Centro de Estudios de Postgrado
Máster Interuniversitario en Enseñanza Bilingüe y AICLE

UNIVERSIDAD DE JAÉN

UNIVERSIDAD DE CÓRDOBA

Master's Dissertation/
Trabajo Fin de Máster

BILINGUAL TEACHING OF PHYSICS AND CHEMISTRY IN BACCALAUREATE THROUGH PROJECT-BASED LEARNING.

Student: MORAL MARTÍNEZ, ANTONIA

Supervisor: Dra. Carmen Plata Luque
Department: English Philology

November, 2019

MIEB

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1. INTRODUCTION

In recent years, in Spain there has been a considerable increase in the number of students who study in bilingual schools. This growing trend in learning a second language more specifically, English, is due to the process of globalization that has been occurring for many years, which has increased the number of commercial, professional and cultural relationships as well as tourism in towns and cities, thus making it essential to master more than one language.

The Common European Framework for Languages (CEFR) provides a common basis for the elaboration of language syllabuses, curriculum guidelines, examinations, textbooks, the design of teaching and learning materials, and the assessment of foreign language proficiency (Council of Europe, 2001a).. It is regulated by education department following those guidelines by the Common European Framework of Reference for language (CEFR).

Multilingualism is an important element of European competitiveness, which is why the European Union funds numerous programmes and projects in this field. In the same year, 2001, the European Language Portfolio (ELP) was published, allowing language students to record their language skills and cultural experiences (Council of Europe, 2001b). In this document the person who learns or has learned a language, both in school and in any other context, can materialize their knowledge and their curative experiences. We can say that it is like a kind of linguistic passport, since it starts from criteria recognized in all European countries. It is a motivating tool that supports the continued learning of a language different from the mother tongue.

This document consists of three parts: first, the Language Passport, which provides a general idea of the individual's proficiency in different languages (in terms of skills and the CEFR) at a given point; second, the Language Biography, which facilitates the student's participation in planning, reflecting upon and assessing his/her language learning process and progress; and third, the Dossier, where the learner can select materials to illustrate achievements or experiences regarding languages.

The European Union is betting so strongly, in this regard, that it has ambitiously proposed a very important goal: that Europeans speak two European languages in addition to their mother tongue (Unión Europea, 2018). In our autonomous community, according to Instrucciones de 15 de mayo de 2019, de la Dirección General de Ordenación y Evaluación Educativa, sobre la organización y funcionamiento de la enseñanza bilingüe para el curso 2019/2020, the 5th. 2 instruction, refers to the ELP recommendation of use:

> Se fomentará la utilización del Portfolio Europeo de las Lenguas (PEL), tanto en su versión papel como en la electrónica (e-PEL). Mediante el PEL, el alumnado y el profesorado se hacen conscientes del desarrollo de sus destrezas comunicativas en las diferentes lenguas que conocen. Para ello podrán desarrollar sus propios materiales o utilizar los publicados en el Portal de Plurilingüismo elaborados por la propia Consejería de Educación, que recibieron el primer Premio del Sello Europeo 2012.

The teaching-learning methods of foreign languages have been varied depending on the use of the language that society has demanded at different times. Thus, initially, the teaching focused on the memorization of grammar rules, vocabulary, leaving the spoken language relegated to the background, since it was not practiced until it was mastered. However, the need to interact in a foreign language made oral language important and began focus on the five different language skills (listening, reading, spoken production, spoken interaction and writing). At the end of the 80s, a new methodological proposal arose that emphasized the student's learning process, through tasks that he had to strive to complete. That was to say, students could learn a language, usually English, without that being the fundamental "purpose", the objective was the acquisition of competences in other non-linguistic subjects, which is known today as CLIL methodology (Content and Language Integrated Learning). This methodology is based on two ideas that are, one that the foreign language is learned in the way in which it is used to resolve a communicative situation. And the second, which is fundamental, is the involvement of the student in the realization of the task, which is authentic and which he considers significant (Díaz, A., 2011: 7).

Also, the new demands and needs of today's society have generated rapid and important changes in schools, at the level of content, methodology, roles, etc. since the ultimate goal of education is to prepare students to live in an international, multicultural, multilingual and technologically advanced world.

Society demands people with interdisciplinary skills such as critical thinking, cooperation, communication, project management and lifelong learning abilities in different settings. Lifelong learning is the process of learning which occurs throughout life, according to personal interests and needs. It refers to formal and informal learning. In fact, it is handled by various international institutions with a holistic approach and has the philosophy ‘education from cradle to grave’ (Melek Demirel, 2009)

According to a council recommendation on Key Competences for Lifelong Learning:

> Learning languages and being able to communicate in more than one language remains one of the key competences for lifelong learning. The focus of the 'Languages competence' is on improving the development of linguistic competences and stressing the importance of learning languages as a tool for communication within multilingual societies and work environments. (European Commission, 2018; 39).

Nowadays, there is a great diversity of methods that can be used in the teaching-learning process, such as: gamification, multiple intelligences, visual thinking, etc .; all these methodologies can respond to the needs specified explicitly in the Organic Law 8/2013, of December 9, for the Improvement of the Educational Quality (LOMCE): " condiciones que permitan el oportuno cambio metodológico, de forma que el alumnado sea un elemento activo en el proceso de aprendizaje "(LOMCE, 2013: 97860). In this way, it is suggested that a methodological change be made, using active teaching methods, which allow students to develop autonomy, collaboration and commitment in order to facilitate their adaptation to society and foster their lifelong learning.

In addition, one of the objectives that we are trying to achieve in our society today in terms of education is to get the attention of the students, motivate them and, at the same time, reformulate the teacher´s role and adapt them to fulfil students’ skills in the 21st century, break with the form of understanding the education that we are so accustomed to and look for more and more ways to innovate so as not to fall into the recurring monotony.

