this CLIL Course (based on Constructivism). In red, main vocabulary or grammar concepts included in this course. In blue, the main academic subjects included in this session.

The main characteristics of the session are included in Table 2. It should be noted that this was a pilot project, aimed to assess the need of future academic formal subjects that could be entirely in English. The course began with an online session where four short exercises were proposed, in order to foster the participation of the students during the session and make a previous evaluation about the initial English skills of the students. Afterwards,

some learning materials in English language (vocabulary lists, scientific papers, audiovisual resources…) adapted to their level was facilitated to the students. This way, the students attended the online sessions (4), aimed to explain and discuss information about: a) the chemistry of biofuels (solid, gas and liquid ones), b) the thermochemical processes associated to their obtaining processes, c) characterization techniques, d) safety and health tips. In this way, our university, as explained in previous studies (Nogales-Delgado et al., 2020), used virtual tools and platforms to provide the students the specific information they needed for their final degree project at the same time that the English level of the students was improved. Consequently, the implementation of these online sessions was easier, as there was a computing infrastructure which was clearly enhanced after COVID-19 outbreak. Finally, the students were given the opportunity (optional) of writing their final project and exposing their presentation in English, with the aid of the teachers involved.

Table 2. Main Characteristics of the CLIL Session

Platform used	Online (zoom/virtual campus)
Number of students (average)	21
Number of sessions	4
Session duration	50 minutes
Slides (including covers)	35-52
Introductory language sets	6
Exercises	4
Final test	1
Satisfaction survey	1

This preliminary information was essential for the establishment of the CLIL course. Nevertheless, the specific design and implementation of the course had the following stages:

- Analysis of the audience.
- Selection of English vocabulary list, grammar and scientific language.
- Selection of scientific content about biorefineries, including biodiesel and biolubricant production.
- Interrelation between the English language and scientific content.
- Design of exercises, final test and satisfaction survey.

The selection and design of CLIL materials has been widely studied in the literature, proposing some guides about it, as this stage is crucial and not many materials are usually found by teachers, requiring extra time for the design of this kind of courses (López Pérez et al., 2017). That is the reason why this experience could be a good guide for future CLIL courses based on similar subjects.

The first step was the analysis of the audience, whose main characteristics are included in Table 3. As it can be seen, the main aspects to be taken into account are the academic level of the students (who are carrying out their final degree project to obtain the degree in Chemistry, Chemical Engineering or Technical Industrial Engineering) and their English level (B1 in general, although there were some students with C1 level). This information is important for the correct design of a CLIL course, as its content will depend on the academic and English level to

a greater or lesser extent.

Table 3. Main Characteristics of the Audience

Degree	Chemistry, Chemical Engineering and Technical Industrial Engineering
Course	Final degree project
Age range	20-25 years
English level (CEFR/Cambridge)	B1 (Lower intermediate)/PET

Once the English level is known, the basic vocabulary and certain grammar aspects were selected to be introduced in this CLIL course, which were linked to the academic content selected for this session. Thus, the basic vocabulary included was related to biofuels (biodiesel, syngas, bioethanol) and biolubricants (that is, terms related to vegetable oils), as well as terms related to basic chemistry (like those related to chemical reactions and molecular structure). Concerning grammar/scientific English, we focused on several main concepts: state of art, trends on experimental data and comparisons of several related field of research.

In particular, we included the following issues: environmental problems (pollution), oil reserves depletion, biorefineries (definition and examples), biofuels (advantages and challenges compared to fossil fuels), thermochemical processing, and quality control (mainly fatty acid methyl ester content, viscosity and oxidative stability), suitable characterization techniques, safety and hazards consideration, and new research trends.

The interrelation between the English vocabulary or grammar and the scientific concepts of the course are included in Table 4. As it can be seen from this table, vocabulary sets are strictly related to the concepts of the course; for instance, when we introduced pollution, we explained concepts like the environment, air pollution, greenhouse gas effect, etc. (see Figure 4).

