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**Trabajo fin de máster**

# Implementing CLIL through PBL in Physics and Chemistry in 2ºESO: The Periodic Table Project

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## ABSTRACT

A common teachers' concern is how to increase students' motivation, self-esteem and autonomy, as they are vital to generate lifelong learning skills. In addition, there is a tendency in science education to reinforce scientific areas such as Science, Technology, Engineering and Mathematics (STEM) due to their importance in the future of our society. Project Based Learning (PBL) is a methodology that fosters students' motivation towards learning science, and at the same time, it promotes the development of life-long and creative skills. Therefore, PBL provides the necessary change from traditional teaching to student centred learning.

On the other hand, nowadays English is a paramount skill, thus, considering bilingual classrooms, we need to motivate students for learning both content and language. An effective and innovative way to do it is by introducing the CLIL approach in the classroom, because it challenges students and develops high order thinking skills. Consequently, the combination of CLIL and PBL methodologies can be a powerful motivational instrument for bilingual education in any subject.

This intervention proposal is designed as an attempt to show, firstly, how to change students' perceptions of learning Physics and Chemistry (P&C) and Foreign Languages (FL), and secondly, to change traditional teaching in P&C subject.

The proposal is based on the combination of CLIL and PBL methodologies in the P&C classroom, in the 2<sup>nd</sup> level of Compulsory Secondary Education. The project arose linked to two facts: firstly, most of the contents of P&C subject in this level are mainly devoted to the matter, their structure and the periodic system; secondly, 2019 has been proclaimed the International Year of the Periodic Table of Chemical Elements by the United Nations General Assembly and UNESCO (UNESCO, 2019a).

The project involves three stages: (1) the creation and assembling the Periodic Table; (2) Students' researches and presentations related to chemical elements and their uses; (3) the generation of a Google site associated to The Periodic Table, where the students will incorporate their investigations and works. The Periodic Table of Chemical Elements is one of the most important achievements in all areas of science, and students will have the opportunity to be aware of that by creating their own table, and by investigating about the chemical elements.

**Keywords:** Content and Language Integrated Learning (CLIL), Problem-based learning (PBL), Language learning, Science education, Secondary Education, The Periodic Table of the Chemical Elements, Motivation, Bilingual classrooms.

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## **1. INTRODUCTION**

Teachers' concerns are diverse, and in addition, they are determined by the subject they teach. However, a common problem for all subjects and at all educational levels is how to increase students' motivation and students' perception of their learning (Dörnyei & Ushioda, 2009; Linares, 2016; Heras & Lagasabaster, 2015). Teachers have realised that the students' motivation is a crucial factor in their learning process, as well as the developing of their self-esteem and autonomy to generate lifelong learning skills (Hayat, Rustaman, Rahmat & Redjeki, 2019). In the same way, by improving the perception of their learning and their autonomy, they will be more motivated to learn. Besides, considering bilingual classrooms, we need to motivate students for learning both content and language (Ramnath, 2017), and an effective way to motivate students is to challenge them and to stimulate high order thinking skills (Tibaldi, 2012).

From science subjects it is intended that students become aware that the human being has always lived in a constantly evolving society, in which science and its applications have a crucial role. Since science needs the cooperation and the teamwork of scientist, a common language (nowadays English) is indispensable to investigate and to transmit the information to other scientists. For this reason, from the P&C subject it is intended to make students be aware of the importance of mastering this language. Besides, it is important to show students that languages will also be useful in their daily life, for future teamwork, traveling, expressing feelings and thoughts or making decisions, and thus, they will be able to live integrated in our society as active and critical citizens without losing their individuality. Through this project is expected that students improve their language skills in L2, especially interaction, oral and written skills.

In addition, through this project, we can encourage and help our students to improve skills related to cooperation, teamwork, critical thinking, researching, analysing, making decisions, the use of Information and Communication Technologies (ICT), etc., so important for continuous learning (Leaton Gray, Scott & Mehisto, 2018).

Finally, we will work from tolerance, respect and coeducation, which are essential aspects in our society. In this way, this project tries to achieve the general objectives of the Compulsory Secondary Education in Spain, that means, a global education that implies the personal development of the student and provides them a lifelong learning for their future as active citizens.

This intervention proposal is designed as an attempt to show how to change, firstly, students' perceptions of learning Physics and Chemistry (P&C) and Foreign Languages (FL), through fostering their motivation and autonomy, and secondly, to change traditional teaching and methodologies used in P&C subject.

The theoretical basis of the proposal is studied in the literature review section, where we will focus on describing Content and Language Integrated Learning (CLIL) approach and Project Based Learning (PBL) methodology, and the common features for their combination. Besides, we will pay attention to the importance of the Scaffolding in Science-CLIL-PBL classes, focusing on the Teachers' Multimodal Discourse, the role of the first language (L1) and Translanguaging.

In the corpus of the intervention proposal we will describe the project in detail, the educational context, the target groups, the aims of the project, the methodology to develop it (integrating CLIL and PBL), the sessions and the activities to carry out it, and how to assess not only the final products, but also, the process and the project itself.

Finally, we will analyse the conclusions and the limitations of the proposal, as well as the further research related to the improvement in the design and the implementation of any future project in the centre, the implementation of CLIL and PBL methodologies in any content subject in the centre, the research in how students' attitude and motivation depend on different factors, how the Multiple Intelligences theory and learning styles can improve teaching in P&C or which are the affective factors and problems in social interaction that can be arise in students' group working.

The research and bibliographic selection for the development of the TFM has been determined by different factors. Firstly, the virtual library of the Universidad Internacional de la Rioja (UNIR) was the main source of documentation. The search has been prioritized according to the topics of the TFM, such as CLIL, PBL, science education and student's motivation. On the other hand, the dates of publication have been considering as well, giving priority to the most up-to-date ones. Finally, other TFMs have been considered as guidance in the structure of the intervention proposal and to get extra documentation. These TFMs have been obtained from the repository of UNIR.

### **1.1. Justification of the Research: Question and Problem**

The concept of learning has changed and the importance of "learning to learn" is highlighted and included in the content of syllabuses. Lifelong learning has become

the new model for improving education (Hayat et al., 2019), as we can see in the Spanish legislation (art. 23, LOE N<sup>o</sup>2, 2003; art.2 and art.11, RD N<sup>o</sup>1105, 2014). However, despite of the fact that students' motivation is essential in their learning process (Heras & Lagasabaster, 2015), it is not included or explicitly specified in Spanish syllabus, and it is assumed that teachers should motivate our students, but nobody trains them to do it properly. Besides, students' perception of teachers' dedication is equally important (Matsumoto, 2009).

On the other side, current globalization demands for multilingual education (Pérez-Ibáñez, 2014) and the European Union encourages multilingualism. According to the Foreign language skills statistics from Eurostat Statistics Explained (2019), 35.4% of the adult working-age population of the EU reported that they did not know any FL. However, 35.2% reported that they knew one FL, 21% knew two FL and 8.4% knew three or more FL. The same analysis shows that there is no gender gap in FL knowledge. In addition, employed persons had the highest level of FL proficiency when compared with unemployed and inactive persons of the same age.

Nowadays English is a paramount skill (Coyle, Hood & Marsh, 2010), and for this reason, governments are changing their curricula to foster FL learning by introducing new educational approaches (Casan-Pitarch, 2015). Many institutions are opting for CLIL based approach due to the improvements in learners' language fluency (McDougald, 2018), as well as it seems to promote students' motivation to learn languages (Heras & Lagasabaster, 2015).

To make this situation worse, in Spain it seems to exist a common point all along the autonomous communities, students at secondary education are not motivated to learn FL (Heras & Lagasabaster, 2015). In addition, the attitude of the students when facing content and language subjects is different; even some content subjects are characterised as more difficult than others, such as P&C, even more if they must study it in English. The problem is that if science is presented as a difficult subject, it becomes just that (Lemke, 1990). It has been detected a reduction in students' motivation towards science (Linares, 2016). Therefore, there is a tendency in science education to reinforce scientific areas such as Science, Technology, Engineering and Mathematics (STEM) due to their importance in the future of our society (Bybee, 2010; European Commission, 2014; Linares, 2016).

Teachers must base our teaching practices following the current Spanish educational laws and stablished curricula, where we can find the incorporation of FL learning as an important issue (art.2 and art.23, LOE N<sup>o</sup>2, 2003; art.11, RD N<sup>o</sup>1105, 2014). Teachers do not have any training from authorities to improve our subjects'

methodologies, not to mention when we must teach the subject through a FL. They must decide what and how to learn facing our language limitations, how to collaborate effectively with other teachers from different subjects and how to teach the subject through a FL. In this aspect, CLIL promotes collaboration between content and language teachers (team teaching) (Banegas, 2011). Bilingual education needs a solid and progressive model, with enough human and economic resources, as well as the training of the teachers for its successful implementation (Asociación Enseñanza Bilingüe, 2016; Linares, 2016).

On the other hand, Project Based Learning (PBL) is a very powerful methodology to help all students, to engage in and foster their motivation towards learning science, even outside the school (Krajcik & Blumenfeld, 2006; Veermans & Järvelä, 2004). PBL and the CLIL approach share many common features and its combination integrates “language and content learning by means of interaction and, at the same time, leading students towards motivation, involvement and efforts in a real-life context”, so it “can serve as a motivational instrument for bilingual teachers and students due to its practical and integrative nature” (Casan-Pitarch, 2015, p229-230).

PBL approach increases the time devoted for language practice and foster autonomous learning; consequently, CLIL-based projects should be a powerful tool in bilingual education, and it can be adapted to any content subject. At the same time, PBL fosters the development of life-long and creative skills (Pérez-Ibáñez, 2014) and it provides the necessary change from traditional teaching to student centred learning through cooperative work; PBL “is the most significant curricular innovation in the history of education” (Jonassen, 2011, p.153).

As we have stated before, this intervention proposal is an attempt to show how to change, on the one hand, students’ perceptions of learning P&C in a FL, and foster their motivation and autonomy, and on the other hand, to change traditional teaching and methodologies used in P&C in order to achieve science education challenges (Dewitt, Archer & Osborne, 2013; European Commission, 2011). It is necessary “to incorporate new teaching and/or learning approaches that enable the development of critical and creative thinking skills” (Granados, 2018, p.5), because even in developed countries students are not be trained to the current requirements of the job market (Popović, 2014).

Due to all these aspects the merger between the CLIL approach and PBL is considered the best option to carry out this project.



## 1.2. Brief Analysis of the State of the Art

Nowadays, the concept of learning has changed and the importance of “learning to learn” is highlighted and included in the content of syllabuses in different countries. Lifelong learning has become the new model for improving education (Hayat et al., 2019). It is necessary “to incorporate new teaching and/or learning approaches that enable the development of critical and creative thinking skills” (Granados, 2018, p.5),

In addition, current globalization demands for multilingual education (Pérez-Ibáñez, 2014) and the European Union encourages multilingualism. Leaton Gray, Scott and Mehisto (2018) provide an analysis and design of the 21<sup>st</sup> Century Curriculum where the importance and the role of languages are underlined.

English has become a paramount skill (Coyle, Hood & Marsh, 2010), and for this reason, governments foster FL learning by introducing new educational approaches (Casan-Pitarch, 2015). Many institutions are opting for CLIL based approach due to the improvements in learners’ language fluency (McDougald, 2018), as well as it seems to foster students’ motivation to learn languages (Heras & Lagasabaster, 2015).

CLIL literature in Europe includes few studies on motivation. However, “motivation has undergone a shift towards more dynamic perspective that takes into account the learning environment” (Heras & Lagasabaster, 2015, p.73), and it puts the focus on students’ teaching-learning, which increases students’ motivation due to its challenging characteristics.

If we considering science subjects, it has been detected a reduction in students’ motivation (Linares, 2016). Therefore, there is a tendency in science education to reinforce scientific areas. PBL is an inquiry educational method that promotes the engagement of students in learning knowledge and skills in a complex and critical thinking activities (Lee et al., 2014). It is usually applied to content and language learning, in which learning is organized around relevant, realistic and complex tasks or projects (Casan-Pitarch, 2015; Lee & Blanchard, 2018), with the advantage of being a neutral methodology, because it can be used in any subject and in any language (Pérez-Ibáñez, 2014). The projects are aligned to the curriculum, so students learn the concepts of the subject while they develop the project. In addition, projects are usually interdisciplinary and cross curricular (Álvarez, 2016; Casan-Pitarch, 2015), thus, students need to connect their knowledge of different subjects to solve the tasks.

Most of the literature available related to science teaching in a CLIL classroom is in primary education. In secondary education there is a limited literature related to the application of CLIL in P&C subject, not to mention if we combine CLIL and PBL in P&C classes. Despite of this, some researchers have been studied the application of CLIL, PBL or both in Science subjects, such as Bueno, (2012), Jalo & Pérez (2014), Jameau & Le Henaff (2018), Jobér (2017), Kääntä, Kasper & Piirainen-Marsh (2016), Kalogeraku, Baka & Lountzi (2017), or Tibaldi (2012). All these authors agree that the active implication of the students in their learning process is crucial for students' self-regulation, for enhancing their motivation and improving their attitude towards science.

Science teachers must be aware of the language demands to plan and be prepared to support students in their learning, as science subjects require specific lexis, typical structures, specific tenses and functional language, that students need to understand and use properly to access the content, with the advantage that content subjects offer contextualised language (Jalo & Pérez, 2014). Different approaches could be useful for CLIL implementation in science subjects, such as PBL, inquiry-based learning or task-based learning (Cenoz 2015; Tibaldi, 2012). By developing cognitive strategies, we may help students in their process of self-regulated learning, fostering their autonomy and independence as learners (Bueno, 2012). In this sense, both CLIL and PBL “can serve as a motivational instrument for bilingual teachers and students due to its practical and integrative nature” (Casan-Pitarch, 2015, p229-230).

The features of CLIL help to structure science lessons and it permits students' improvement in L2 learning. On the other hand, PBL offers flexibility to be adapted to any content subject and it fulfils the objectives and principles of CLIL, as it “emphasizes the use of the target language as a medium of instruction”, and it “integrates language and content learning by means of interaction, leading students towards motivation” (Casan-Pitarch, 2015, p.229). PBL fosters scientific methodology, making students need to seek alternatives and develop creative thinking skills. In addition, both approaches increase students' motivation towards the content subject, by providing a contextualised and authentic learning environment.