According to a study carried out by Nastiti Handayani (2018) on the new roles of English teachers in 21st century, English teachers in senior high school believe their roles as life-long learners, facilitator, collaborator, assessor, technology expert, and project manager

sequentially. The study also found that they adopt particular roles to meet students' learning and innovation skills, information, media and technology skills, and then life and career skills.

2. JUSTIFICATION

As mentioned in the introduction, bilingual education in our society is of great importance today due to the mobility between countries produced in recent years, being in many cases essential for the performance of certain professions. "The EU already has an excellent track record of actively promoting mobility, starting with university students but also including secondary level pupils, vocational students and young professionals as well as teachers, thanks to the Erasmus+ programme"… to work towards a European Education Area in 2025. (European Commission, 2.017: 4)

The emergence of new needs in our society puts into question the main purposes of the traditional educational system. The Organic Law 2/2006, of 3 May, of Education (LOE) has already spoken of the importance of the acquisition of some basic competences as a method to fight against the high school dropout rates, nevertheless, the first law that made mention of the basic competences with integration into the curriculum has been the Organic Law 8/2013, of December 9, for the Improvement of Educational Quality (LOMCE).

This new approach requires not only a restructuring of the curriculum, but also substantial changes to the incorporation of innovative methodologies that allow a new definition of the roles of the educator and the student, as well as significant experience of the teaching-learning process.

In Order ECD/65/2015, of January 21, in which describing the relationships between competencies, content and assessment criteria for primary education, compulsory secondary education and post-secondary specifically in its annex II a series of methodological guidelines appear that facilitate working by competences in the classroom. Among them, we can read the use of active and contextualized methodologies, cooperative working, diversity of materials and resources, project-based learning, etc.

Of all the active methodologies existing, I have opted for project-based learning (PBL) in combination with the CLIL methodology for the bilingual teaching of the subject of the 1st baccalaureate in Physics and Chemistry for various reasons. On the one hand, it is a didactic technique that is based on interdisciplinary and the integration of the multiple intelligences that Gardner proposed. Besides, it responds to a greater extent to the interests of the students, based on their previous ideas and adapts to their pace, it means, it is a student focused methodology. Thus, learning based on projects (PBL) helps the development of transversal competences such as group work, order and preparation, material management, resources and time, the sharing of tasks and integration in the group and fosters critical thinking, inquiring and the use of the scientific method.

On the other hand, the subject of Physics and Chemistry is a subject with a marked experimental character that makes it suitable to work through projects, intertwining theoretical and practical concepts and developing competences. It also allows the implementation of 21st CENTURY skills: critical thinking, creativity, collaboration, communication, information literacy, media literacy, technology literacy, flexibility, leadership, initiative, productivity and social skills.

The 21st century is characterized by its rapid technological advance, so today more than ever, education plays an integral role in preparing students to become global and aware citizens, and also to be prepared for the associated challenges with a society which is highly mobilized and dominated by technology (Berry, 2010, Castells, 2005).

In order to strengthen one's understanding of 21st century skills, many frameworks have been developed with the support of international organizations, governments and consulting firms (Chu *et al.*, 2016). One of them, Partnership for 21st Century Skills (P21, 2009) is an American organization founded in 2002 (http://www.p21.org), formed by business leaders, consultants and educators, which conceptualized a framework for 21st century skills. It consists of eleven competencies which are classified into three gist elements including (1) learning and innovation skills, (2) information, media and technology skills, and (3) life and career skills. Table 1 is an adapted version of the P21 framework with the three skill sets.

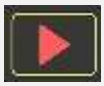
21st century skills		
Learning and innovation	**Digital literacies**	**Life and career skills**
Core subject  Critical thinking and problem solving  Creativity  Collaboration  Communication 	Information literacy  Media literacy  Information and communication technology literacy 	Flexibility and adaptability  Initiative and self-direction  Social and cross-cultural interaction  Productivity and accountability  Leadership and responsibility 

Table 1 Capabilities for each set of 21st century skills (adapted from P21, 2009)

3. OBJECTIVES

The main objectives of this master dissertation are to justify that PBL and CLIL are two complementary and beneficial approaches to learning a second language, and to design a didactic proposal for teaching Physics and Chemistry based on CLIL and PBL.

Therefore, this work was born with the purpose of contributing in a small way to this field in 1st post-obligatory courses (1st baccalaureate).

4. THEORETICAL FRAMEWORK

This section is dedicated to provide a theoretical framework that justifies the choice of this methodology.

4.1. CLIL methodology: definition and general considerations.

There are many CLIL definitions in the specialized literature. The term CLIL "Content and Language Integrated Learning" was coined in 1994 by Marsh and one of its most accepted definitions is the following: "It is a dual focused educational approach in which an additional language is used for the learning and teaching of both content and language" (Mehisto *et al.*2008, p.9). This definition perfectly reflects the main characteristic of the CLIL methodology, by defining it as a dual approach in which a foreign language is used in the teaching and learning of both content and language.