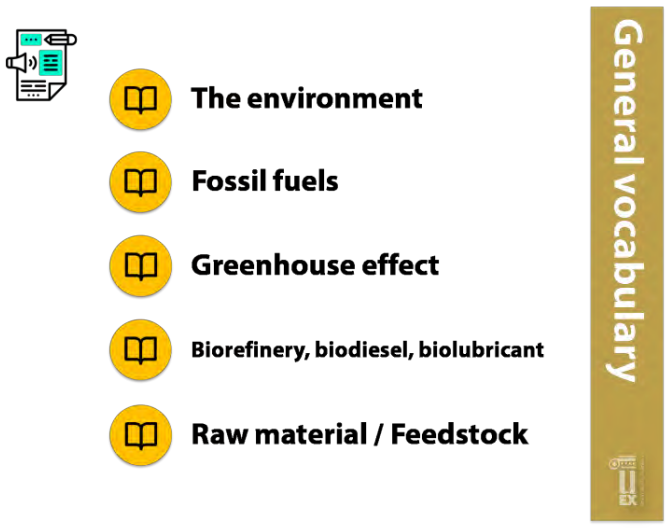

Figure 4. Example of a Vocabulary Set introduced during the CLIL Lesson

In the case of grammar or scientific language, the concepts included in this course, that is, trends and comparisons, were introduced when oil reserves (and biodiesel consumption) and biodiesel production worldwide were

explained, respectively. This was due to the fact that, in these slides, we had to use figures where trends or comparisons were necessary to be clearly understood by the students. The final correlation between the concepts of the course, the vocabulary set and grammar is included in Table 4.

Table 4. Concepts explained and the Corresponding Introduction of Vocabulary/grammar

Concept	**Vocabulary set**	**Grammar or Scientific language**
Pollution	The environment / pollutants	--
Oil reserves/biodiesel consumption	Biofuels	Trends
Biodiesel	Vegetable oils	--
Biodiesel production worldwide	--	Comparisons
Transesterification	Chemical reactions	--
Biolubricants	Molecules-structures-functional groups- free radicals	--

Later on, different activities (lectures, exercises and final evaluation) were carried out. During the practical activities, including typical problems and practical cases, two video playback activities where the students were asked to answer easy questions were also applied, in order to foster their participation in class. At the end of the course, the students were asked to solve a final test, as well as a satisfaction survey in order to get some feedback about the performance of the course. The content and results of these tests are explained in following sections. To sum up, Figure 5 explains briefly the design of this CLIL course.

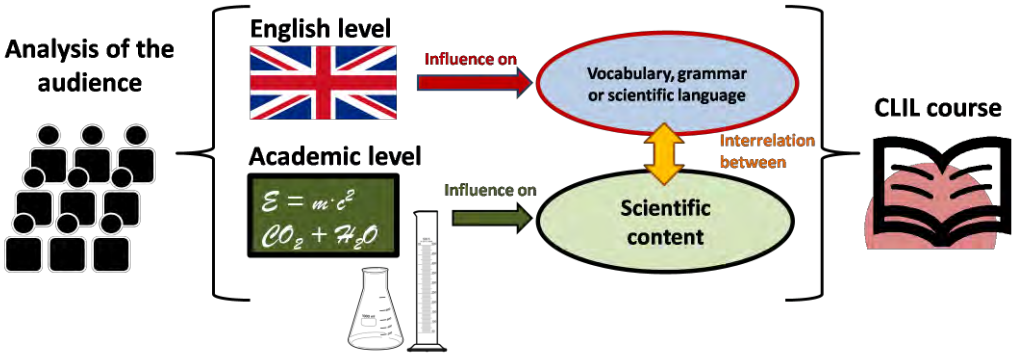

Figure 5. Design of the CLIL Course

Results and Discussion

The design of a CLIL course should take into account one important aspect, that is, the introduction of vocabulary/grammar points during the presentation. In this course, we opted for introducing these terms at the beginning, but also when necessary along the course. This was due to the fact that, once the corresponding term was introduced, it could be adapted to the context immediately, reinforcing the knowledge acquisition. Thus, as it can be seen in Figure 6, some symbols were presented at the beginning of the course in order to let the student know when there will be an introduction about vocabulary, grammar or some exercises.