Finally, considering the promotion of life-long learning skills and the necessity to change the methodologies of teaching science subjects, “CLIL becomes a genuine tool for educational innovation” (Van de Craen and Surmont, 2017, p.25), “it is an answer for educational change. It is an interactive teaching approach that creates a meaningful environment in which the learner actively has to participate in the

creation of knowledge on both content and language” (Van de Craen and Surmont, 2017, p.30). On the other hand, PBL fosters the development of life-long and creative skills (Pérez-Ibáñez, 2014), and it also provides the change from traditional teaching to student centred learning through cooperative work. PBL “is the most significant curricular innovation in the history of education” (Jonassen, 2011, p.153).

### **1.3. Objectives of the Study**

This intervention proposal is the last step of the master’s degree in Bilingual Education. However, it has not been designed solely for that purpose, but rather it has been intended to develop a useful project that can be implemented in an educational centre. The project is designed for compulsory secondary education stage and it covers most of the contents of the P&C subject in 2ºESO, where this subject is mandatory.

#### Main objective:

The design of an intervention proposal to perform the Periodic Table Project, by combining the CLIL approach and the PBL methodology in P&C subject.

The basis of this project is theoretical, so it is an attempt to show how to change traditional teaching and methodologies used in P&C, in order to achieve the current science education challenges (Dewitt, Archer & Osborne, 2013; European commission, 2011). Through the development of this project, it is expected to achieve the following secondary objectives, related to teaching science, students’ motivation and the generation of students’ lifelong learning skills:

#### Secondary objectives:

- 1.** To foster innovative teaching in P&C subject.
- 2.** To improve students’ motivation towards learning science.
- 3.** To change students’ perceptions and attitudes about learning and using FL.
- 4.** To develop students’ critical thinking and autonomy.
- 5.** To encourage the use of FL inside and outside the classroom.
- 6.** To promote students’ communication and team work to face any problem or situation.

## **2. LITERATURE REVIEW**

As we have stated before, the theoretical basis of this proposal is focused on CLIL approach and PBL methodology. These concepts will be examined and described, as well as some previous studies and works of their application in science

classes. We highlight the importance of the Scaffolding in CLIL classes, focusing on the Teachers' Multimodal Discourse (TMD) and Translanguaging.

## 2.1. Content and Language Integrated Learning

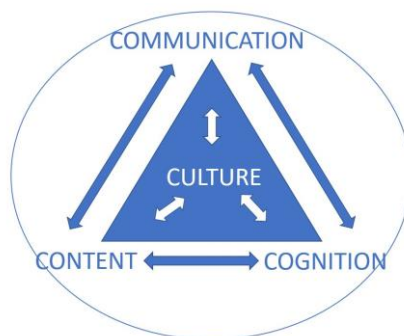
The Content and Language Integrated Learning (CLIL) approach emerged in Europe in the 1990's associated to the use of English as a medium of instruction (Cenoz, 2015), to meet plurilingual and multicultural European demands (Banegas, 2011; Dalton-Puffer, Llinares, Lorenzo & Nikula, 2014). Coyle, Hood and Marsh (2010) defined as "a dual-focused educational approach in which an additional language is used for the learning and teaching of both content and language" (p.1). This definition does not define the language, in fact, any language can be use in a CLIL classroom (Cenoz, 2015). Terminova and Westall (2015) defined CLIL as a pedagogical approach that combines the learning of a content subject and language, so the term CLIL describes any activity that uses language as a tool to develop content learning. "CLIL can be seen as a foreign language enrichment measure packaged into content teaching" (Dalton-Puffer & Smit, 2013, p.546).

CLIL is based on building knowledge and meaning from the learners' experiences. It is a constructivist approach which fosters learning content consciously while the language is acquired unconsciously in communicative situations (Casan-Pitarch, 2015). Different types of interactions in the classroom let students improve their language skills; the role between teacher and students change, as learning becomes a pupil-centred process in which the teacher is a facilitator of learning, to support students and to ensure the process is cognitive challenging.

### 2.1.1. The four Cs framework of CLIL

According to Do Coyle (2007), CLIL is based on the 4Cs framework (pillars of CLIL), which integrates **content, communication, cognition and culture** in a cross-curricular and interdisciplinary approach:

It is through progression in knowledge, skills and understanding of the content, engagement in associated cognitive processing, interaction in the communicative context, the development of appropriate language knowledge and skills as well as experiencing a deepening intercultural awareness that effective CLIL takes place (Do Coyle, 2007, p.550).



**Figure 1.** The 4Cs framework of CLIL (Adapted from Do Coyle, 2007, p.551)

Is for this reason that in CLIL classroom we must use the appropriate methodology to the development of the 4Cs in an integrative way, because all of them are related. To understand what the 4 Cs framework means, it is necessary to define them from the CIL perspective. UNESCO's International Bureau of Education (2018) gives the definition of **content** as “topics, themes, beliefs, behaviours, concepts and facts, often grouped within each subject or learning area under knowledge, skills, values and attitudes” (p.1). In education, content is usually associated with subjects such as mathematics, science or geography, but not with language subjects (Mc Dougald, 2018). However, FL learning makes no emphasis on acquiring content, but on developing skills (listening, reading, writing and speaking), so the language knowledge acquisition can occur by using the target language (Jaleniauskiene, 2016).

In the CLIL classroom the focus is both on content and language (dual-focused education) where language is a tool to access and learn content. Language is integrated in content classes and content is used in language classes. The difference between CLIL and other language teaching approaches is that CLIL is content-driven, increasing the experience of learning a language (Coyle et al., 2010) and it promotes the development of higher-order language skills (Cenoz, Genese & Gortner, 2013). Besides, the mastering in L2 becomes high when focusing on meaning rather than on form (Karim, 2016).

Focusing on **communication**, according to the 4Cs Framework, language must be taught from different perspectives:

Communication involves CLIL teachers and learners in using and developing language of learning, for learning and through learning. Applying this triptych linguistic approach marks a shift in emphasis from language learning based on linguistic form and grammatical progression to a more 'language

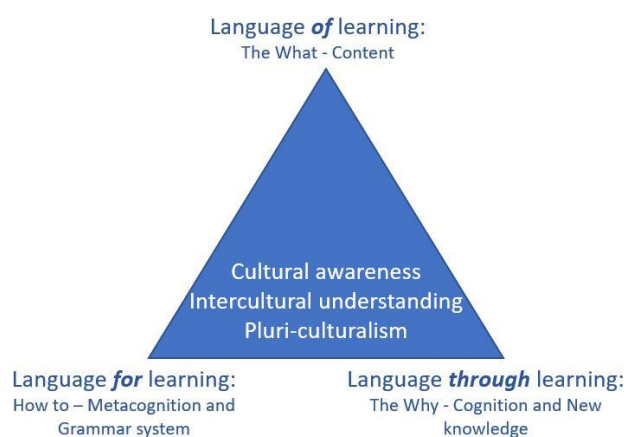
using' one which takes account of functional and cultural imperatives (Do Coyle, 2007, p.552).

Do Coyle (2007) described the language triptych as follows:

Language of learning is based on an analysis of the language needed for learners to access basic concepts and skills relating to the subject.

Language for learning focuses on the kind of language which all learners need in order to operate in a foreign language using environment. In CLIL settings this means learning how to learn effectively and developing skills such as those required for pair group, cooperative group work, asking questions, debating, chatting, enquiring, thinking, memorising and so on.

Language through learning is predicated on the sociocultural tenet that learning cannot take place without active involvement of language and thinking; when learners articulate what they understand then a deeper level of learning takes place. CLIL learners need language to assist their thinking and they need to develop their higher-order thinking skills to assist their language learning (p.553-554).



**Figure 2.** The Language Triptych (Adapted from Do Coyle, 2007, p.552)

Once we have identified what content and language are, we must consider that CLIL works in a Content-Language continuum. Some previous researches indicate that CLIL classrooms are more concerned with subject content than language content (Kääntä, Kasper & Piirainen-Marsh, 2016; Nikula, 2015). Depending on whether the objective is, the language or the content subject, it could be defined two types of CLIL: hard CLIL refers to curricular subjects that are taught in the target language but emphasising content; soft CLIL refers to linguistic subjects in which the focus is the language (Bentley, 2010). Massler, Stotz and Queisses (2014) defined them in other words as CLIL-type A in subject lessons, when learning goals are

based on the content, and CLIL-type B in language lessons, using contents from other subjects as a topic. Independent of the type of CLIL considered, it is necessary to move students from Basic Interpersonal Communication Skills (BICS) to Cognitive Academic Language Proficiency (CALP) (Tibaldi, 2012; McDougald, 2018).

Regarding **cognitive** development, CLIL implies learning by construction not only by instruction (Wolf, 2007), so it is necessary to place students at the centre of their learning process, giving them opportunities to develop cognitive skills (Higher-Order Thinking Skills and Lower-Order Thinking Skills) and communication skills through using a second language (Tibaldi, 2012). Van de Craen & Surmont (2017) stated that thinking processes and knowledge construction are related and CLIL stimulates both content and language acquisition, as it is cognitively challenging. In this aspect, the authors distinguish three important features of CLIL pedagogies: the meaningful environment with the activation of students' previous knowledge; the content is learnt through interaction by the active role of the students; finally, scaffolding is used to support students' learning. As a result, students have better language performance (Dalton-Puffer, 2011) and gain fluency in a foreign language (Tardieu & Dolitsky, 2012).

Finally, CLIL aims at plurilingualism and the better understanding of other **cultures** (Cenoz, 2015). As we have mentioned before, the beginnings of CLIL are based in European integration and intercultural competence (Dalton-Puffer et al., 2014). CLIL fosters the awareness of the cultural context of students as well as it favours the knowledge and understanding of other cultures (Tibaldi, 2012). Nowadays, classrooms are multicultural and the CLIL approach in these diverse contexts contributes to the development of multiculturalism.

### 2.1.2. Core Features of CLIL

In addition to the 4Cs framework, Mehisto, Marsh and Frigols (2008) proposed six core features that characterising any good teaching practice and they are paramount in the CLIL approach:

- **Multiple focus:** in the CLIL classroom, the focus is not just the content or just the language (Coyle, Hood & Marsh, 2010), language classes support content subjects and content subjects support the language, so CLIL implies a cross curricular learning process.
- **Safe and enriching learning environment:** this refers to the techniques, materials and practices used in the classroom to maximize the quality and the quantity of the students' exposure to both language and content. The authors

emphasize the importance of creating opportunities to foster communication in a safe learning environment and considering that “the quality of content should not be compromised by the lack of language knowledge” (Tibaldi, 2012, p.177).

- **Authenticity:** teachers must link the language, the content and learning skills to students’ lives and interest, so they need to use authentic methods, materials and resources to engage students and create a meaningful environment.
- **Active learning:** CLIL is a pupil-centred approach where students can actively participate and be aware of their learning processes. The role of teachers changes, and they must be facilitators of learning, which is achieved through activating methods, such as activating prior knowledge and scaffolding (Van de Craen & Surmont, 2017).
- **Scaffolding:** is a metaphor (coined by Jerome Bruner) referred to anything the teacher does to help students in their learning process. Scaffolding is used to assist students during their learning in order to help them to acquire new skills, concepts or levels of understanding, and it is gradually removed when students gain autonomy (Gibbons, 2002).
- **Cooperation:** CLIL approach needs the collaboration between content teachers and language teachers. In addition, this cooperation is needed between all the staff of the centre, the educational community, families and even local authorities, institutions, etc.

### 2.1.3. [CLIL in Science Teaching](#)

In the latest years, science education is modifying its pedagogy to enhance students’ motivation and scientific literacy, especially in the STEM areas (Linares, 2016). It is necessary a renewal in science subjects, from traditional teaching to new and innovative methodologies that foster group work and learner-centred strategies to enhance students’ motivation. The active implication of the students in their learning process is beneficial for students’ self-regulation (Linares, 2016) but also for enhancing their motivation and improving their attitude towards science (Hassan & Davies, 2014). “Learning about science involves, developing knowledge and understanding of: the material and physical world; the impact science makes on life and the environment; scientific concepts; scientific enquiry. In addition, learners need to develop the accurate use of scientific language” (Cambridge, 2011, p3).

As English language has become the generalized way to communicate, particularly in science contexts, different bilingual programs have been introduced in the past years, to promote English learning in different countries. If teaching English is sometimes difficult, “teaching science in English is exponentially more



challenging” (Bueno, 2012, p.130), especially if teachers lack training. It is necessary to support students in learning content and developing language skills: students need to learn the content language and to use the language to investigate and to express what they have learnt.

The CLIL approach fulfils these goals providing a different and interesting learning environment for students, thus in CLIL contexts, students are more motivated to learn languages (Linares, 2016) and it is positively evaluated by students and teachers in science subjects (Grant, 2009). Research indicates that CLIL is beneficial for developing language skills (Dalton-Puffer, 2007; Nikula, 2015) and improves language awareness of students (Grant, 2009); as a result, students use a better lexical repertoire and improve their fluency in L2-science contexts (Escobar and Sánchez, 2009), without no negative impact or loss regarding content learning (Tibaldi, 2012). As Kääntä, Kasper and Piirainen-Marsh (2016) affirm, “doing science and doing language... are intrinsically connected” (p.714) in L2 science lessons. In addition, students use their whole repertoire, linguistic and non-verbal resources (translanguaging and multimodal resources), to communicate, interact and develop the tasks (Evnitskaya & Morton, 2011).

When teaching science in English it is important to consider that teachers need to deal with language as well. They must integrate all the elements of the content subject with the language of instruction, and at the same time, it is necessary to foster or maintain students’ motivation. “This aspect affects how hard students are willing to work on a task, how much they will persevere when they are challenged, and how much satisfaction they feel when they accomplish a learning task” (Bueno, 2012, p.134).