There is no single way to develop a CLIL approach, since it is a flexible methodology, and it can be applied to a wide variety of contexts and conditions. In addition, it can be introduced in any educational level (Infant, Primary, Secondary, Bachelor and even in the University). Also, it is important to indicate that under this educational approach, authentic, active learning is produced, based on experience and that necessarily involves scaffolding techniques, both at the content level and the language itself. CLIL requires innovative and active methodologies that are focused on the students and the context, thus moving away from the role of the teacher as a central figure in the classroom. For Coyle, *et al*. (2010) this methodology is based on four basic elements. This is what Coyle (2008) refers to as the 4 C "s framework. The first element is the content of the different subjects, with the aim of improving learning and communication skills in English. The second element is Communication, making students communicate in English both orally (listening and speaking) and writing (reading and writing). Within these communication skills, and as Bentley (2010, p.8) notes, are the "Basic Interpersonal Communicative Skills - BICS-", which are the necessary communication skills for social and conversational situations. These skills are the least demanded of high-level cognitive resources. Among them are the repetition of daily greetings, and associate images with words. Also, there are the "Cognitive Academic Language Proficiency -CALP-, which use a more academic language and require specific study. The third element is Cognition, where the development of cognitive or thinking skills is promoted. It is intended to develop both the higher cognitive abilities (HOTS -High Order Thinking Skills-) and the basic skills (LOTS -Low Order Thinking Skills-). And finally, the fourth element is Culture. The language determines the culture, and the culture the language, for that reason it is necessary to know the culture in which the language develops. Since this forms them as citizens of the world, and encourages relationships between students from different countries and cultures, in our case those of English language.

According to, Sapir-Whorf hypothesis, how we look at the world is largely determined by our thought processes, and our language limits our thought processes. It states that there are certain thoughts of an individual in one language that cannot be understood by those who live in another language. In other words, the language that we use shapes the way we think and how we see the world. Therefore, it follows that people who speak different languages have different world views (Basel Hussein, 2012).

Some of the most important CLIL characteristics enumerated by Mehisto *et al*. (2008:7) are:

- » Implies innovation, new ways of working and changing the way we do things.
- » Contributes to an integrated academic work replacing fragmentation.
- » Creates fusion between subjects that have been apart.
- » Invites convergence between the learning of content and language.
- » Encourages independent and co-operative learning.
- » Contributes to create a common purpose and forums for lifelong development.
- » Adds extra value to language learning.
- » Helps students build integrated knowledge and skills for an increasingly integrated world.

Other authors such as Ena Harrop (2012) who wrote an essay on the limitations and possibilities of the CLIL methodology, established on the one hand, that CLIL leads to greater linguistic competence, increases motivation, is suitable for learners of all abilities and leads to greater intercultural awareness.

However, on the other hand, CLIL also has inherent limitations not often recognised, but which are beginning to emerge and which point at both theoretical and methodological shortcomings. For example, the CLIL learners can have an imbalanced linguistic development which favours their receptive rather than productive skills, while their motivation is still subject to contextual and social influences. The extra level of difficulty which CLIL entails can leave the weakest learners very vulnerable if insufficient scaffolding is provided for linguistic development, and finally, while CLIL's greatest potential lies in its intercultural dimension, the role of cultural awareness in CLIL models where English is the vehicular language is less well established. Besides, CLIL is a costly model, in terms of financial and human resources.

Pérez Cañado (2017), carried out a longitudinal study with 1,033 CLIL students and 991 EFL learners in 53 public, private, and charter schools across 12 Spanish provinces on the effects of CLIL on foreign language achievement (grammar, vocabulary, reading, listening, and speaking). This study provided updated empirical evidence on the effects of CLIL programmes on the foreign language competence of students across three

different educational levels: Primary Education, Compulsory Secondary Education, and Baccalaureate. The outcomes allow us to firmly believe that there is indeed a linguistic competence differential between CLIL and EFL groups, in favour of the former, specifically in compulsory secondary education.

San Isidro (2019), following this line of thought he analysed the impact of CLIL on different aspects such as stakeholders' perceptions, attitudes and motivations, on the first language (L1) or on content learning. Some of his conclusions were the following**:**

- Stakeholders involved in CLIL show positive views and attitudes as well as higher motivation regarding the foreign language
- CLIL does not have a detrimental effect on L1
- CLIL either makes no impact on the learning of subject matter or shows a positive effect.

4.2. Project based learning (PBL)

4.2.1. Definition and general considerations

PBL is a teaching method where students are the protagonist of their own learning. This methodology was created in the mid 1960's, in the Faculty of Medicine of the University of McMaster (Canada) trying to institute a system of medical education that corrected some of the deficiencies of the health care system (García Sevilla, 2008). Later it began to be applied in other areas, being at the beginning of the 70s when this methodology reached Europe. From here it expanded throughout Europe, including Spain.

Some of the most important authors of PBL are Dewey and Kilpatrick. Kilpatrick was an American pedagogue who developed an innovative and revolutionary study technique based mainly on John Dewey's project method. Teaching Kilpatrick projects is a technique that states that learning is more effective when it is based on experiences, it means, when it responds to a real world need, since in this way the student is part of the planning, production and understanding of them.

This technique is based on the fact that any research work must be based on the interests of the students to be effective. If a student is interested and motivated by something, you will get better results. The classrooms became learning spaces where students could not only connect with their reality but also work with it: analyse it, evaluate it, reflect on it and act to improve it.

Sola Ayape (2006), says that PBL is "an educational model that shifts its centre of gravity from teaching to learning [and] that bases its raison d'être on the student" (p 41). PBL uses learning by discovery and, even more importantly, by cooperative work.

Baro Cálciz (2011, 5) reminds us that learning by discovery is that which occurs "when the teacher presents all the tools necessary for the student to discover for himself what he wants to learn". Certainly, this fits with the teaching philosophy of PBL, since it remains faithful to that conception of the student as the focus of attention of the process of teaching learning process, since it is the student who must select what really arouses interest.

PBL is, since it first appeared, the teaching approach that is thriving all around the world, from teaching medicine at universities to pre-school stage at schools. This is so because its constructivist features, that makes the student the centre and the responsible of learning, not the teacher, makes the classroom environment a place where people enjoy their work.