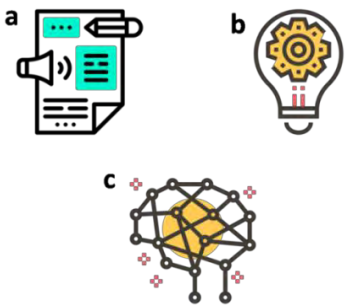

Figure 6. Symbols (hyperlinks) used in the Presentation to introduce: a) Specific Vocabulary; b) Grammar/scientific Language; c) Exercises. Icons created by Eucalyp Studio.

The slides about vocabulary/grammar were introduced when necessary (see an example in Figure 7, where the vocabulary required to understand biodiesel concepts was introduced with the corresponding hyperlink), and they were quite simple, as it can be seen in the examples selected for vocabulary and grammar (see Figures 4 and 8, respectively).

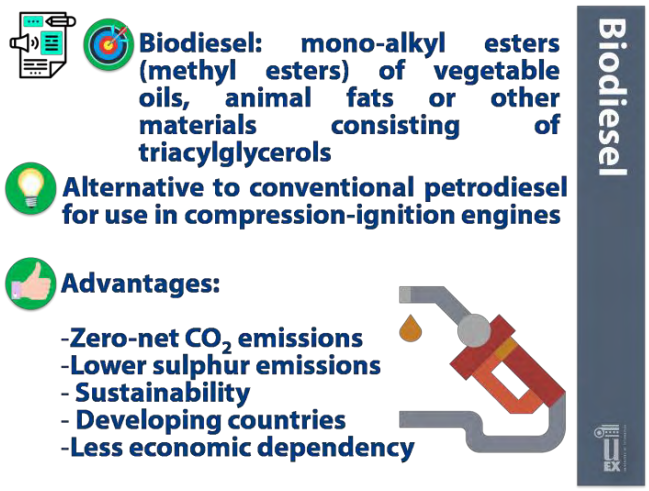

Figure 7. Example of a Slide with a Vocabulary Symbol/hyperlink (top left)

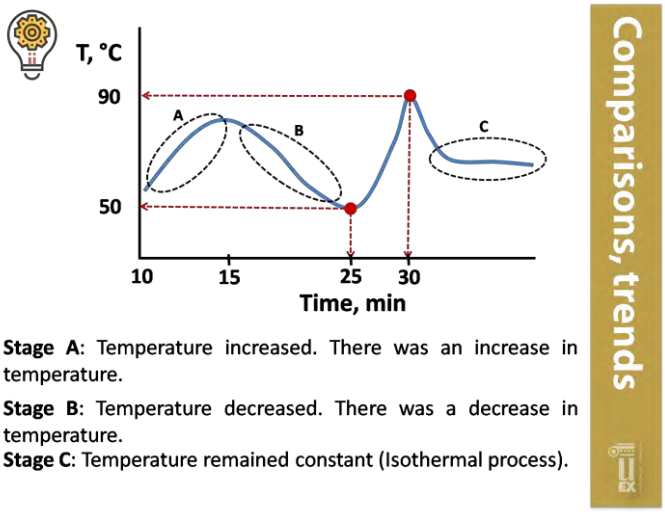

Figure 8.Slide about Grammar (in this case, about trends)

Thus, according to our experience, the introduction of vocabulary terms or grammar concepts should be balanced, depending on the English level of the audience. This way, a minimum English level is required in order to avoid excessive breaks during the lesson, which could make the course difficult to follow. Moreover, if many breaks took place in order to explain vocabulary or grammar, there would be less room for the theoretical explanation about biorefineries and biodiesel or biolubricant production. In a way, this fact could be compared to a balance (see Figure 9), where the English level and the vocabulary and grammar requirements should be balanced in order to carry out a satisfactory CLIL session, especially promoting more scientific content and continuity during the lesson. However, this balance is clearly influenced by the English and academic level of the audience.