Science subjects allow students to realize that most of the phenomena that surround us daily are related to some area of science. Therefore, students need to make the appropriate connections between the concepts studied in class and their daily lives. In addition, everyday language uses many science words and many times they are used with other meaning or in a wrong context. Therefore, by studying these concepts in class, students can not only learn the specific subject language, but also its use in everyday language. On the other hand, science subjects require specific lexis, typical structures, specific tenses and functional language, that students need to understand and use properly to access the content. Science teachers must be aware of the language demands to plan and be prepared to support students in their learning (Jalo & Pérez, 2014).

Most of the basic principles of P&C are based on experimental facts that we can observe daily, so students will be able to experiment at home, in the classroom and

in the laboratory, and make the relevant connections between the concepts studied and their daily lives. That is, work in an authentic environment and with authentic materials; as Jalo & Pérez (2014) stated, content subjects offer contextualised language. As a result, students develop learning strategies (mental processes) that associate new learning with prior knowledge. Cognitive strategies help students in their process of self-regulated learning, fostering their autonomy and independence as learners (Bueno, 2012). As Álvarez (2016) affirms, hands-on activities and experiments let students be at the centre of the teaching-learning process and become responsible of their learning, because they develop cognitive skills (problem solving) and practical skills, they cooperate in group work and they need to use the language for communication, making P&C meaningful.

## 2.2. Project Based Learning

Project Based Learning (PBL) is an educational method, to content and language learning, in which learning is organized around relevant, realistic and complex tasks or projects (Casan-Pitarch, 2015; Lee & Blanchard, 2018), with the advantage of being a neutral methodology, as it can be used in any subject (Pérez-Ibáñez, 2014).

PBL takes a problem as the starting point for the learning process, which is student-centered, experience-based, activity-based, interdisciplinary, focused on practical examples, and collaborative group learning. Some of the advantages of PBL are “its potential to motivate students, as well as its emphasis on active and collaborative learning and the development of lifelong learning skills, management changes, teamwork, conflict resolution and problem solving” (Da Silva, Bispo, Rodríguez & Vasquez, 2018, p.163).

On the other hand, educational methodologies must be oriented to ensure that “learners are challenged to (a) know how to learn, (b) access changing information, (c) apply what is learned, and (d) address complex real-world problems in order to be successful” (Larkin, 2002).

In addition, Wagner (2019) affirmed that students need to develop seven survival skills: (1) critical thinking and problem solving, (2) collaboration, (3) adaptability and flexibility, (4) entrepreneurship, (5) access and analyse the available information, (6) effective communication (oral and written), (7) curiosity.

PBL addresses many of the aspects specified by Larkin (2002) and Wagner (2009), because it is an inquiry method that promotes the engagement of students in learning knowledge and skills in a complex and critical thinking tasks or projects (Lee et al., 2014). These projects are designed around a real-world problem to help students making connections between their knowledge and the activities, and they

are aligned to the curriculum, so students learn the concepts of the subject while they develop the project. Besides, projects are usually interdisciplinary and cross curricular (Álvarez, 2016; Casan-Pitarch, 2015).

Some of the principal goals of educational reforms are how to increase students' interests as well as their understanding of the content subjects. PBL is accepted as an innovative way which concentrates on students' use of knowledge, experiences and technologies to solve real problems (Lee, Blackwell, Drake & Moran, 2014). As Jaleniauskiene (2016) affirms, PBL approach can serve to reach the most important current tendencies in education, oriented to a learning-centred environment:

<b>Moving from...</b>	<b>To...</b>
Individual learning	Collaborative learning
Passive learning	Active learning
Broadcast-oriented education	Discussion oriented education
Learners as consumers of knowledge	Learners as producers of knowledge
Teacher-centred learning	Student-centred learning
Content offered by educators	Content created by learners
Focus on teaching, outcomes, content and transmission	Focus on learning, experience and processes
Control	Creativity
Excessive standardization	Reach and engaging educational environments

**Table 1.** Tendencies in education (adapted from Jaleniauskiene, 2016, p.266)

The six core principles of PBL approach defined by Barrows (1996) are:

- **Learner centred approach.**

PBL is an active teaching strategy, as students are encouraged to take the lead in their own learning process. It allows them to move from a passive role, to an active role, in which the process is learner centred and students develop a sense of self-direction solving different problems. "It is an educational strategy that takes into account the complex nature of learning and values the practical experience of learning" (Da Silva et al., 2018, p 161).

PBL focuses on increasing students' capacity to understand, acquiring and using information (Lee & Blanchard, 2018). Projects are student-driven, so students build their knowledge in a constructive research (goal-oriented process). For this reason, students' active involvement and freedom play an important role, because they must organise their work collaboratively (Casan-Pitarch, 2015).

PBL permits cultivate students' creativity (which involves personality, environment and cognition) in an appropriate learning context (Hung, 2015). As

Hung (2015) affirms, creativity is the best qualification for being competitive: “creativity is an important ability not only to advance human civilization, but also to survive in today’s world” (p.1); “creativity is an act of a problem-solving process” (p.2) mixed with originality and novelty. “PBL prepares students for real world challenges” (Cho, Kaleon & Kapur, 2015, p. 75) and fosters students’ personal growth (Jaleniauskiene, 2016).

As PBL is students-centred learning, learners must use their creativity and knowledge to plan, investigate, solve the tasks, make inquiries, develop explanations, make decisions, and communicate ideas and results, in cooperation with peers, over different periods of time, to create different final products (artefacts or cooperative presentations).

- **Small group work.**

Students work in small groups and develop cooperative work in an interactive learning environment, that promotes communication by increasing students’ opportunities for participation: they must debate ideas; negotiate and decide the best options for each problem; give support; criticise and give feedback one each other; (Casan-Pitarch, 2015; Hung, 2015); they revise (assess) their products together; etc., so “learners develop their knowledge through learning and doing” (Casan-Pitarch, 2015, p.226).

Social Pedagogical Research in Group Work (SPRinG) project, launched in 2000, identified some key principles for effective group work (Fung, Hung & Lui, 2018): (1) enhance team dynamics and encourage students to participate actively; (2) classroom and grouping arrangements to facilitate group work; (3) the nature of tasks must promote interactions between students; (4) teachers involvement to facilitate group working, at the preparatory stage, during the learning process, and at the end of the task encouraging group reflection.

In collaborative learning, students work together and make possible mutual learning (peer scaffolding): students who do not understand the task can ask other members of the group, which can help and explain it to their partners. Learning takes place in a shared activity and all the students gain (Winarti, Ichsan, Listyarini and Hijriyanti, 2019).

- **Teachers as facilitators.**

On the other hand, the role of teachers changes from knowledge provider to a facilitator of learning (Lee et al. 2014), by guiding learners in developing skills to answer questions and solve problems (Pérez-Ibáñez, 2014). According to Da Silva et al. (2018), teachers must:

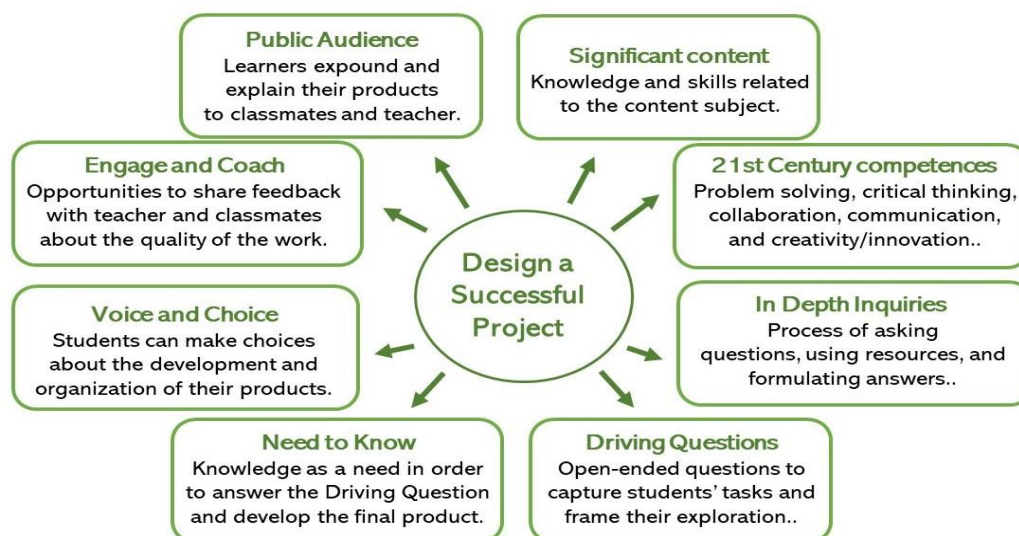
- Facilitate group's work and communication among students.
- Provide guidance and explain to the students what they can learn and which skills they need to develop.
- Give support and enough feedback, providing the appropriate scaffolding in order to avoid students' frustration.
- Assess both the implementation of the project and the students' products: they must underline the students' work; question the development of the process; assess students' processes and final products. Assessing students' work in PBL is challenging and some researchers suggest new assessment strategies, such as peer assessment, the production of rubrics with students' contributions, individual and group grades, etc., in order to assess the process and the students' progress (Lee et al. 2014).

As Larmer (2015) states, transition to PBL is not easy and some traditional practices must be reframed. The seven project-based teachers practices suggested by the author are shown in the figure 3:



**Figure 3.** Seven project-based teachers' practices (adapted from Larmer, 2015)

From the point of view of the design, project work needs rigorous planning to reach the outlined objectives. According to Casan-Pitarch (2015), the following issues must be considered to success in the design and implementation of any project:



**Figure 4.** Design a successful project (adapted from Casan-Pitarch, 2015, p.228)

- **Authentic problems to stimulate learning.**

PBL is problem-driven learning that motivates students and engage them by challenging with a problem to solve, giving meaning to the content and describing the context of the future problems. “By solving authentic problems, students will be able to see how abstract concepts are applied in solving problems” (Hung, 2015, p.243). Project work is a constructivist methodology that permits the connection of the objectives within the curriculum to real-life situations and contexts (Casan-Pitarch, 2015), so through PBL, students can apply the concepts studied (subject, interdisciplinary and cross curricular) in a contextualized learning environment (Hung, 2015).

- **Problem-solving skill developing.**

“Problem-solving can be defined as a mental and intellectual process of finding problems and solving on the basis of accurate data and information.” (Winarti et al., 2019, p.1). This process will be easier with the appropriate scaffolding by interaction and cooperation with teachers and peers.

PBL engages students with real and meaningful problems, while they can improve their creativity and problem-solving abilities (Lee et al., 2014; Weiss & Belland, 2018). PBL structures content knowledge from simple to complex problems, and the knowledge and skills needed to solve the tasks are based on previous students’ knowledge and developed skills (prior knowledge). Regarding cognition, students are responsible for making decisions and creating solutions (Álvarez, 2016).

- **Self-directed learning**

PBL requires the integration of various areas of knowledge (interdisciplinary), and it presents real problems to develop skills such as autonomy, self-regulation and self-directed learning (Da Silva et al., 2018; Casan-Pitarch, 2015; Weiss & Belland, 2018). Students can choose the topics, create the learning objectives, establish members' roles of the group, teach others and self-assess their learning progress. This makes students' learning more meaningful and it promotes students' independence as learners, as it helps them to reflect on their own needs and to be more responsible for their own learning (Da Silva et al., 2018). "Thus, students are self-managers of their learning process" (Casan-Pitarch, 2015, p.227).

### 2.2.1. PBL in Science Teaching

Science is vital for the evolution and improvement of the society. As National Research Council (1996) states in the National Science Education Standards, "Science is an active process. Learning science is something that students do, not something that is done to them" (p.2).

Teaching science should look for improving students' motivation and attitudes to participate actively in their learning and to reach a high level in scientific literacy. The concept of literacy includes (Linares, 2016): knowledge, attitudes and skills to identify and explain scientific questions and topics; understand the features of STEM areas as diverse forms of knowledge, investigation and design; active and constructive participation in debates from a critical point of view.

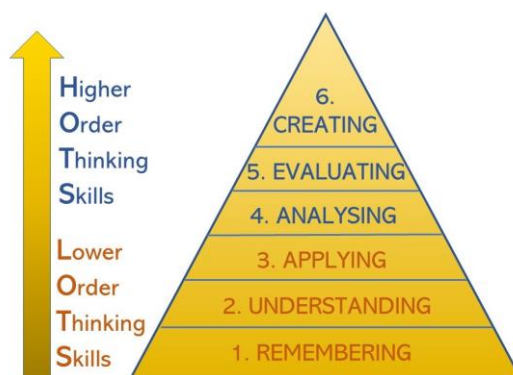
PBL is an inquiry method that promotes the engagement of students in learning knowledge and skills in a complex and critical thinking tasks or projects (Lee et al., 2014). It fulfils the requirements and principles of science learning: collaborative learning, learning by doing, cognitive developing and knowledge construction. PBL permits students to be engaged in real and meaningful problems and it allows them to investigate, make hypotheses and discuss conclusions related to science. Therefore, students are more motivated, more focused on learning science and more engaged in an interactive collaboration (Álvarez, 2016).

Nowadays, the different sub-areas of science are divided into separated subjects in the current curricula. Because of this, students usually see science subjects as independent topics. The advantage of working through PBL is that learners must use all their knowledge to achieve the goal, and in consequence, this perception of separated science subjects change, with the consequent improvement in their science literacy and academic performance (Linares, 2016).

PBL usually consists of different small tasks, which are aimed at achieving the main objective of the project. The Council of Europe (2001), in the Common European Framework of Reference for Languages, defined a task as:

Any purposeful action considered by an individual as necessary in order to achieve a given result in the context of a problem to be solved, an obligation to fulfil or an objective to be achieved. This definition would cover a wide range of actions such as moving a wardrobe, writing a book, obtaining certain conditions in the negotiation of a contract, playing a game of cards, ordering a meal in a restaurant, translating a foreign language text or preparing a class newspaper through group work (CEFRL, 2001, p.10).

Tasks must have some characteristics such as the importance of meaning, a established goal to achieve, a real-world connection, and the cognitive progression from lower order thinking skills (LOTS) to higher order thinking skills (HOTS), as Bloom's revised Taxonomy recommends.



**Figure 5.** Bloom's revised Taxonomy

These characteristics concur with science teaching features and, in order to achieve a student-centred learning, inquiry problem solving fits perfectly with scientific methodology.