In words of Donato and Terry (1995: 98) the constructivism is defined in the following terms:

> Constructivism is a theory of learning which emphasizes the importance of the learner's active construction of knowledge and the interplay between new knowledge and the learner's prior knowledge. The key tenet of constructivism theory is that people learn by actively constructing knowledge, weighing new information against their previous understanding, thinking about and working through discrepancies and coming to a new understanding.

Among the main founders and defenders of this ideology we find well-known educators and psychologists such as: Piaget, Vygotsky, Ausubel, Bruner or Dewey. Ausubel (1976) said that Education supported by constructivism involves experimentation and problem solving and considers that errors are not contrary to learning, but rather the basis of it.
Besides, constructivism is the core meeting point where PBL and CLIL find their place together as we can see in the following figure:

Figure 1. Meeting point between CLIL, PBL and Constructivism. A*n Introductory Study of Project-Based Learning (PBL) and Content and Language Integrated Learning (CLIL) in TEFL*. Lastra Mercado, D. (2016)

According to Casal (2007) practitioners involved in implementing CLIL / integrated curriculum programmes should be aware that learners are active constructors of their knowledge by building correlations between areas of knowledge as well as between old and new information; that cognitive conflict allows students to reach a higher level of understanding and, finally that dialogue and negotiation among students do not only promote a higher competence at a linguistic level, but also at a cognitive one. Therefore, it is essential for practitioners to be familiar with its belief in order to successfully implement the integrated curriculum and CLIL. Manzanares (2015, 19) said that "it is a didactic system that requires students to become actively involved in their own learning to the point of defining a scenario of self-directed training".

PBL is an educational approach in which the multidisciplinary, cooperative and functional nature of learning is emphasized, contextualized in its environment and connected with challenges and problems, which redefines the role of the teacher, as a guide, facilitator, contributing criteria and organizing knowledge, in short, accompanying the students in their training itineraries.

This methodology consists of the elaboration of a final product, normally of some importance (adequate to the knowledge of the students) and in a cooperative way based

on a specific planning. The function of the teaching staff lies on the orientation of the students so that they can find the solution to these problems on their own. When planning a PBL, it must be tried to awaken the interest of the students, which is related to daily life, favouring the interrelation with the other subjects, by posing a driving question.
Sometimes PBL has been confused with problem-based learning, since both strategies share many common characteristics. The table 2 shows the main similarities and differences of both methods:

SIMILARITIES	DIFFERENCES	
• Active participation of students in the resolution of authentic problems related to real life • Use of the same abbreviation to define them PBL ("Project Based Learning", and "Problem Based Learning"),	Problem Based Learning	Project Based Learning
	• The problem presented is not complex, so there are no previous explanations • Emphasis on the process by which the problem is solved	• The problem presented is complex, so they need to have previous concepts • Emphasis on the final product

Table 2. Similarities and differences between Problem Based Learning and Project Based Learning. Adapted from LARMER, 2013.

4.2.2. Phases of project-based learning

The development of PBL methodology has certain phases according to the different authors who have addressed the issue but in general features they all agree in a first phase of presentation and definition of the project, to later detect what information is necessary to solve it and, finally, the results are presented.

The model that I am going to follow is that of the "Buck Institute for Education (BIE) ", which is a non-profit organization that has researched and developed the methodology by projects since 1990. The BIE systematized this learning and disseminated it among the teachers, teaching them how to use this methodology in all educational levels and areas.

This establishes 10 phases for the development of PBL (BIE, 2019), which are listed in table 3.

PHASES OF PROJECT-BASED LEARNING
1) Before planning a project. It is suggested to start with short projects and as you gain experience you will be able to do more extensive projects and it is also necessary to know to what extent the students will be involved in the same.
2) Define the goals or objectives that students are expects to achieve at the end
3) Expected results of students They may be divided into two parts, knowledge and skills development and results of the work process (it refers to the competences, strategies and attitudes)
4) Driving questions They must be thought provoking, develop high levels of thinking, represent a challenge, be consistent with curricular standards and must be achievable.
5) Subquestions and potential activities They must be answered before the guiding question is resolved and they define what students must do in the search for the answer to the question guide.
6) Products, which must be relevant and interesting for the students.
7) Learning activities, which must be built in blocks, so the teacher can take the contents of knowledge, development of skills and results of processes. These can be of planning, research, consultation ...
8) Instructional support (scaffolding) in order to guide the learning of the students, as well as facilitate a successful development of the project product.
9) The learning environment. Teachers can promote the success of the project by creating optimal conditions for work such as taking the project beyond the classroom, carefully defining the groups or using different contexts.
10) Identification of resources such as texts, web pages, applications ... to promote learning.

Table 3. Phases of the learning process in PBL. Adapted from B.I.E (2019).

During the different phases of development of the project, it contributes to the acquisition of the key competencies established in the syllabi. For example, when students have to decide the topic they want to investigate, they develop linguistic and social competence, entrepreneurship competence and cultural awareness or when they have to implement the activities that they have designed to the project, they develop literacy, digital, social and science and mathematics competence (applying the scientific method), entrepreneurship competence, learning to learn and cultural awareness. All successful projects are developed the way described in figure 2 below.

Figure 2. Ideal PBL. Image taken from KNIL (2019)

PBL sets in the students the **need to know** from the beginning, by posing a relevant question (**driving question**) or sets of questions that will engage students actively in a chase for information and references and that will help them to find out the right answers **(in depth enquiry**). Then students themselves will decide about how they will express the results of their search (**voice and choice**) and present their final result. Outcomes will then be critically assessed, analysed and revised (**revision and reflection**) before their final presentation to a predetermined audience (**public audience**).