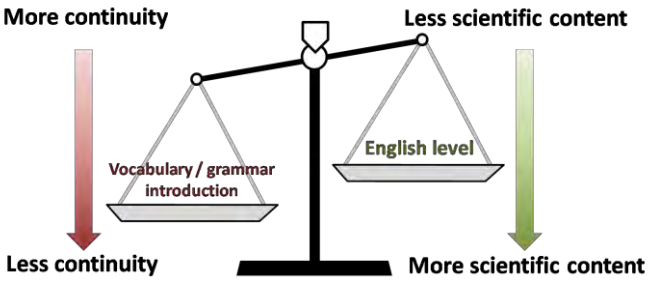

Figure 9. Balance between English Level and the Introduction of Vocabulary/grammar required in the CLIL Course

In order to enhance the participation of the audience, different activities were proposed during this course. Apart from two exercises based on questions about two video playbacks, there were several simple exercises dealing with the main quality subjects included in this course: for example, Figures 10 and 11 show exercises involving the concepts of viscosity and oxidative stability. After introducing the concept of viscosity, the students were asked to order three molecular structures according to their viscosity (see Figure 10).

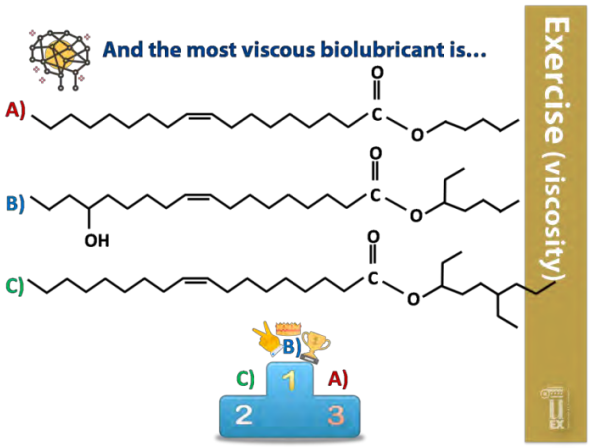

Figure 10. Exercise about Viscosity (including the Final Answer)

These molecular structures showed clear differences (like functional groups in case b and branching in case c) so that the students were able to put them in order if they understood the concept. On the other hand, after explaining oxidative stability, a similar exercise was presented to the students, where they had to select which biolubricant had the longest oxidative stability (see Figure 11).