As National Research Council (1996) states:

Inquiry is central to science learning ... students actively develop their understanding of science by combining scientific knowledge with reasoning and thinking skills" (p.2).

Inquiry is a multifaceted activity that involves making observations; posing questions; examining books and other sources of information to see what is already known; planning investigations; reviewing what is known in light of experimental evidence; using tools to gather, analyse, and interpret data; proposing answers, explanations, and predictions; and communicating



results. Inquiry requires identifications of assumptions, use of critical and logical thinking, and consideration of alternative explanations. (p.23).

Most of P&C concepts are microscopic, mathematical and symbolic, thus P&C learning requires visualization and problem-solving skills. Students need the former to understand concepts such as elements, atoms, subatomic particles, forces acting at a distance or gravity. Meanwhile, students need problem-solving skills to understand and solve quantitative and qualitative problems, or conceptual activities. Problem-solving involves three abilities: understand and specify the problem, develop or design how to solve the problem, and implement the solution designed (Winarti et al., 2019).

National Research Council (2000) outlined five essential features of classroom inquiry that can be applied to science classrooms: (1) Scientifically oriented questions; (2) Give priority to evidence in answering questions; (3) Formulate explanations from evidence; (4) Students evaluate their explanations considering scientific knowledge; (5) Communication and justification of their explanations.

By teaching science through PBL students are engaged in meaningful problems and they can investigate phenomena and questions, discuss ideas and develop substantiated conclusions. In addition, PBL help all kind of students letting them advance in learning at their own rhythm.

### **2.3. The merger of CLIL and PBL**

Different approaches could be useful for CLIL implementation in science subjects, such as PBL, inquiry-based learning or task-based learning (Tibaldi, 2012). However, by combining CLIL and PBL, students work cooperatively, and they can access the content while interacting and learning. PBL offers flexibility to be adapted to any content subject and it fulfils the objectives and principles of CLIL, as it “emphasizes the use of the target language as a medium of instruction during the development of the content subject”, and it “integrates language and content learning by means of interaction and learning at the same time, leading students towards motivation” (Casan-Pitarch, 2015, p.229).

The features of CLIL help to structure science lessons and it permits students' improvement in L2 learning. On the other hand, PBL fosters scientific methodology, making students need to seek alternatives and develop creative thinking skills. In addition, both approaches increase students' motivation towards the content subject, by providing a contextualised and authentic learning environment.

Both in CLIL and in PBL we can find several common features that make their combination a powerful tandem to learn content and language integrated:

- PBL and CLIL are neutral and flexible to be adapted to any subject and they have positive results in science subjects. In addition, both “can enhance students’ motivation and promote positive beliefs and opinions about science” (Linares, 2016).
- PBL and CLIL are constructivist approaches that aim to improve students’ higher order thinking skills (Lee & Blanchard, 2018). By solving tasks and problems students must be creative and activate their prior knowledge (Hung, 2015), and they learn not only L2, but also how to think in L2 (Jaleniauskiene, 2016). By enhancing students’ critical thinking, language and content are acquired (Álvarez, 2016).
- PBL and CLIL are student centred approaches, in which teachers’ role changes to facilitators and they must support and guide students through the learning process (Lee et al., 2014). Teachers encourage students to be autonomous, make decisions and be responsible of their own learning (Lee & Blanchard, 2018) so both methodologies promote students’ active involvement.
- PBL and CLIL boost self-confidence and empower students to act as a team to solve problems in a FL (Jaleniauskiene, 2016), developing collaboration and learners’ critical thinking looking for a deeper students’ understanding (Lee & Blanchard, 2018).
- PBL and CLIL promote students’ motivation and learning attitudes (Li, 2013), because by working in groups, students collaborate, feel supported and more competent, and they are willing to persevere in solving challenges (Lee & Blanchard, 2018).
- The combination of PBL and CLIL can revitalize FL learning by increasing the use of language in a creative, meaningful and authentic communication. “Students move from reproductive to creative and meaningful language use, which undoubtedly contributes to meaningful learning and increased motivation” (Jaleniauskiene, 2016, p.1). PBL also increases the time for language practice by creating students’ opportunities to interact and participate (students’ talk), because it “involves asking and refining questions, debating ideas, making predictions, designing plans and experiments, collecting and analysing data, drawing conclusions, communicating ideas and findings to others, asking new questions and creating artefacts. These actions involve real language use” (Casan-Pitarch, 2015, p.227).
- Teacher and peer scaffolding are needed to provide the necessary support to students (Lee et al., 2014), both on content and language: students need to ask

questions, debate ideas, make predictions, design, collect and analyse information or data, draw, settle conclusions, communicate ideas and findings, and create... All these actions involve real and complex language use (Casan-Pitarch, 2015). On the other hand, teachers must avoid students' frustration and aid students with possible emotional and social challenges (Álvarez, 2016).

### 2.3.1. Scaffolding in PBL and CLIL classrooms

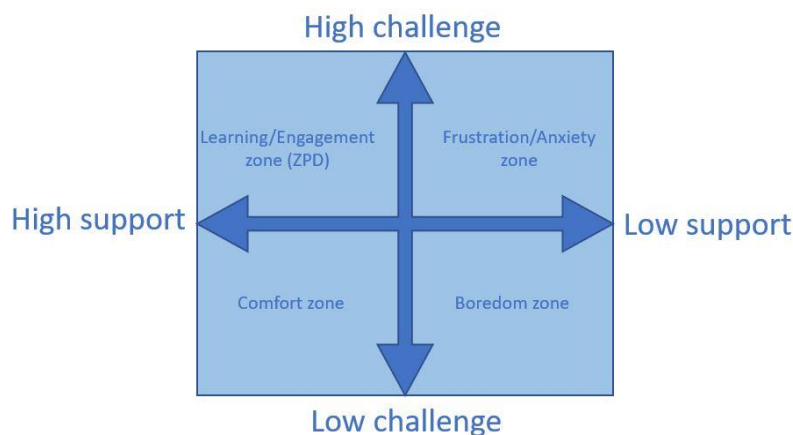
Special attention must be paid in the importance of the scaffolding and the different ways to use it in the bilingual classroom. Even more if we consider the intrinsic difficulty of some science concepts and the PBL methodology, in which students need to lead their learning process. It is not a technique only used in language classes, but also in all academic classes. Scaffolding is used to assist students in their learning while they become autonomous and independent in accomplishing tasks, thus the responsibility of learning is gradually transferred, from the teacher to the students, looking for a pupil-centred learning process. As Gibbons (2002) states, scaffolding is future-oriented, and it aims for increasing students' autonomy.

According to Larkin (2002):

The ultimate academic goal is for students to become independent lifetime learners, so that they can continue to learn on their own or with limited support. Scaffolding optimizes student learning by providing a supportive environment while facilitating student independence.

In CLIL classes scaffolding is essential and it must be related both on content and language. There are three types of scaffolding depending on the focus of the support: verbal scaffolding by adapting the language to the level of the learners; content scaffolding by using techniques to engage and support students' understanding of the content; and learning process scaffolding used to support students' work and learning processes (Van de Craen & Surmont, 2017).

In addition, scaffolding must be related with the level of challenge of the tasks, thus we need to maintain students in their Zone of Proximal Development (ZPD) (Vigotsky, 1978). Figure 3 shows four possible zones in the teaching-learning process relating to the level of support and the level of challenge of the tasks. The most productive learning environment is the one where students are engaged in a high-challenge classroom with a high level of scaffolding (Gibbons, 2002).



**Figure 6.** Four Zones of Learning (Adapted from Gibbons, 2002, p.17)

The techniques to scaffold students are varied and it is considered important to highlight the following ones:

- Differentiation:

It occurs when the content, the process or the product are modified or adapted to help pupils' comprehension. It is based on the way the pupil learns best (Tomlinson, 2000). Being aware of the students' learning styles allows teachers to choose the resources, materials and activities that better suits students' learning.

- Cooperative learning and Peer-scaffolding:

It is very important to encourage students' cooperation rather students' competition. Cooperative learning gives the opportunity to create an environment to foster mutual aid (Richards, 2014), where students can share doubts and clarify concepts. In addition, by working in groups, communicative interaction is promoted, students' motivation and classroom climate is enhanced, and pupils can develop social skills in a more relaxed environment (Jobér, 2017; Tibaldi, 2012; Richards, 2014). CLIL contexts foster communication because in peer interactional contexts communication, cognitive development and learning are related (Duarte 2019).

- Translanguaging and the use of L1:

In CLIL classroom the use of L1 and other languages is allowed and, in some cases, advisable (Van de Craen & Surmont, 2017). CLIL environment creates a relaxed and meaningful environment to learn and use language for communication, while learners think and become aware of their own and other cultures (Terminova & Westall, 2015). CLIL enhances overall linguistic and cultural competence. As Cenoz (2015) states, CLIL aims at multilingualism, pluralism and enrichment of the language and culture knowledge, "by becoming multilingual, students will be able to communicate with other people, to get a better understanding of other cultures and

to be better prepared for the job market” (p.19). Nowadays, classes are not homogeneous, there are students of majority and immigrant languages together, which are multilingual speakers, so it is necessary “to integrate not only language and content but also all the languages of the students’ multilingual repertoire” (Cenoz, 2013, p.393).

Translanguaging is defined both as an “act of bilingual performance and a pedagogical approach for systematically teaching multilinguals” (Duarte, 2019, p.151). Nikula and Moore (2019) define Classroom translanguaging as a classroom practice (planned and with pedagogical aims), and Universal translanguaging as a bilingual behaviour (to promote communication). Translanguaging considers that the entire linguistic knowledge of the student integrates only one single language system (García & Li Wei, 2014; Van de Craen & Surmont, 2017). By allowing the use of other languages in the CLIL classroom, content and language learning is facilitated and the quality of the interaction is improved. Translanguaging maximizes the learning and reinforces knowledge building on previous experiences, letting students acquire knowledge in both language and content (Duarte, 2019; Van de Craen & Surmont, 2017). In addition, it plays central functions in students collaborative talk, such as making sense of the tasks and constructing joint knowledge and understanding (Duarte, 2019).

- Multimodal discourse:

Pozzer-Ardenghi (2007) affirms that language is the dominant representational mode in teaching. However, it is needed to understand teaching “as a communicative, dynamic, multimodal and social activity” (p. 2), in which there are a variety of signs, expressed in several forms to communicate specific conceptual meanings. As the author affirms, semiotic resources support and encourage the understanding and development of the ideas and concepts. Teaching, as a form of communicative interaction, include a great variety of gestures, body positions, verbal, and material resources to create and communicate meaning. Kääntä, Kasper and Piirainen-Marsh (2016) analysed how the teacher’s multimodal discourse scaffolds students in their understanding of science concepts and shows “the need to attend the artful coordination of multilingual and multimodal practices” (p. 715).

In addition, a multimodal approach to teaching and learning needs focusing the attention on nonverbal aspects of communication, not only on teachers’ communication but students’ communication as well, thus it will provide students with different possibilities of articulating their knowledge (Pozzer-Ardenghi, 2007).

### 2.3.2. Relationships between Life-long learning, PBL and CLIL

As we have seen, PBL and CLIL foster student motivation towards content subjects and they have many common characteristics that make them fit perfectly with teaching science subjects, such as the promotion of critical thinking, the importance given to communication and group work, the relevant role of students in their learning process and self-directed learning (Linares, 2016).

In addition, if we consider the importance of the acquisition and developing of life-long learning skills, we can take into consideration the five standards of life-long learning that Marzano, Pickering and McTighe (1994) established. The table 2 (annex II) shows the relationships between PBL, CLIL and Marzano's standards, as well as the categories into each standard is divided.

## 3. INTERVENTION PROPOSAL

The proposal is based on the merger of CLIL and PBL methodologies in the P&C classroom, in the 2<sup>nd</sup> level of Compulsory Secondary Education.

The project arose linked to two facts, firstly, most of the contents of P&C subject in this level are mainly devoted to the matter, their structure and the periodic system. Secondly, 2019 is the 150<sup>th</sup> anniversary of the discovery of the Periodic System, and therefore it has been proclaimed the International Year of the Periodic Table of Chemical Elements by the United Nations General Assembly and UNESCO (UNESCO, 2019a).

The project involves three stages:

1. The creation of the cards of the chemical elements and the assembling of the Periodic Table.
2. Students' researches and development of presentations related to the properties of the chemical elements and their uses in our society.
3. The generation of a Google site associated to The Periodic Table, where the students will incorporate their investigations and works.

The Periodic Table of Chemical Elements is one of the most important achievements in all areas of science, and students will have the opportunity to be aware of that by creating their own table, and by investigating about the uses and the importance of the chemical elements in our society.

### 3.1. Educational Context

The Spanish Foundation for Science and Technology (FECYT) aims to promote the integration of science in the Spanish society through several projects and actions

that contribute to stimulate students' interest towards science. On the other hand, educational tendencies have shifted from traditional perspectives of education to new educational approaches, in which learning is the centre of education, and they look for developing students' life-long learning skills.

Students' motivation towards learning in general, and learning science specifically, is another crucial unresolved matter in education. In addition, teachers' motivation and some traditional methodologies negatively influence student learning. On the other hand, families at home must contribute by instilling the importance of the effort and perseverance in their children. According to Gallardo y Camacho (2008), motivation can be intrinsic or extrinsic: the first one refers to the interest towards the subject and it depends on affective, cognitive, social, and intellectual qualities; the extrinsic motivation is related to external factors of the subject and the student, such as prizes and punishments.

We live in a fluid and changing society, both in socio-cultural and scientific-technological aspects. In addition, we must consider the boom and easy access to the media. For these reasons, education plays an important role in our society, not only to transmit knowledge but to generate culture, values and prejudices. It is necessary to educate students in scientific subjects, to form them as active and critical citizens being able to live in the society that awaits them. Maybe the main cause of the students' demotivation towards learning science is that the way of teaching science is oriented to train future scientists. However, nowadays, we should try to form future citizens of an increasingly scientific and technologically developed society (Cáceres, 2017).