In addition, to check the quality of a project, the Framework for High Quality Project Based Learning (HQPBL, 2018), which describes PBL in terms of the student experience and is intended to provide educators everywhere with a shared basis for designing and implementing good projects (https://hqpbl.org/), proposes using a set of 6 criteria each of which must be at least minimally present in a project in order for it to be judged "high quality". These criteria are the following:

a) Intellectual challenge and accomplishment

Projects should not just be “fun activities” or “hands-on experiences” requiring minimal intellectual effort. A high quality project requires students to think critically about a complex problem, question, or issue with multiple answers, and then work on that project over the course of days, weeks, and even months. To complete a project successfully, students need to learn important academic content, concepts, and skills. They should also be challenged to produce the highest-quality work possible and guided and supported as they try to do so.

b) Authenticity

A high quality project reflects what happens in the world outside of school. It uses the tools, techniques, and technology found there. It means, work on projects that are meaningful and relevant to their culture, their lives, and their future.

c) Public product

Students’ work is publicly displayed, discussed, and critiqued. This public process and final presentation encourages students to improve the quality of their work and demonstrates what students know and can do.

d) Collaboration

Students collaborate with other students in person or online and/or receive guidance from adult mentors and experts.

e) Project management

Students use a project management process that enables them to proceed effectively from project initiation to completion. It helps them to know how to manage time, tasks, and resources efficiently

f) Reflection

In a high quality project, students learn to assess the quality of their work and think about how to make it better. They pause regularly—not just at the end of the project, but throughout the process—to think about what they are doing and learning.

Figure 3. The Buck Institute for Education convened a steering committee of project-based learning stakeholders to write a framework for high quality PBL. *(Courtesy/HQPBL, 2018)*

In addition, in the webpage of BIE (https://www.pblworks.org/) we can find numerous useful material to design a PBL project with confidence, which we will be used in in the development of the didactic proposal, such as:

- **Project planner**.

It's a helpful tool to capture our ideas and organize our plans. The Project Planner has five parts:

1. Project Overview: Key features of your project
2. Learning Goals: Standards, success skills, literacy skills, rubrics
3. Project Milestones: Significant steps in the project
4. Project Calendar: Day-by-day activities in the project
5. Lesson Planner: Supporting resource with guidance on planning daily lessons to meet the needs of all learners.

- **The Essential Project Design Elements Checklist**, which can be used for a quick evaluation of a project's design, to see if it includes all the essential elements of rigorous, effective PBL. We can use this tool before, during, and after designing projects to check on their quality. Also helpful for communicating the meaning of PBL to various audiences.

- **The Driving Question Tubric 2.0**, which helps us practice writing Driving Questions by framing initial words, person or entity, action or challenge, and audience/purpose.

The work out of driving questions is an important step in the development of the PBL due to, among other things, that it guides the programming and serves to rethink the essential

learning. In addition, it captures and communicates the purpose of the project and is a reminder of "why are we doing this today".

- **English Learner Scaffolds for PBL document** provides strategies and recommendations to support English Learners during each phase of a project. It includes guidance on scaffolding the project process, content learning, and language development.

- **The Project Assessment Map** helps us plan how we will use formative assessment in a project, to be sure students are learning content and building 21st century competencies.

4.2.3. The roles of the agents: teachers and students

4.2.3.1. The teacher´s role

In the words of Sierra (2005), with PBL the teacher becomes a designer and his work begins long before entering the classroom as he has to review the thematic programme to be suitable for the PBL and to design the problem / situation itself.

Once the problem has been designed and in the classroom, the teacher becomes an observer, facilitator, guide, strategist and source of motivation. It is necessary to dedicate to observe and to evaluate the different attitudes of the students and, in addition, to make interventions in the moment that he or she considers opportune to motivate the students or to formulate new questions to activate their curiosity. In short, the teacher who applies the PBL methodology must, according to Sierra (2005):

- Generate a favourable work environment.
- Not intervene too much.
- Carry out a process of constant monitoring of their students.
- Try to be a good motivator.
- Try to get all students involved.
- Try to maintain an adequate discipline that allows everyone to work.

Arpí Miró, *et al*. (2015) stresses that "PBL groups depend to a large extent on the skills of teachers to encourage student participation, teamwork and higher order thinking"

In conclusion, during the development of the PBL methodology, the role that the teacher develops is very important due to the fact that he or she has to make sure that students gradually complete the tasks and partial goals of the project, and guide the groups with

the problems and doubts that will arise during the course of the project and encourage cooperative learning and cooperative problem solving.

4.2.3.2. The student´s role

The PBL student has to assume new roles differentiated from the student of the traditional methodology, for this, it has been considered appropriate to include a list prepared by the Directorate of Educational Research and Development of the Academic Vice-Chancellor of Monterrey Institute of Technology and Higher Education (ITESM), cited in Sierra Longeva (2006, 112-113). Here are the main actions that a student develops throughout the different phases of the methodology. They contribute to values as important as tolerance, empathy and leadership, apart from:

- Develop their ability to face problems
- Learn to manage time
- Participate in team discussions
- Become familiar with different roles (leader, secretary, representative, etc.)
- Interact with other students
- Generate conclusions
- Develop a willingness to work as a team
- Self-assessment
- Evaluate their teammates
- Take responsibility for their own learning
- Develop study autonomy
- Familiarize themselves and commit to their environment
- Make use of technology
- Develop their critical thinking
- Reflect individually and collaboratively
- Learn to make decisions
- Investigate, analyse and synthesize information

It is true that students enjoy a great deal of autonomy, but it is also important to emphasize the fact that the teacher must feel free to intervene as much as he considers appropriate.