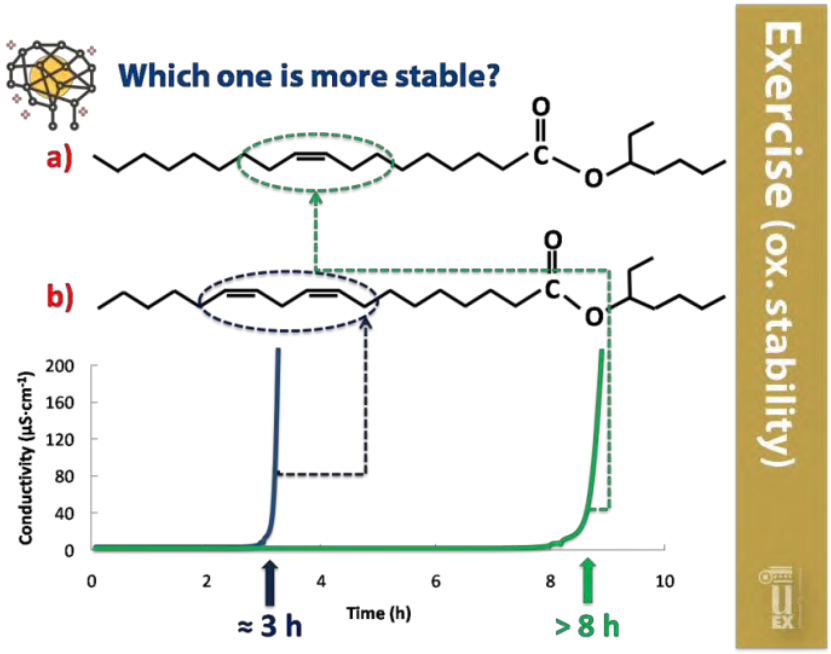

Figure 11. Exercise about Oxidative Stability (including the Final Solution with Arrows)

As in the case of viscosity, clear differences were found between both examples of molecules, especially concerning the number of unsaturations (which has a strong influence on the oxidative stability). Thus, the students could tell the difference between both cases. The aim of these short exercises was to foster the participation of the students, allowing smooth communication between the speaker and the students. Thus, it was a good opportunity for the students to practice the English language, by using short and easy sentences.

At the end of the session, in order to assess the knowledge acquired during this course, a final test was sent to the students. Some of the questions used are included in Table 5, with the corresponding answers.

Table 5. Final Test for CLIL Students (including Answers and Grades)

1. – Can you use biodiesel in diesel cars? a) No, because it is worse than diesel b) Yes, as long as it complies with the EN 14214 standard c) Yes, as long as it complies with the EN 14890 standard
2. – What happens with methanol in a biorefinery? a) It is removed as a by-product b) It is added for biodiesel production and evolved in biolubricant production, and it can be re-used for the first stage c) It is not necessary at all
3. – What is the lower limit for biodiesel oxidative stability, according to the standard? a) 3 b) 12 c) 8

4. – What are flash and combustion points? a) A measurement related to storage safety b) The temperature at which the biodiesel sample starts sparkling and flaming, respectively c) a and b are correct
5. – According to our experience, did oxidative stability depend on the molecular structure of biolubricants? a) Not at all b) It depended on the length and branching c) It depended on the functional groups d) B and C are correct e) The dependence was almost negligible
If the student got less than 3 answers right, the knowledge about biorefineries was not enough; If the student got between 3 and 4 answers right, the knowledge about biorefineries was enough; If the student got 5 answers right, the knowledge about biorefineries was excellent (Answers: 1b, 2b, 3c, 4c, 5d)

Equally, a satisfaction survey was sent to the students after the CLIL course, in order to assess the design and performance of the whole process and identify areas of improvement. The questions were simple and focused on the presentation, the vocabulary and grammar selected and the speaker, as it can be seen in Figure 12.