In addition, the current curricula are composed of unbound subjects, and they are complex and dense in content. Contents are repeated in different subjects but in an uncoordinated way; for instance, in P&C students do not know or master some mathematical operations, which makes it very difficult for them to understand certain processes and phenomena of science. Another problem is that students perceive the concepts they study in the classroom as irrelevant to their daily lives, so it is paramount to contextualize the contents to make them clear the relationships between science and current problems of the society. Nevertheless, the project must be based in the current curriculum, established by Royal Decree N°1105 (2014) and the Decree N°220 (2015).

On the other hand, we should motivate our students towards learning FL as well, due to their importance in this globalized world. According to Asociación de Enseñanza Bilingüe (2016), the first steps in bilingual education in Murcia began in the year 1996 after signing a collaboration agreement between the Ministry of

Education and the British Council. However, until 2001, bilingual teaching in compulsory secondary education was not regulated. Currently, 85% of the centres in the region offer bilingual sections. Outside the context of the schools assigned to the British-Council MEC Program, other initiatives were authorised for the development of bilingual Spanish-French and Spanish-German programs.

The current FL teaching system may be developed under three modalities of immersion, depending on the number of subjects taught in a FL: Basic (one non-linguistic subject); Intermediate (two or three non-linguistic subjects); Advanced (more than three non-linguistic subjects). Multilingual education system lets students attend first and second FL, as well as the teaching of non-linguistic subjects in accordance with the established modalities for those languages (Asociación Enseñanza Bilingüe, 2016).

### 3.2. Target Group

The project is designed to be implemented in the IES Arzobispo Lozano, a multilingual centre located in Jumilla (Murcia). The centre is an example in the area of how to encourage the use of FL as a medium of instruction. The target stage is the 2<sup>nd</sup> level of Compulsory Secondary Education, and the project will cover part of the contents of the P&C subject (section 3.5).

In this level, the centre counts on two multilingual groups with 30 pupils per group (Spanish-English-French) and one bilingual group (Spanish-English) with 25 pupils, so the total amount of students that will participate in the project will be 85. The level of English of these students is A2, but there is some diversity associated to extracurricular classes (higher level) or to learning difficulties (lower level). In general terms all the pupils present good and homogeneous academic results in the different subjects.

### 3.3. Aims of the Proposal

To reach the objectives of the project, the activities must be planned previously in cooperation with language teachers in order to maximize both the content subject sessions and language sessions devoted to the project. From P&C subject we will attempt to not compromise the quality of the content by the lack of language knowledge (Tibaldi, 2012).

In the implementation and development of the project it is intended to reach the following objectives:

#### **General objectives of the project:**

- To implement innovative teaching in P&C subject.



- To develop collaborative and interdepartmental teaching.
- To create and use students' learning skills in order to generate lifelong learning.
- To promote students' personal development and autonomy.
- To engage student with teamwork.

**Subject objectives:**

In addition to all the objectives that are directly related to the acquisition and the development of the Assessable Learning Standards (ALS) of the subject (Decree N<sup>o</sup>220, 2015) we will strive to achieve the following objectives:

- Improve students' motivation towards learning science.
- Foster and develop students' critical thinking.
- Promote students' awareness of the role of science in the society and the environment.
- Develop responsible attitudes towards the environment making students being aware of the role of the human beings in the future of our world.
- Facilitate the assimilation of new knowledge and new skills related to subject contents.

**Language objectives:**

In order to plan the language objectives, it is necessary a coordinated work between English language department and P&C department, thus from the English language department more language objectives could be developed with this project. Nevertheless, it was impossible to produce this intervention proposal in coordination with any English language department, so we will attempt to reach the following language objectives:

- Encourage students' communication.
- Promote the use of FL inside and outside the classroom.
- Change students' perceptions and attitudes about learning and using FL.
- Facilitate students' acquisition of BICS and CALP.
- Use lexicon and structures related to the subject accurately.
- Foster the use of different text types, oral or written, with varied communicative purposes, such as hypothesising, presenting, describing, explaining, expressing causes and effects...

**Cross curricular objectives:**

Besides, from all the subjects that integrate the secondary education, it is a must to develop the general objectives of the ESO stage established in the art. 11 of the Royal Decree N<sup>o</sup>1105 (2014). By implementing this project is intended to promote all of them, either because they are related to the contents and procedures of the

subject, or because of the cross curricular methodology involved in the project. We mention the most relevant to the project:

- Show students the connections between the different subjects they study, so they will be able to use all their resources and knowledge to solve different tasks and problems.
- Foster the use of ICT both for information research and for organising, creating and presenting their works.
- Boost students' communication and team work to face any problem or situation.
- Cultivate students' attitude to be tolerant and open minded towards people and diversity, other cultures and traditions.
- Promote students' autonomy by making decisions, taking risks and assuming responsibilities.
- Assist students in being aware of their learning styles and to be conscious of their learning process.

### 3.4. Key competencies

The project will foster the development of all the key competences established in the current curriculum. By working with PBL, an action-oriented learning is favoured, so all the students' knowledge, abilities, skills and personal attitudes are employed, that is, all the elements that comprise the key competences. Following it is described how the project will encourage the different key competences:

**Competence in linguistic communication** requires the representation, interpretation and understanding of the reality. It will be developed through oral and written products, peer communication and argumentation. Students must understand the concepts and the specific terminology of science; argumentation and communication let students to improve their oral and written expression and comprehension; the analysis of scientific texts will reinforce their written comprehension; the organization and classification of information will facilitate the development of written comprehension and expression.

**Mathematical competence and basic skills in science and technology** are needed for studying and representing science phenomena. The application of the mathematical language, the scientific methodology, the organization and interpretation of the data, etc., constitute the basis to understand the reality that surrounds us. Mathematical reasoning will be applied to describe, interpret and predict different phenomena; experimental activities will allow students to establish cause/effect relationships, identify the variables of the processes, and the

application of scientific and technological skills can contribute to a sustainable development.

**Digital competence** involves a creative, critical and safety use of Information and Communication Technologies (ICT). An adequate development of this competence requires skills such as organization, analysis, relationship, synthesis, hypothesis, deduction, etc. Information and knowledge communication need the development of abilities related to access, process and use the information in diverse contexts; maintain an active, critical and realistic attitude towards technological devices and media, assessing their strengths and weaknesses and respecting ethical principles in their use; participation and collaborative work, motivation and curiosity for learning.

**Learning to learn** is fundamental for lifelong learning and it is characterized by the ability to initiate, organize and persist in learning. It implies the awareness, management and control of one's own abilities and knowledge. It includes strategic thinking, cooperation, self-evaluation and an efficient management of different resources and techniques. This competence can be developed by making students to be the protagonists of the process and responsible of the result of their learning. By teaching them to plan, supervise and evaluate the learning process, they can reflect and be aware of their own learning.

**Social and civic competences** imply the ability to interpret social phenomena and problems, develop responses, make decisions and resolve conflicts, as well as to interact with other people and groups from respect and democratic rules. The role of science is the preparation of future democratic citizens, as well as their participation in based decision-making. Group work will allow students to face situations and tasks related to the group, the environment and society, from different perspectives and they can value the importance of teamwork in making decisions. They will develop skills such as communication, negotiation, confidence, decision-making, collaboration, responsibility, tolerance, integrity and honesty.

**Initiative and entrepreneurial spirit** implies the ability to transform ideas into actions, which means being aware of the situation to be solved, planning and managing the necessary knowledge, skills, abilities and attitudes with, to achieve the objectives. This requires the ability to think creatively, manage risk and uncertainty, with motivation and determination. The development of this competence will be fostered by asking questions, identifying and analysing problems, planning, designing and implementing their products, promoting an effective participation, communication and negotiation, etc.

**Awareness and cultural expressions** require knowing, understanding, appreciating and evaluating with a critical, open and respectful spirit, the different cultural and artistic manifestations, using them as a source of enrichment and enjoyment. This competence incorporates the initiative, imagination and creativity in the design of laboratory experiences, models, presentations, etc., in which students will show their ability to use different materials and techniques. On the other hand, they will study some certain essential debates, happened in the advancement of science, to understand the evolution of the society and the implications and risks that technological advances may bring to people or the environment.

### 3.5. Contents

The project is designed for a bilingual subject and it is based in the CLIL approach, so it is necessary to establish both subject and language contents. The contents of compulsory secondary education in Murcia is determined by the annex II of the Decree N°220 (2015), so it has been taken as reference.

#### 3.5.1. Physics and Chemistry contents in 2<sup>nd</sup> of ESO

The project is related to the contents that will be studied in normal classes and reviewed in laboratory sessions. The project will allow students for reinforcing and delving into these concepts and procedures of the subject. At the same time, it will promote the objectives described previously (content, language and cross curricular objectives).

The contents of the P&C subject of 2<sup>o</sup>ESO are established in the annex II of the Decree N°220 (2015, p. 30817-30832). They are organised in five blocks and the project will cover three of them. We specify those contents which will be reinforced with the project:

- **Block 1 - The scientific activity:** The scientific method and its steps; Science and ICT; Science in society; Research Project.
- **Block 2 - The matter:** The structure of matter, atoms and subatomic particles; The Periodic System; Elements and compounds in the society.
- **Block 3 - The changes:** Chemistry in the society and the environment.

#### 3.5.2. Language contents in 2<sup>nd</sup> of ESO

We expect to encourage students' motivation for using and learning English Language (L2), in a natural and real way, by creating a context that favours the autonomy of the students, teamwork, communication, critical thinking, equality, tolerance, the development of responsible attitudes towards the environment... It is

paramount to maintain a relaxed environment that promotes communication by creating opportunities to interact, that implies reducing teacher's talk and increasing students' talk. "Using the language to learn is as important as learning to use language" (Coyle et al., 2010, p. 35).

The contents of the FL subjects of 2<sup>o</sup>ESO are established in the annex II of the Decree N<sup>o</sup>220 (2015, p. 31063-31078). They are organised in four general blocks and the syntactic-discursive contents specified for each language. The project will foster all the blocks, and almost all the syntactic-discursive contents of the English language subject will be needed:

- **Block 1 - Comprehension of oral texts:** acquisition of strategies and basic learning for a correct understanding of the FL in oral communication; encouraging active listening to oral texts, as well as the promotion of the understanding of the FL.
- **Block 2 - Production of oral texts:** the block aims to develop the expression and interaction of oral texts; the achievement of the oral expression of the knowledge acquired and the implementation of the language; the exhibition, the active and cooperative participation in an effective communication.
- **Block 3 - Comprehension of written texts:** the knowledge and the use of the techniques and strategies for reading, comprehension, interpretation and evaluation of different types of written texts in the FL are encouraged.
- **Block 4 - Production of written texts:** the knowledge and the use of techniques and strategies to produce written texts, highlighting writing as a process where planning, obtaining data, organizing information, drafting and revising the text take place.
- **Syntactic-Discursive contents in English Language subject** - Expression of logical and Temporal relationships; Affirmation, exclamation, negation and interrogation; Expression of time: present, past and future; Expression of appearance: punctual and habitual; Expression of the modality: factuality, capacity, possibility and probability, necessity, obligation, permission, intention; Expression of existence, entity, quality, quantity, space, time and the mode.

It is necessary to consider that students will face new and difficult vocabulary related to science, especially because is the first time they study this subject. Much of this vocabulary refers to abstract concepts so students' scaffolding must be a priority to make the content understandable for them. Students need to understand and acquire academic language (CALP) and the basic language for communication

(BICS). In addition, science contexts need the use of specific verbs, patterns, conditionals or passive voice, as well as specific vocabulary which is used in society contexts with different meaning than in a scientific context. Teachers must consider the students' preparation for the language demands in information researches.

### **3.6. Methodology**

Science teachers must awaken students' interest in science problems, as well as make student be aware of the important relationships between science and society. On the other hand, by personalising the learning context, students are more engaged, and they can understand that any problem has multiple solutions, so they can choose the one that best suits their circumstances, needs or capabilities.

#### **3.6.1. CLIL and PBL approach**

The starting point will always be the cognitive progression of subject contents but following the 4Cs framework of CLIL and PBL features, to ensure the appropriate integration of content and language. In addition, we will try to develop the quality of learning and the quality of teaching as Dalton-Puffer & Smit (2013) explain. The first one refers to the students' and teachers' motivation, students' self-confidence, a deeper processing of knowledge and the cognitive advantages of the learning process. The second one is related to fostering learners' autonomy, an inquiry-based teaching and the interactivity.

As we have stated, PBL is a student-centered approach that aims to encourage students to be independent learners and it tries to make connections between what students learn and their needs. Students must use all their resources and knowledge related to other subjects and/or languages to achieve the final product, so teachers will foster students global learning.

The introduction of PBL methodology to students must be progressive, from simple to complex problems. With the goal of implementing PBL and drawing on Da Silva et al. (2018) the following phases are proposed to develop the process:

- Describe the problem and its steps.
- Create students' groups.
- Activate prior knowledge, identify gaps or misconceptions, and determine the future knowledge that may be needed.
- Establish the problem, make hypotheses and questions to guide students' researches.
- Identify useful sources of information.
- Set goals and distribute resources within each group.

- Decide and establish student's roles and duties.
- Share important or useful knowledge in order to facilitate the learning process.
- Apply new knowledge to solve the problem.
- Create products and presentations.
- Assessment and reflection on the process and the solution.

Boss (2012), provides the following table in which specifies the actions of both students and teachers do in a PBL process:

Process	Students do	Teacher's support
Frame problem	Researching to identify root causes of issues, finding right-sized problems understanding multiple perspectives.	Crafting a driving question or briefly framing problem, ensuring students have a need to know, aligning project and academic content, incorporating students' voice and choice, building empathy.
Generate solutions	Brainstorming, borrowing, adapting or improving on existing ideas.	Asking questions to encourage in-depth inquiry, encouraging risk-taking, modelling brainstorming strategies.
Refine ideas	Engaging in interactive cycles, testing, getting feedback, reflecting, evaluating, revising.	Allowing for multiple cycles of review and revision, providing timely feedback, encouraging learning from failure.
Engage with others	Collaborating with team members, engaging with experts, networking.	Encouraging effective collaborations skills, helping students identify and connect with experts.
Share results	Communicating through various media, advocating, inspiring others to grow ideas.	Conducting authentic assessment, inviting public audience, encouraging reflection.