4.2.4. PBL as a methodological response to the CLIL approach

According to Navés y Muñoz (2000, 2):

> El Aprendizaje Integrado de Lenguas Extranjeras y otros Contenidos Curriculares implica estudiar asignaturas como la historia o las ciencias naturales en una lengua distinta de la propia. AICLE resulta muy beneficioso tanto para el aprendizaje de otras lenguas (francés, inglés,...) como para las asignaturas impartidas en dichas lenguas. El énfasis de AICLE en la "resolución de problemas" y "saber hacer cosas" hace que los estudiantes se sientan motivados al poder resolver problemas y hacer cosas incluso en otras lenguas.

CLIL, given its characteristics, cannot be approached from a traditional methodology centered on the teacher's figure as the central axis of the classroom, and therefore requires active and innovative methodologies that, together with the use of new technologies, guarantee its correct implementation.

PBL has a series of features that respond perfectly to the model of methodology needed in the use of the CLIL approach, since it involves changing the role of the teacher, the assumption of work by competences, it has communicative, active character and learning is connected with reality. Besides, it is an effective tool in the learning of the L2, since the tasks and projects are facilitators of the acquisition of the language ensuring, in turn, the comprehension of the contents of the different areas; In addition, the integration of areas, cooperation and scaffolding are characteristics of the PBL intrinsic to the CLIL approach.

In table 4 the common characteristics between CLIL and PBL are shown:

Common characteristics between CLIL and PBL
Cross curricular approach to knowledge
Learner- centered
Cooperative learning
Meaningful communication (Development of the communicative competence)
Comprehensible and varied input (Krashen, 1985)
Language is a tool to achieve an outcome
Teacher as a guide
Learning how to learn

Formative assessment
Fosters students autonomy and motivation
21st century skills:
- Critical thinking
- Creative thinking
- Problem solving skills
- Decision making
- Cooperation
- Interpersonal skills
- Communication
- Creativity and innovation
- Digital competence

Table 4. Common characteristics between CLIL and PBL. Adapted from CLIL and Project Based Learning: two approaches working together. A proposal for 6th Grade in Social Science. Moliner Iranzo. (2017)

According to Alvarez (2016), PBL fits perfectly with CLIL environments where cognition is integrated with content learning and communication due to the fact that it requires innovative and active methodologies that are focused on the students and the context (Hedge, 1993). In PBL, students receive comprehensible and multimodal input and are challenged to produce comprehensible output (Beckett, 2006) through the creation of a final product. Besides, both methodologies facilitate the development of each of the components of the 4 C´s framework as you can see in table 5.

CLIL 4 C´s Framework	**PBL**
Community	It creates connections between the foreign language and the learner´s world.
Communication	It promotes the use of a wide variety of communicative skills, since students have to cooperate with their classmates, making decisions from the very beginning.
Cognition	Students are expected to solve the problems, plan their projects, finding things by themselves using a variety of sources, specially the Internet.

Content	Cross-curricular approach to knowledge, students investigate about a topic that relates directly to their interests and needs. Content materials are developed through projects.

Table 5. *PBL contribution to CLIL 4 C´s Framework.* Adapted from Moliner Iranzo, (2017)

4.2.5. Benefits regarding conventional methods

There are multiple studies that support the methodology of Project-Based Learning [ITESM, (2004), Fernández *et al. (*2006), Sola, (2005)] due to its benefits. Some of these are:

- **Significant learning**: Students see directly in a practical way the use of the knowledge they are acquiring.
- **Higher rate of retention of knowledge**: As students are facing real situations, and must learn to solve them on their own, the knowledge they acquire is more meaningful and remains for longer in their memory.
- **Students are more motivated**: This method causes students to be involved in the realization of their project. This coupled with the fact that the student remains in an active role, causes them to be more motivated, leading to a decrease in school absenteeism and an increase in student participation. [Bottoms & Webb, (1998), Moursund *et al* (1997)].
- **Development of teamwork skills**: During the project development process, students are obliged to coordinate, develop the project as a team and solve the different problems that may arise in the process.
- **Most critical students**: In the course of this methodology students face real-life problems, they have to try to understand them and solve them. This allows them to better understand the real world and have a more critical view of the society in which they live.
- **Development of creative skills**: The fact of presenting students with open activities together with the resolution of problems helps them to develop their creative capacity to solve them. Students can develop creative solutions that have not been previously conceived by the teacher.
- **Integration of the students within a work model**: The resolution of the projects demands that the students acquire information in a very similar way to how they

will have to acquire it in future situations. The PBL is preparing them for their future work.

PBL develops mental abilities located in upper order according to BLOOM'S TAXONOMY. In 1956 Benjamin Bloom published his taxonomy outlining six different thinking skills. In this taxonomy, thinking skills are divided into lower-order thinking skills (remembering, understanding and applying), and higher-order thinking skills (analysing, evaluating and creating).