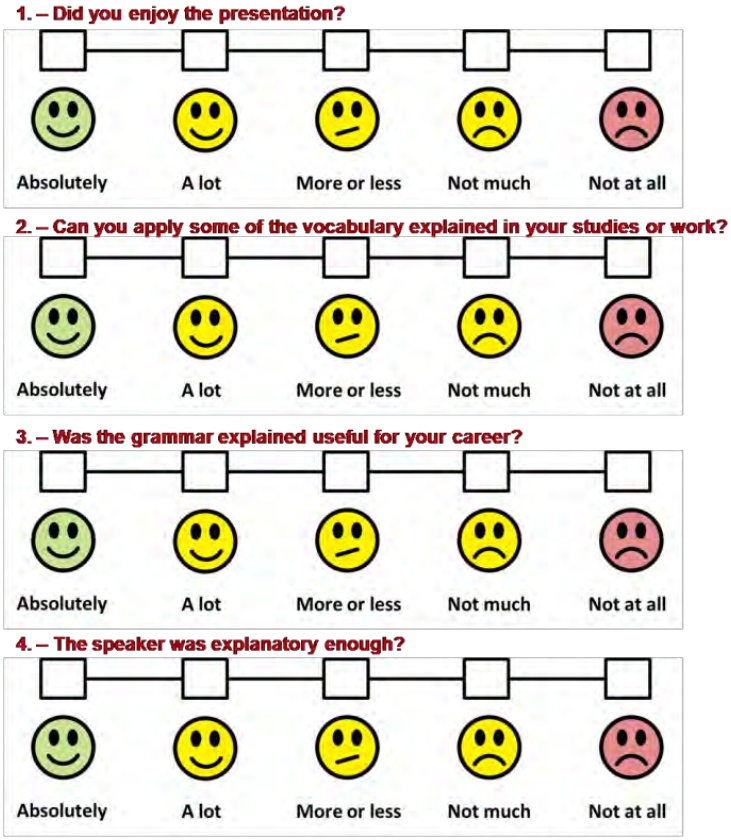

Figure 12. Satisfaction Survey for CLIL Students. Score: Absolutely: 5 points; A lot: 4 points; More or less: 3 points; Not much: 2 points; Not at all: 1 point. The presentation was (according to points): 4-8: poor; 9-12: acceptable; 13-16: good; 17-20: excellent

Finally, as it can be observed in Table 5, the average results obtained were satisfactory, according to the students.

Table 5. Results related to CLIL Activities

Activity	**Result**
Final test	4.39 (enough/excellent)
Satisfaction survey (average)	18.14 (excellent)
Question 1: Presentation	4.62 (a lot/absolutely)
Question 2: Vocabulary application	4.19 (a lot)
Question 3: Grammar usefulness	4.62 (a lot)
Question 4: Speaker	4.71 (a lot/absolutely)

In this way, the results concerning the final test showed that the understanding of the course was, on average, enough or excellent, pointing out the suitable adaptation of this CLIL course to the audience and the correct assimilation of knowledge. Regarding the satisfaction test, the average results were, in general, excellent. Specifically, the most rated aspects of the course were the presentation and the speaker, whereas the vocabulary application was the least rated aspect. This could be due to the fact that many of the terms introduced were too specific, which makes its regular use difficult. Moreover, the heterogeneity of the audience (Chemical, Chemical Engineering and Mechanical Industrial Engineering) made the usefulness of this vocabulary set variable. Nevertheless, the grammar (or scientific language) implementation was considered to be easier, due to their general nature (for instance, trends and comparisons are used in many aspects, regardless the scientific field) and the subsequent ease of use by the audience in their corresponding fields.

Conclusion

The main findings about this experience were the following:

- Online CLIL sessions might be an important tool which could contribute to the ongoing adaptation of universities to technological and society changes.
- The implementation of an online CLIL course about biofuels and biorefineries showed positive results on the acquisition of both specific and transversal English skills, as the final test and the satisfaction survey pointed out.
- The initiative could be a good starting point for the implementation of a complete subject at university level, within the formal degree framework.
- The gradual introduction of vocabulary and grammar sets related to the concepts explained during the CLIL session seemed to be suitable, although in such short sessions the introduction of these sets should be limited so that the students do not lose track of the lesson. This circumstance would be less problematic in complete subjects or long courses, where vocabulary or grammar sets could be less frequently introduced.
- Concerning the online sessions, the students seemed to prefer the interaction through the chat instead of using the webcam/microphone, which could be a drawback as one of the main objectives of this kind of sessions is the spoken interaction between the speaker and the audience. In order to solve that, the

promotion of student-student interaction through group exercises could be a good solution.

- Nevertheless, the combined use of online and CLIL lessons applied to university education could be a suitable way to improve the English level of university students, being an alternative for in-person classes in certain situations like the COVID-19 outbreak. Indeed, it could be a perfect supplement to face-to-face sessions under these circumstances.

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