**Table 3.** Innovative Learning Processes (Boss, 2012, p.38)

### 3.6.2. Group work

The project is based in group work to several reasons. Firstly, group work is one of the principal features of PBL. As it was mentioned in section 2.2 (p. 19), when students work in small groups, they can develop an interactive cooperation, there are more opportunities for participation, and communication is promoted. They will debate ideas, negotiate options, give support, criticise, give feedback, assess, etc. Students working together make possible peer scaffolding, mutual learning takes place and all the students gain (Winarti et al., 2019).

In addition, students' motivation is improved when they are challenged with cooperative and cognitively demanding tasks (Fung, Hung & Lui, 2018; Tibaldi, 2012). As Jobér (2017) affirms, students must work in groups because science is a social process and it can create equal opportunities, contributing to "a more multifaceted understanding of the science classroom" (p. 620).

Following the principles of the Social Pedagogical Research in Group Work (SPRinG) project (Fung, Hung & Lui, 2018), teachers involved in this project will encourage pupils to participate actively, and they will manage classroom dynamics and grouping arrangements to facilitate cooperative work, at the preparatory stage, during the learning process, and at the end of the task, fostering group reflection and promoting interactions between students.

On the other hand, teachers must be alert to the social interactions, to avoid students' frustration or society's discriminatory structures. It is essential to make students feel secure in the classroom to make it possible the appropriate learning process (Jobér, 2017).

### 3.6.3. Scaffolding

As it was explained, special attention must be paid in the importance of the scaffolding in the bilingual-science classroom. Scaffolding is used to assist students in their learning while they become autonomous and independent. In CLIL classes scaffolding must be related both on content and language and it can be verbal scaffolding, content scaffolding and learning process scaffolding (Van de Craen & Surmont, 2017).

In addition, we need to maintain students in their Zone of Proximal Development (ZPD) (Vigotsky, 1978), where the most productive learning is achieved, because students are engaged in a high-challenge task with a high level of scaffolding (Gibbons, 2002).

The techniques to scaffold students were highlighted in section 2.3.1 (p. 28) and we summarise them below:

- Differentiation in terms of the content, the process or the product, which can be modified or adapted to maintain pupils on the way where they learn best (Tomlinson, 2000).
- Cooperative learning and Peer-scaffolding gives the opportunity to foster mutual aid (Richards, 2014), and by working in groups, communicative interaction is promoted.
- Translanguaging and the use of L1 to enhance overall linguistic and cultural competence. By allowing the use of other languages, content and language learning is facilitated and the quality of the interaction is improved. Translanguaging maximizes the learning and reinforces knowledge building, playing a central role in students collaborative talk.



- Multimodal discourse to create and communicate meaning, both on teachers' and students' communication. There are a great variety of gestures, body positions, verbal, and material resources that support and encourage the understanding and development of the ideas and concepts (Pozzer-Ardenghi, 2007).

#### 3.6.4. Enhancing ICT Learning

This project is based on inquiry learning, so students must be the protagonists of their learning and they must seek the necessary information and knowledge for the development of their work. Due to ICT, we live in an era in which we have a practically unlimited access to information. Teachers must show students how to use effectively the technological tools at their disposal, which means that students must learn and internalise a critical and rational use of these technologies. On the other hand, students must learn how to manipulate the information, that is to analyse, organize and process all the information to screen it critically and rationally.

Through developing this project, students will have the opportunity to face different sources of information and they will use ICT tools to analyse, process and use the information for communication, for the creation of their products and for constructing their learning.

### 3.7. **Timing: sessions and activities**

#### 3.7.1. Justification of the long-term project

This project has a long-term planning and it designed for a whole school year. The reasons for this decision are diverse and they are explained below:

Firstly, the main objective of this project is to show how to change traditional teaching in P&C. Usually, the split sessions have been used to reinforce contents with photocopies in the classroom. Some students feel that we repeat concepts and that they are wasting their time. On the other hand, many of them come to these split sessions with the intention of doing nothing. By using these sessions in developing and performing the project, we can change this traditional view of split sessions, in consequence, students' motivation will be increased, subject contents will be reviewed, and language use will be improved. By maintaining the parallelism between the project and the contents of the subject, students can be aware of the advance of their subject knowledge at the same rhythm they perform the project.

Secondly, students at this level usually develop short-term researches, so this project can be an opportunity to introduce them in a long-term investigation. This will promote students' autonomy, perseverance and self-confidence. At the same time, with a long-term project, it is easier to make connections with other content

subjects and collaborate with other subject teachers, because the curricula of different subjects do not coincide in their planning and they are not synchronised.

Finally, as students' cooperative work is concerned, pupils are not used to working in groups for long periods of time, so this project can be an opportunity for students to be aware that, in real life, it is usual working in long-term groups, where we must deal with situations and problems that do not arise in short-term projects.

### 3.7.2. Timing and Split sessions

The P&C subject is compulsory in this level and it implies three hours per week in the students' timetable. In the centre, the subject has one hour of weekly group split in all selected groups (2A, 2B and 2C). This split is usually devoted to laboratory work due to the limited capacity of the laboratory. The rest of the students usually make the most of the time by reinforcing concepts and procedures of the subject in the classroom or, sometimes, in the computer room (simulations). Many of the laboratory practices and simulations will be related to the project, such as the study of the properties of metals and non-metals, some chemical reactions, the properties and behaviour of gases, how to build atoms, isotopes and ions, etc., so students will be able to include them in the project as well.

The developing of the project will be during these weekly splits and it involves the following phases:

- The design of the cards for each element of the Periodic Table.
- The realisation of the cards.
- The assembly of the Periodic Table in the corridor of the P&C department.
- The students' works related to the elements.
- The elaboration of the students' presentations.
- The generation of the Google site and the QR code linked to it.
- The incorporation of the students' investigations and works on the Google site.

The school year usually begins on 15<sup>th</sup> of September and it finishes on 24<sup>th</sup> of June, that is 40 weeks. If we discount 4 weeks of school holidays (Christmas and Easter), some local school holidays, 2 weeks devoted to school exchanges and camps and between 6-8 sessions devoted to specific exams, we count with approximately 26 weeks to develop the project. The project is divided into three stages, however, due to the lack of templates to create the names of the elements, the first stage will overlap the second to make the most of the time and the resources, so the amount of time planned for those stages could change. Anyway, to follow the timetable of the scholar year, the stages are planned as follows:

- **1<sup>st</sup> stage:** Creation of the cards of the chemical elements and assembling the Periodic Table (10 weeks).
- **2<sup>nd</sup> stage:** Students' research, development, and presentations (8 weeks).
- **3<sup>rd</sup> stage:** Google site generation and development (8 weeks).

Considering that we will work with half of the group in each session, we need to repeat sessions to work the same time and concepts with all the students. Half group will work in the classroom and the other half will do it in the laboratory. In laboratory sessions students will reinforce science procedures and they will discover properties and the behaviour of the elements, chemical reactions, etc. This knowledge and experiments will also be used as research works for the second stage. In addition, some laboratory sessions could be devoted to students' research in the computer classroom if it was necessary.

One or two normal session will be devoted to the explanation of the project to the whole group, in which teachers will provide explanations of the research works to students: stages of the project, development, making groups, contents, rubrics and assessment, etc. Besides, teachers will describe to students how to use Google Presentations: features, advantages for group and individual work, the monitoring and delivery of the work, etc. Students must deliver two different documents or products: the first one must include an explanation of the process and the group dynamics, and the second one will be an oral presentation for their classmates.

After the explanation of the project, teachers and students will negotiate how the groups will be arranged and students will begin to think on the research work. The stages of the project and the sessions are detailed below.

### 3.7.3. Stages of the project

#### 3.7.3.1. *1st stage: Creation of the cards of the chemical elements and assembling the Periodic Table.*

This is a manipulative stage in which it is intended to let students understand the relationships between the contents studied in normal classes and the different chemical elements, its properties and how they are arranged in the Periodic Table.

The stage finishes with the assembling of the Periodic Table in the corridor of the P&C department. Due to the lack of templates and to take the most of the students' time, this stage will be developed concurrently with the second one.

### Session 1a-1b (2 weeks):

This session will be dedicated to discovering the history and the development of the Periodic Table: why and how elements are arranged in the Periodic Table; types of elements, properties and its position in the Periodic Table.

We will show students the adaptable table, made by Art. Lebedev Studio (<https://periodic.artlebedev.ru/?gshl=ZsoT>), which permits users create the table that fits better their necessities and make their own discoveries: to see only the element symbols, to find out which country discovered each element, etc. (UNESCO, 2019b). Students and teacher will negotiate the most relevant information to show in the cards of the elements.

### Session 2a-4b (6 weeks):

Split groups will work in the computer classroom or in the classroom for both creating the cards and information research, depending on if students can bring digital resources (laptop, tablet, mobile phone) and the availability of the computer classroom.

#### Creation of the cards:

Students will use coloured cards (craft foam) and coloured pens, maintaining the colours of the Periodic Table of the textbook (figure 7), to help students in the understanding of the types of the elements.

**Periodic Table of the Elements**

The image shows a standard periodic table of elements. A callout box for Hydrogen (H) is positioned above the first element, with arrows pointing to its atomic number (1), name (Hydrogen), symbol (H), and atomic weight (1.008).

1 IA	2 IIA											13 IIIA	14 IVA	15 VA	16 VIA	17 VIIA	18 VIIIA	
H	Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar	
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr	
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe	
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn	
Fr	Ra	Ac	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og	
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu		
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr		

**Figure 7.** The Periodic Table of the Chemical Elements (Adapted from Periodic Table Elements Vector Illustration, 2019)

### Session 5a-5b (2 weeks):

The department will prepare a white wood board in the P&C corridor for assembling the cards of the chemical elements to create the Periodic Table. The craft foam is adhesive to facilitate the assembling of the cards.

### 3.7.3.2. 2<sup>nd</sup> stage: *Research and development of students' works and presentations*

As it has been explained, this stage will overlap the former so more sessions will be devoted to students' researches. This second stage mixes digital and cooperative work and it implies an investigation process. Thus, students will discover the properties of the elements and they will be able to hypothesise about their positions in the Periodic Table.

The introduction of the research stages and the tasks related to them must be progressive (Pérez-Ibáñez, 2014). The first task will be a research process in which students must look for information related with each element of the Periodic Table and create a poster with the most important information of each one. Secondly, we introduce students to the Lotus Blossom technique to understand the important relationships between the elements and our life (Figure 11, annex I). Finally, they will develop the corresponding investigations about the uses of the elements in several fields, to produce their presentations and products.

These sessions will be devoted to review, guide and correct students' investigations and presentations. Students will have permission of the centre to bring their laptops, tablets or mobile phones to their research works and to create their presentations. If any student could not bring any of the previous devices, they will be able to use the computer of the classroom.

#### **Session 6a-9b (8 weeks):**

As we have explained before, students will be able to choose between different types of presentations, so the material and resources needed will be varied depending on the students' final products. The centre will try to provide as much material as possible for the development of the works. In addition, we will try to use the largest possible number of materials reused and recycled, making students aware of the multiple uses that different products can have.

#### **a. Information research about the elements:**

Split students will look for information about the different elements, such as their discoverers and the year of their discovery; which elements were discovered by women or by Spaniards; the origin of their names; their properties and principal uses; the advantages and disadvantages of their extraction or production; etc.

Secondly, they will investigate which elements are useful in different fields: Physics, Chemistry, Biology, Medicine, Geology, Archaeology, Technology, Engineering, Music, Art, or even at home (Plaza, 2017). In order to guide students' investigations, we will create a Lotus Blossom considering the different areas

provided for the pupils and they will fill each area or subtopic with their ideas, to share them in the classroom (Figure 12, annex I).

**b. Investigation reports and products:**

Students must deliver different products:

1. The first one must be a document in which they have to include an explanation of the process followed during the investigation (group document) and a brief reflection about their work, results and learning during the process (individual).
2. The second product will be a poster with the most relevant information about the element that each student has chosen to investigate (individual work). This information or poster will be incorporated into the Google site.
3. The last product will be an oral presentation for their classmates about the importance of some element in one of the fields of the investigation (Lotus blossom diagram, annex I). Students will be free to choose the programmes or applications to perform their final product, as well as the final format for their oral presentation, such as Google presentation, Power Point presentation, mock-ups, videos, news, leaflets, posters, etc. (group product). This final product could also be uploaded to the Google site.

*3.7.3.3. 3<sup>rd</sup> stage: Google site generation and incorporation of the students' works*

As Jalienauskiene (2016) affirms, "PBL cannot be successful without technology enhanced learning environments" (p. 272). Besides, both in PBL and science contexts, results and final products must be shared and communicated, to be corroborated and to let others to continue the line of investigation.

For this reason, the project involves the generation of a final product that summarises and shows all the students' work. Students and teachers will create a Google site associated to The Periodic Table, where the students will incorporate their investigations and works. One session with the whole group will be dedicated to explaining how the Google site works and how it must be developed.

This is a digital stage in which students will learn how to create and grow a Google site, how to produce a QR code linked to the Google site web page, and finally, students will personalise and grow the Google site by uploading their digital works to show and make them public. The principal page of the Google site will show an image of the Periodic Table performed by students, as well as the explanation of the project. The real Periodic Table will have the QR code to link it to the Google site.

### Session 10a-13b (8 weeks):

Same as in the previous stage, students will have permission of the centre to bring their laptops, tablets or mobile phones to develop the Google site.

Initially, pupils and teachers will create different pages (2A, 2B, 2C), where the students' researches and works about the elements will be uploaded. In addition, students will be able to decide which other works they want to share in the Google site, both related to their investigations or to laboratory practices.