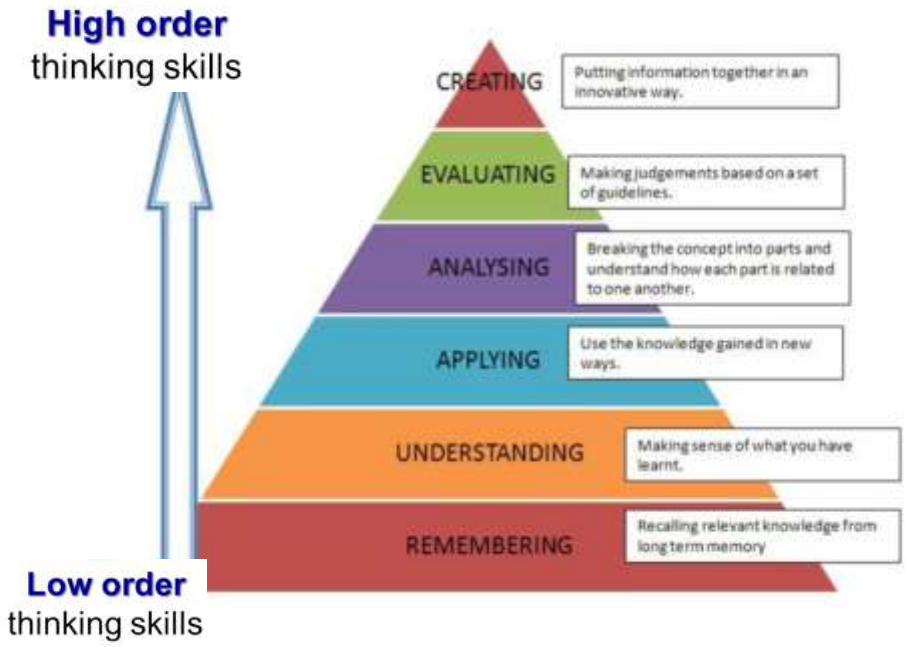


Figure 4. Bloom´s Taxonomy. Adapted from: Asmuje *et al.* (2016.)

5. DIDACTIC PROPOSAL

In this section, a didactic proposal has been designed based on the combination of the CLIL approach and the PBL methodology in the first year of baccalaureate for the subject of Physics and Chemistry to facilitate the learning of the different blocks of contents in English. The objective is that our students do not learn just using rote learning but also by working with projects, develop creative skills, critical reasoning, collaboration and autonomy that allow them to face the problems of real life.

This project is titled "Wine and its Chemistry". It is a constructivist project where our department collaborates together with the vocational studies stream (Professional Family: Food Industry (INA) according to the Spanish National Catalogue of Professional

Qualifications (CNCP), specifically in the use of the facilities to carry out the vinification process, in our secondary school. In addition, this methodology favouring the inclusion in the classroom according to Instructions of 8th of March of 2017 de la Dirección General de Participación y Equidad, por las que se actualiza el protocolo de detección, identificación del alumnado con necesidades específicas de apoyo educativo y organización de la respuesta educativa (Andalusia).

The project consists of winemaking on a small scale, so that students know first-hand the processes for obtaining wine, relating it with disciplinary contents of the subject of Physics and Chemistry. In addition, through this project, we will analyse the different elaborations of wine, at the same time as we delve into the contents of the curriculum of the 1st baccalaureate, we will do this during the first and second term. During this time, different activities will be carried out in the classroom and in the laboratory. These activities will be considered as group work or student's individual work, as it will be explained in Table 6.

This proposal is intended to encourage motivation and curiosity for the topic proposed due the importance of this sector (winemaking) in our socioeconomic context. The project designed for this Master Dissertation can be said to fulfil the law parameters by contributing to the development of the key competences as well as the curricular objectives and standards of both English as a foreign language and Physics and Chemistry as a non-linguistic subject.

5.1. Justification of the project

This project arises fundamentally for two reasons:

1. To try to increase the number of experiments for the baccalaureate classes, especially in the subject of Physics and Chemistry. The current situation, due to the pressure on the chosen course, is that students are mere receivers of knowledge in most class sessions, when they should be the protagonists of their own learning process (Paredes *et al*, 2009). A recent study that supports this is given by Snětinov et al. (2018:57). According to this research, it is clear that active involvement (e.g., hands-on activities, doing experiments) together with

novelty and social involvement (e.g., group work) play a key role in supporting students' situational interest.

2. In addition, Manilva-Málaga is a town that has traditionally been dedicated to the cultivation of vineyards, for the elaboration of both wine and tables grapes. For this reason vinification has been added as a professional training course in the high school (vocational studies stream).

Combining both reasons, it has been proposed to design this project in which the students learn about wine and the winemaking process. With this project it is intended to promote the group and autonomous work of the students, the resolution of real problems and knowledge of the viticulture of our region. In addition, the topic of alcoholism and the problems derived from it will be discussed as a cross-curricular element, a worrying theme in today's society especially in youngsters.

5.2. Educational context and target group

The didactic proposal is designed for the blocks of Contents 1 to 5 which corresponds to the chemistry part. This project complies with the current legal regulations, all the contents are embodied in the Real Decreto 1105/2014, del 26 de diciembre, por el cual establece el curriculo básico de la Educación Secundaria obligatoria y del Bachillerato.

This programme is taught in "Las Viñas" High School in the town of Manilva, Malaga. This high school has a diversity of students, who have come from the local public school, although there are also students from neighbouring villages. Therefore, we can say that our students come from very different families, although the majority are placed in a medium/low social rank.

The age of students of 1st of baccalaureate is between 16 and 18. At this age, the development of formal thinking allows them to assume new skills and social roles, acquire higher moral values and enables them to focus on the resolution of difficult situations in real life.

Specifically, my 1st year of baccalaureate of the IES Las Viñas is made up of 20 students. It is a very cohesive group, all the students are known from 1st year of CSE (compulsory secondary education) with the exception of two boys who have arrived this year.

However, there are no signs of rejection or serious exclusion among them. It should be noted that inside the classroom there are several well-differentiated groups, it is not something problematic, but it makes cooperative work difficult to be developed. There are several very independent students who always prefer individual work.

The Development and acquisition of skills at a general level is adequate. In general, the group's attention span is short, they tend to be easily distracted. When using a behavioural methodology (direct teaching), there are few students who manage to maintain attention. They are very participative students, they ask a lot of questions related to the subject. Besides, all of them are Spanish and their English level is between B1 and B2, according to the CEFR.

5.3. Project Planner

In this section, the project planner of my Master Dissertation is presented in the form of a summary table (Table 6) taken from web PBL resources (PBLWorks, 2019).