### 3.8. Material and Resources

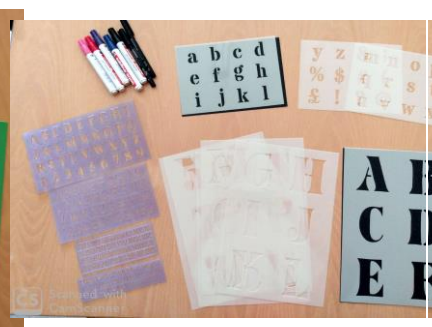
To develop The Periodic Table (1<sup>st</sup> stage) some materials and resources will be needed. Students will use coloured card of craft foam and markers, maintaining the colours of The Periodic Table of the textbook, to help learners in the understanding of the types of the elements, and the reasons of their arrangement. The centre will provide the craft foam to create the cards of the elements, the markers and letter templates in order to preserve the format and the size of the letters, and all the materials needed for the project.

The colours of the cards and the letters are related to the type of the element and its most stable state:

- Cards: blue (metals), yellow (semimetals), green (non-metals) and orange (noble gases).
- Letters: dark (solids), navy blue (liquids), red (gases) and pink (synthetics).



**Figure 8.** Craft foam



**Figure 9.** Markers and templates



**Figure 10.** Sample cards (Spanish version)

For creating presentations and the Google site, students will need digital resources (pc, laptop, tablet or mobile phone) and material resources. As students will be able to perform different types of presentations, such as mock-ups, posters, etc., if they need specific material and resources, the centre will try to provide the material and to reuse and recycle as much as possible (plastic, metals, cardboard...).

### 3.9. Assessment

Since this master's dissertation is an intervention proposal project, it is necessary to establish the learning assessment of the students and the assessment of the proposal itself.

#### 3.9.1. Learning assessment

Even though some teachers often only measure the final task or product (Casan-Pitarch, 2015), "assessment must not be only based on the final product, but on the processes that students follow in order to create such a product" (Pérez-Ibáñez, 2014, p.99). This makes assessing students' work in CLIL and PBL challenging, and some researchers suggest new assessment strategies, such as peer assessment, the production of rubrics with students' contributions, individual and group grades, etc., in order to assess both the process and the students' progress (Lee et al. 2014).

In PBL, assessment makes students responsible of the analysis of their own progress and of classmates work in the group. There are varied assessment methods, such as individual reports, presentations, group assessments, self-assessment, peer assessment, open group assessment, written assessments, patchwork assessment, etc. (Da Silva et al., 2018). As Lee et al. (2014) stated, "the balance between group work and individual work is a big challenge" (p.26).

We will evaluate the process (formative assessment) by observation of classroom performance, as it provides useful information about students' skills development (Kalogeraku, Baka & Lountzi, 2017), as well as the use and improvement of the language. Teachers' and students' formative assessment can be used to evaluate the effectiveness of the learning process, and by giving to students the opportunity to participate in the assessment process, they will be more motivated, and their autonomy and self-stem will be encouraged (Jalo & Pérez, 2014). Considering the products, we will use a summative assessment with its rubrics. However, there is a contradiction when we develop group projects because, even when students are working in groups, we must provide an individual mark based on the Assessable Learning Standards.

On the other hand, we should consider how to evaluate language learning, but considering that the students' language level does not interfere with the content assessment (Coyle, Hood & Marsh, 2012; Tibaldi, 2012). The most important thing is that content subjects offer contextualised language (Jalo & Pérez, 2014), and regarding language learning, the principal aims of the project are to encourage students' communication and to change students' attitudes about learning and using FL.



Considering content goals, the project aims to foster and develop students' critical thinking, promote students' awareness of the role of science, develop responsible attitudes towards the environment, foster the use of ICT, cultivate students' attitude towards people and diversity, and promote students' autonomy and self-stem. In addition, as specific subject tests will be done to assess the acquisition of subject contents in normal classes, this project does not aim to evaluate students' content learning but reinforce it. However, some of these issues are related with the Assessable Learning Standards of the subject (annex III), so the project will be included in the 40% of the mark of the subject devoted to simulations, laboratory practices and research works.

For these reasons, we will centre the students' assessment in communication, group dynamics, the use of ICTs, the development of oral and written presentations, and learning reflections. As we have stated, students must deliver different products, and the expected results will be:

- 1.** The Periodic Table (group work): the creation of the cards of the chemical elements and its assembling in the corridor of the P&C department.
- 2.** A poster of an element with the most relevant information extracted from their investigations such as symbol, atomic and mass numbers, properties, most important uses, discovering, by who and when, etc. Students must negotiate which element are going to investigate (individual work).
- 3.** Written and oral presentation (group work): once students have chosen the element and the field in which it is important (Lotus blossom diagram), they must develop a presentation with two parts to deliver:
  - a.** Written product: students will be free to choose different applications to perform it (Google presentation, Power Point presentation, Prezi, etc.), as well as the format for their oral presentation.
  - b.** Oral presentation: students can use mock-ups, videos, news, leaflets, posters, etc., to support their oral performance in addition to the written presentation.
- 4.** Individual reflection: a document in which they must include:
  - a.** An explanation of the process followed during the investigation: the members of the group, the steps taken during the investigation, the development of the work, advantages and difficulties of group working...
  - b.** A personal reflection about their individual work, results and learning during the process (synthesis of the quality of the knowledge acquired).

The percentage assigned to the project will be the 25% of the final mark, where each part of the project will be evaluated with the corresponding rubric. The students' products involve both group and individual assessment:

- a. Group assessment:** (group mark, the same mark for each pupil, except of some specific attitudes).
  - i.** Classroom dynamics and teamwork: the periodic table development, research works, group interaction and communication.
  - ii.** Presentations: visual (format, content, images...) and oral (group performance: how the group interacts and manage the presentation).
- b. Individual assessment:** (individual mark).
  - iii.** Research work about the chosen element and the creation of the poster.
  - iv.** Individual reflections about their work, group work and their learning.
  - v.** Individual oral presentation (how effectively the pupil communicates or interacts with the audience).

The several rubrics will be created in cooperation and negotiation between teachers and students, to involucrate them in the assessment of their learning process, to give them autonomy, and to foster their responsibility. The rubrics will serve to assess students' work and products, as well as to students' self-assessment. The rubrics will be developed following the models and the most important features from Rubric Maker (Teach4Learning, Inc., 2019) and Cedec (2019):

RUBRIC	FEATURES
<b>Research work</b>	<ul style="list-style-type: none"> <li>- Research quantity and quality.</li> <li>- Ideas and details are interesting and presented in logical sequence: introduction, body and conclusion.</li> <li>- Writing: spelling, grammar and punctuation.</li> <li>- Bibliography and documentation.</li> </ul>
<b>Oral Presentation</b>	<ul style="list-style-type: none"> <li>- Content: related to the topic, accurate and updated.</li> <li>- Images, colour, font, format and background.</li> <li>- Knowledge of subject and audience questions.</li> <li>- Posture and eye contact.</li> <li>- Enthusiasm and interaction with audience.</li> <li>- Pace and volume.</li> </ul>
<b>Teamwork</b>	<ul style="list-style-type: none"> <li>- Attitude and motivation.</li> <li>- Cooperation: listens, shares ideas and work, group support.</li> <li>- Contributions to the group dynamics and work.</li> <li>- Problem-solving: identifying, giving solutions.</li> <li>- Group and tasks assignment.</li> <li>- Responsibility and autonomy.</li> <li>- Self and peer assessment.</li> </ul>

<b>Poster</b>	<ul style="list-style-type: none"> <li>- Content and information organization.</li> <li>- Creativity and originality.</li> <li>- Writing: spelling, grammar and punctuation.</li> <li>- Images and pictures.</li> <li>- Design: colour, font, format and background.</li> </ul>
<b>Reflections</b>	<ul style="list-style-type: none"> <li>- Investigation process and group work: members collaboration and work, steps of the investigation, work development, advantages and difficulties of group working...</li> <li>- Individual work: results and learning, reflection about the quality of the knowledge acquired.</li> </ul>

**Table 4.** Rubric assessment features (based on Rubric Maker and Cedec, 2019)

### 3.9.2. Assessment of the proposal

In the design and development of any project its evaluation and effectiveness should be analysed. This implies to assess and evaluate both its development and its achievements, during and at the end of the process. The proposal must be analysed from different perspectives: the project design, secondly, the project implementation, and the project achievements.

Regarding the project design, the proposal is based on the merger of CLIL and PBL methodologies in the P&C classroom, in the 2<sup>nd</sup> level of Compulsory Secondary Education. The educational context has been considered by describing the situation of science subjects and the promotion of both teachers' and students' motivation towards science, the current curricula and the contextualisation of contents. On the other hand, we have considered the importance of fostering FL learning, and the current situation of bilingual education in the Region of Murcia.

The project has been designed to satisfy the curriculum requirements of the stage and the CLIL and PBL methodologies. The aims of the project have been established considering the target group and they have been divided into four categories: general objectives of the project, subject objectives, language objectives, and cross-curricular objectives. We have described subject and language contents, and how by implementing the project students will develop all the key competences of the stage.

As far as the project implementation is concerned, the methodology has been detailed considering the merger of CLIL and PBL and the phases to develop a PBL project. Special emphasis has been given to group work, scaffolding and the ICT learning, due to their importance in the learning process and for life-long learning skills. The timing and sessions devoted to the development of the project have been specified and justified properly, where the description of the stages of the project and the students' works produced in each of them have been specified. To evaluate

the success in the implementation of the project, we have produced different questionnaires, both for teachers and students involucrated in it (annex IV).

Finally, the products and the students' learning assessment have been described, and project assessment must be considered. To evaluate the project and its effectiveness, we will consider the features of the Project Design Rubric, which was elaborated for any PBL project by Buck Institute of Education (2019) and they are summarized in table 5:

Features	Description
Project objectives are based on Student Learning:	<ul style="list-style-type: none"> <li>- The project is based on Assessable Learning Standards and the objectives of the stage.</li> <li>- The objectives of the project are real and achievable.</li> <li>- The project fosters students' skills development: critical thinking, collaboration, creativity and autonomy.</li> </ul>
Challenging Topic	<ul style="list-style-type: none"> <li>- The project is based on a challenging central problem, at the appropriate level.</li> <li>- The project is framed by open-ended questions, understandable and inspiring tasks, and aligned with learning goals and the project objectives.</li> </ul>
Inquiry & Research Development	<ul style="list-style-type: none"> <li>- They are student-centred.</li> <li>- They are extended throughout the project and they are academically rigorous.</li> </ul>
Authenticity	<ul style="list-style-type: none"> <li>- Context, real tasks and problems, tools, materials, students' personal interests, etc.</li> </ul>
Students' Autonomy	<ul style="list-style-type: none"> <li>- Students can express and make decisions.</li> <li>- Students can develop their autonomy and responsibility.</li> </ul>
Learning Reflection	<ul style="list-style-type: none"> <li>- Both teachers and students reflect about the learning process and the design and management of the project.</li> </ul>
Feedback	<ul style="list-style-type: none"> <li>- Students receive/give feedback from/to teachers and peers.</li> <li>- Students use feedback to revise and improve their work.</li> </ul>
Public Product	<ul style="list-style-type: none"> <li>- Students make public their works.</li> <li>- Students reflect and justify their decisions, work development and learning.</li> </ul>

**Table 5.** Features of effective PBL (adapted from Buck Institute for Education, 2019)

Finally, to evaluate the achievements and the success of the project, we have created different questionnaires to analyse the students' and teachers' opinions and feelings about the project design, its implementation and achievements (annex IV).

## 4. DISCUSSION

As it has been mentioned in the literature review, PBL approach can serve to reach the most important current tendencies in education, oriented to a learning-centred environment, and it "represents a new way of perceiving learning and learners and teachers' roles" (Jaleniauskiene, 2016, p. 274). Besides, "PBL helps

students to establish a solid domain knowledge base” and it provides a learning environment which “fosters students’ development of problem-solving abilities, and more importantly, creative minds” (Hung, 2015, p.244).

On the other hand, “CLIL raises important issues about the complex interrelationships between language use, learning and competence” and CLIL students can focus on “communicative and interactional competences displayed by students in doing learning in an additional language” (Evnitskaya & Morton, 2011, p.124).

The combination of PBL and CLIL can revitalize FL learning by increasing the use of language in a creative, meaningful and authentic communication. In addition, as Jaleniauskiene (2016) affirms, “PBL in FL education leads to meaningful and authentic communication central to the learning process and allows students to move from reproductive to creative and meaningful FL use, which undoubtedly increases motivation” (p. 273) and “empowers students to succeed in contexts where they are required to act as a team and solve problems in an FL (p. 124). Thus, “PBL prepares students for real world challenges” (Cho, Kaleon & Kapur, 2015, p. 75).

As far science lessons are concerned, CLIL features help to structure them and it permits students’ improvement in L2 learning. On the other hand, PBL offers flexibility to be adapted to any content subject, it fulfils the objectives and principles of CLIL, and it fosters scientific methodology. Both approaches increase students’ motivation towards the content subject by providing a collaborative learning (Fung, Hung & Lui, 2018) and a contextualised learning environment. In addition, Heras and Lagasabaster (2015) affirm that CLIL has beneficial effects in learners’ motivation and self-esteem because it is used in a real communicative and meaningful context. On the other hand, the authors suggest that CLIL contexts tend to diminish the gender differences towards learning languages, maybe because in CLIL classroom students mix both motivation towards subject and language. However, it is necessary to consider the effect of the content subject, because students are not equally motivated towards Sciences or another subject.

Although teamwork can be considered both a facilitating and a limiting factor (Da Silva et al., 2018), undoubtedly, group work has important benefits for students’ learning, motivation and self-esteem. Effective group strategies “help them to advance much further in the development of science concepts” and “group work tasks contribute to greater student accomplishment and more intense interaction in shared cognitive activities” (Fung, Hung & Lui, 2018, p. 1309). For this reason, the project involves three stages where group work receives the principal attention to encourage and improve different skills, such as cooperation, teamwork,

communication, critical thinking, researching, analysing, making decisions, the use of ICTs, etc., so important for continuous learning (Leaton Gray, Scott & Mehisto, 2018). The proposal is designed to foster students in making decisions and choices, creating products, reaching an effective communication, using peer-scaffolding, peer and self-assessment, etc. The different authors cited in this proposal agree that the active implication of the students in their learning process is crucial for students' self-regulation, for enhancing their motivation and improving their attitude towards science.

Regarding the analysis of the scaffolding, the different strategies help students to be focused on the tasks, to develop students' autonomy and it improves students' motivation (Bueno, 2012). The benefits of the multimodal discourse and translanguaging have been highlighted because they "can play a central role for learning through collaborative talk" (Duarte, 2019, p. 162), and the students' L1 may help them to "better understand scientific actions, results and descriptions, in order to make both advance scientific and linguistic contents" (Jameau & Le Henaf, 2018, p. 36). "It would be helpful for teachers to have an overall understanding of translanguaging, not only as a pedagogic strategy to support learning but also as a feature of natural bilingual discourse" (Nikula & Moore, 2019, p. 245).

Since the project is an intervention proposal, there are not results to analyse related to the improvement in teachers' and students' motivation, the difficulties in its implementation or the achievement of its aims. The project has been designed following the characteristics of current Spanish curriculum and the features of CLIL and PBL approach. It has been well contextualised to the centre and the students, its methodology has been specified, and the students' assessment has been described. For this reason, the proposal could be implemented anytime in this centre or it could be adapted to another one.

## 5. CONCLUSIONS

The concept of learning has changed and the importance of "learning to learn" is highlighted and included in the content of syllabuses. Lifelong learning has become the new model for improving education (Hayat et al., 2019). In addition, there is a tendency in science education to reinforce scientific areas due to their importance in the future of our society.

For these reasons, this intervention proposal has been designed as an attempt to show, firstly, how to change students' perceptions of learning P&C and FL, and secondly, to change traditional teaching in P&C subject. PBL provides the necessary educational innovation from traditional teaching to student centred learning, it

fosters students' motivation and promotes the development of life-long and creative skills. On the other hand, by introducing the CLIL approach in the classroom, we challenge students and develop their high order thinking skills. The features of CLIL help to structure science lessons and PBL offers flexibility to be adapted to any subject. Consequently, the merger of CLIL and PBL methodologies can be a powerful motivational instrument for bilingual education in science subjects. In addition, we highlighted the importance of the scaffolding to assist students in their learning while they become gradually autonomous and independent, looking for a pupil-centred learning process.

The proposal is based on the current curriculum and contextualised to the 2<sup>nd</sup> level of Compulsory Secondary Education. The key competences, the contents of the subject and language contents have been specified and the methodology has been described, following the CLIL and PBL approaches and looking for the development of the quality of learning and the quality of teaching (Dalton-Puffer & Smit, 2013). Special attention has been given to group work, the importance of scaffolding, and the ICT learning. The sessions and activities have been detailed, as well as the needed material for the development of the project. Regarding the assessment of the project, the students' learning assessment has been justified by means of the assessment of both the learning process and the students' products. Finally, the evaluation of the project has been made by the analysis of its characteristics and stages, and different questionnaires has been created for the assessment of the project by teachers and students, once it will be implemented.

Since this intervention proposal is a theoretical project, there are not results to analyse, but some difficulties and limitations in its design and implementation could be considered, as well as some future research lines.

## **6.LIMITATIONS AND FURTHER RESEARCH**

### **6.1. Limitations**

Several factors can be considered as restricting or difficult in the development of this project. We justify some of the most important to consider:

- Teamwork can be both a facilitating and a limiting factor, due to “the passive role taken by some students and the difficulty of arriving at consensus on the solutions” (Da Silva et al., 2017, p.174).

- The schedule of teachers in the centres has not enough time for meetings between content teacher, language teachers and language assistants to plan and work collaboratively. “Putting together a CLIL curriculum requires a coordinated and unified effort amongst all the involved personnel. Design and implementation teams be constituted coherently, with periodic meetings in which responsibilities can be assigned and plans put into place” (McDougald, 2018, p.12). In addition, “PBL curriculum is often expensive and time-consuming” (Weiss & Belland, 2018, p. 85).
- Reluctant teachers’ attitudes to change traditional methodologies can make difficult the collaboration in the implementation of any project. PBL is very different from traditional teaching, so “teachers ought to be flexible, motivated and open to changing their practices” (Lee & Blanchard, 2018, p.3). PBL methodology needs more: time to plan, resources, scaffolding, effort to assess, communication and support from the administration (scheduling and curriculum alignment). Besides, transitioning from a traditional instructional model to a PBL model is difficult for students too (Lee et al., 2014), so we must to deal with their resistance to change as well, and their reduced experience in group working (Weiss & Belland, 2018).
- Students’ “motivation is not stable and changes over time as a result of personal progress, multi-level interactions with environmental factors and other individual factors” (Heras & Lagasabaster, 2015, p. 85). For this reason, motivation needs a multidimensional perspective study (Linares, 2016).
- Classroom diversity needs more time to scaffolding and to adapt the activities and tasks to the students’ necessities. Large classes make difficult “to meet all students needs and interests” (Kalogeraku et al., 2017, p.143), and “manage the classroom, controlling student behaviour, using technology, supporting, and assessing students’ learning” (Lee et al., 2014, p.20).
- The lack of the students’ previous knowledge of the subject (Álvarez, 2016) and the students’ language level can make them discouraged and make difficult to develop the project in the planned time (Kalogeraku et al., 2017)
- Content teachers’ language proficiency is another difficulty to overcome. It is necessary to train content teachers because “CLIL teachers are usually L2 speakers of the language of instruction who are likely had a minimal training in CLIL” (Evnitskaya & Morton, 2011, p.124).



## 6.2. Future research

Once any project is designed and implemented, several lines to future researches can be opened. As Heras & Lagasabaster (2015) stated, “Education, research and innovation need to work together” (p.71). In this sense, to close this project, we mention some interesting lines to future research:

- Students’ and teachers’ view and comments to improve the design and the implementation of any future project.
- Students’ and teachers’ considerations to improve the implementation of CLIL and PBL methodologies in any content subject in the centre.
- Research in how students’ attitude and motivation depend on different factors (multidimensional perspective study).
- Research on the effect of the content subject taught through a FL.
- Study the Multiple Intelligences and learning styles to improve teaching in P&C.
- Research on affective factors and problems in social interaction in students’ group work.

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## 8. ANNEXES

### 8.1. Annex I. Lotus Blossom Templates

	8. THE EARTH			1. BIOLOGY			2. GEOLOGY	
			8. THE EARTH	1. BIOLOGY	2. GEOLOGY			
	7. AT HOME/SCHOOL		7. AT HOME/SCHOOL	THE ELEMENTS IN OUR LIVES	3. MEDICINE		3. MEDICINE	
			6. MUSIC AND ART	5. TECHNOLOGY AND ENGINEERING	4. HISTORY			
	6. MUSIC AND ART			5. TECHNOLOGY AND ENGINEERING			4. HISTORY	

**Figure 11.** The elements in our lives (a) (Plaza, 2019. Adapted from Riley template, 2013)

After this first diagram, students will fill each area or subtopic with their ideas, and they will be shared in the classroom. For example:

	8.1 WATER	8.2 GROUND		1.1. ELEMENTS IN PLANTS	1.2. ELEMENTS IN ANIMALS		2.1 CRISTALOGRAPHY	2.2 JEWELRY
8.7 THE UNIVERSE	8. THE EARTH	8.3 ATMOSPHERE		1. BIOLOGY	1.3 ELEMENTS IN HUMANS		2. GEOLOGY	2.3 MINERALS
8.6 SOLAR SYSTEM	8.5 POLLUTION	8.4 ICE AND GLACIARS	1.6 BALANCED DIET	1.5 POISONED PROTECTION	1.4 DANGEROUS ELEMENTS		2.5 ELEMENTS IN GLACIARS	2.4 ELEMENTS IN THE EARTH
	7.1 KITCHEN TECHNOLOGY	7.2 KITCHEN TOOLS	8. THE EARTH	1. BIOLOGY	2. GEOLOGY		3.1 DIAGNOSIS	3.2 RADIOTHERAPY
7.6 CLEANLINESS	7. AT HOME/SCHOOL	7.2 FOOD	7. AT HOME/SCHOOL	THE ELEMENTS IN OUR LIVES	3. MEDICINE		3. MEDICINE	3.3 CHEMOTHERAPY
7.5 BEAUTY	7.4 CLOTHES	7.3 BALANCED DIET	6. MUSIC AND ART	5. TECHNOLOGY AND ENGINEERING	4. HISTORY	3.6 IMPLANTS	3.5 PHARMACOLOGY	3.4 MEDICINES
	6.1 INSTRUMENTS	6.2 COLOURS AND PAINTINGS		5.1 DIARY THINGS (WATCH, MOBILE, PC...)	5.2 VEHICLES		4.1 ALCHEMY	4.2 EVOLUTION OF THE PERIODIC TABLE
	6. MUSIC AND ART	6.3 CONSERVATION OF ARTWORKS		5. TECHNOLOGY AND ENGINEERING	5.3 BUILDINGS		4. HISTORY	4.3 ARCHEOLOGY
	6.5 SCULPTURE	6.4 MONUMENTS		5.5 COMMUNICATIONS	5.4 ENERGY SYSTEMS		4.5 WOMEN IN THE PERIODIC TABLE	4.4 DATING

**Figure 12.** The elements in our lives (b) (Plaza, 2019. Adapted from Riley template, 2013)

### 8.2. Annex II. Relationships between Life-long learning, PBL and CLIL

Life-long learning framework		PBL	CLIL
Standards	Categories	Features	Core Features
1. Complex thinking	a. Effectively uses a variety of complex reasoning strategies. b. Effectively translates issues and situation into manageable tasks that have a clear purpose	<b>A.</b> Learner centred approach: 1, 2, 5. <b>B.</b> Small group work: 1, 2, 3, 4, 5. <b>C.</b> Teachers as facilitators: 1, 2, 3, 5. <b>D.</b> Authentic problems to stimulate learning: 1, 2, 4, 5. <b>E.</b> Problem-solving skill developing: 1, 2, 3, 4, 5. <b>F.</b> Self-directed learning: 1, 2, 3  (Numbers show the relationships with life-long learning standards)	- Multiple focus and Authenticity are related to <b>D</b> . - Safe and enriching learning environment involves <b>A, B, C</b> . - Active learning needs <b>A, B, C, D, E, F</b> . - Scaffolding is linked to <b>A, B</b> . - Cooperation involves <b>A, C</b> .  (Letters show the relationships with PBL features)
2. Information processing	a. Effectively uses a variety of information gathering techniques and information resources. b. Effectively interprets and synthesizes information. c. Accurately assesses the value of information. d. Recognizes where and how projects would benefit from additional information.		
3. Effective communication	a. Expresses ideas clearly. b. Effectively communicates with diverse audiences. c. Effectively communicates in a variety of ways. d. Effectively communicates for a variety of purposes. e. Creates quality products.		
4. Cooperation and collaboration	a. Works toward the achievement of group goals. b. Effectively uses interpersonal skills. c. Contributes to group maintenance. d. Effectively performs variety of roles.		
5. Habits of mind	a. Self-regulation. b. Critical thinking. c. Creative thinking.		

**Table 2.** Relationships between Life-long learning, PBL and CLIL (Based on Hayat et al., 2019, p. 2)

### 8.3. Annex III. Assessable Learning Standards

The annex II of the Decree N°220 (2015, p. 30817-30832) establishes the Assessable Learning Standards (ALS) of the P&C subject, in the 2<sup>nd</sup> level of Compulsory Secondary Education. The following table summarises those ALS that are related to the project:

Contents	ALS
Block 1 - The scientific activity	B112, B121, B151, B152, B161, B162.
Block 2 - The matter	B212, B261, B262, B263, B271, B282.
Block 3 - The changes	B341, B342, B351, B352.

### 8.4. Annex IV. Questionnaires to evaluate the success and the achievements of the project.

1. Unsatisfactory; 2. Fair; 3. Good; 4. Excellent

QUESTIONNAIRE FOR TEACHERS				
PROJECT DESIGN	1	2	3	4
1. Contextualization to the centre and students				
2. Development of the key competences and objectives of the stage				
3. Based on contents and ALS of the subject				
4. Consideration of the 4Cs framework of CLIL approach				
5. PBL methodology features				
6. Consideration of different scaffolding techniques				
7. The assessment is focused on both the learning process (formative) and the products (summative)				
PROJECT DEVELOPMENT	1	2	3	4
8. Evaluation of the coordination between P&C and English language departments				
9. Evaluation of the involvement of P&C and language teachers				
10. Improvement of the teachers' attitude and motivation				
11. Evaluation of the participation of the language assistant				
12. Evaluation of the students' teamwork				
PROJECT ACHIEVEMENTS	1	2	3	4
13. Progress of the students' attitude and motivation towards P&C subject				
14. Improvement of the students' academic performance in P&C				
15. Progress of the students' attitude and motivation towards English language				
16. Improvement of the students' academic performance in English language				
17. Increase of communication students- students				
18. Increase of communication students-teachers				
19. Progress in the use of ICT				
20. Promotion of the students' autonomy and self-stem				
21. General evaluation of the project success				
Comments and improvements:				

<b>QUESTIONNAIRE FOR STUDENTS</b>				
<b>PROJECT DEVELOPMENT</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
1. Evaluation of the students' group work				
2. Classroom dynamics coordinated by students and teachers				
3. Students' decisions and choices have been considered to make the researches and products				
4. Consideration of the students' participation to elaborate rubrics				
5. Effectiveness of peer-assessment and self-assessment				
6. The assessment is focused on both the process and the products of the project				
7. Evaluation of the students-students' relationships				
8. Evaluation of the students-teachers' relationships				
9. Evaluation of the involvement of P&C and language teachers				
10. Evaluation of the participation of the language assistant				
<b>PROJECT ACHIEVEMENTS</b>	<b>1</b>	<b>2</b>	<b>3</b>	<b>4</b>
11. Progress of your attitude and motivation towards P&C subject				
12. Improvement of your knowledge of P&C				
13. Relation between the project and daily life/society problems				
14. Improvement of your academic performance in P&C				
15. Progress of your attitude and motivation towards English language				
16. Improvement of your knowledge of English language				
17. Improvement of your academic performance in English language				
18. Increase of communication students- students				
19. Increase of communication students-teachers				
20. Your interest in the use of ICT at school				
21. Your progress in the use of ICT at school				
22. Improvement of your autonomy and self-stem				
23. General evaluation of the project success				
Comments and improvements:				