PROJECT PLANNER

1. Project Overview

Project Title	The wine and its chemistry	**Public Product(s) (Individual and Team)**	**Individual** • Research work on wine compounds and health • Graphs that relate different parameters to control during the process and its evolution **Specific content and competencies to be assessed**: Summarizing information, relevant vocabulary, graphs interpretation, collaborative discussions, engagement in the design process, presentation skills, creativity and innovation. **Team** • Poster and video with the stages of the wine elaboration process. • Group Presentation (video /interactive presentation/ a possible school repository)
Driving Question	How do chemical processes influence the production of a wine?.		
Grade Level/ Subject	1st Baccalaureate of sciences/ Physics and Chemistry		
Time Frame	First and second terms		
Project Summary	The students will present in an innovative way (video /interactive presentation/design a school repository for vocational students) all		

the stages of the elaboration of a red wine from the processing of the grape to its analysis in the laboratory. In addition, they will investigate the diverse chemical compounds that constitute the grape and the wine and how these evolve throughout the different stages of the process to know the importance of vineyards in the area, how chemistry affects winemaking, red wine specifically, to sensibilize about a responsible wine consumption.

2. Learning Goals

Standards

The contents, attending R.D. 1105/2014 and the Order 14/07/2016, are structured in two major sections (Physics and Chemistry) and within each of them the corresponding thematic blocks:

- Block 1. Scientific activity
- Block 2. Quantitative aspects of Chemistry
- Block 3. Chemical reactions
- Block 4. Energy transformations and spontaneity of chemical reactions.
- Block 5. Carbon chemistry
- Block 6. Kinematics
- Block 7. Dynamics
- Block 8. Energy

Literacy Skills

- To find relevant information on the internet
- To prepare a written presentation with the information
- To present findings to rest of the class using PowerPoint or some similar.
- Technology literacy: reading Web sites, using map searches, accessing videos and podcasts, evaluating Web resources and researching on the Internet;

During the development of this project we will work with the blocks of contents 1, 2, 3, 4 and 5 corresponding to Chemical´s section. These contents will have a logical sequencing, according to the chronological order that is followed in a commercial warehouse, although the practical sessions will be developed according to the process that is needed. Besides, they are in relation to evaluable learning standards of Physics and Chemistry. In this project we will develop the following:		• Media literacy: Students need to learn how to critically analyse and evaluate messages coming to them through any medium.
BLOCK 1. SCIENTIFIC ACTIVITY **EA.1.1.1.** Apply necessary skills for scientific research. **EA.1.1.6.** From a scientific text, extract and interpret the information, argue with rigor and precision using the appropriate terminology. **Key competences**: Linguistic, entrepreneurship, science and mathematics, literacy, digital competence and learning to learn. **BLOCK 2. QUANTITATIVE ASPECTS OF CHEMISTRY** **EA.2.4.1.** Express the concentration of a solution in different ways and describe the procedure of preparation in the laboratory and perform the necessary calculations. **Key competences**: learning to learn, social, linguistic /communicative and science and mathematics competence.	**Success Skills**	Critical thinking, collaboration, self-management, team group, communication, self-organization, creativity and innovation

BLOCK 3. CHEMICAL REACTIONS

EA.3.1.1. Write and adjust chemical equations of biochemical or industrial interest.

EA.3.2.2. Perform the stoichiometric calculations in different reactions.

Key competences: learning to learn, cultural awareness, social, linguistic /communicative and science and mathematics competence.

BLOCK 4. ENERGY TRANSFORMATIONS AND SPONTANEITY OF CHEMICAL REACTIONS.

EA.4.6.2. Justify the spontaneity of a chemical reaction based on enthalpic, entropic and temperature factors.

Key competences: learning to learn, social, linguistic /communicative and science and mathematics competence.

BLOCK 5. CARBON CHEMISTRY

EA.5.6.2 It relates the organic reactions with processes that occur at the biological level.

Key competences: learning to learn, cultural awareness, social, linguistic /communicative and science and mathematics competence.

Key Vocabulary	CALP: Polyphenols, alcohol content, density, total acidity, anthocyanins, maceration, malolactic fermentation, decantin, yeast, ,oenology, winemaking steps, oak, cork, tannins, terroir, aging, grape parts BICS: Expressing opinions (I think this is a/I think so/ I don't agree/Do you agree?/What do you think?/I understand what you say but/As you probably know/I see your point/What I meant was) Synthesizing ideas (Firstly/On the one hand/On the other hand/To begin with/In addition/ Finally) Present, past and future/ Conditionals/ Comparatives	**Rubric(s)**	• Oral presentation (annexe 1) • Writing skill (annexe 2) • Portfolio (annexe 3) • Collaborative work (annexe 4) • Peer assessment (annexe 5) • Infography (annexe 6)

3. Project Milestones

Milestone #1	Milestone #2	Milestone #3	Milestone #4	Milestone #5	Milestone #6

Student explores the project and develops a set of need to know questions (NTKs). Scientific research of the main chemical components of the grape and in which parts are located (grape skin, seeds, pulp)	Elaboration of a poster where the different processes of elaboration of all the types of wines are represented (White, rosé, red and sparkling wine)	Elaboration of a red wine, following the process of fermentation, performing density and temperature controls (Protocol in annexe 8). Record a video during the process.	Analysis of the wines obtained (acidity through a titration, pH, colour and index of total polyphenols using spectrophotometry) (Protocols in annexes 9-14) and presentation of the results carried out on the wines obtained.	Research on the influence of wine consumption on health	Compilation of the different aspects developed in the project in a video, interactive presentation to a target audience and design a school repository for vocational students.
Key Student Question	**Key Student Question**	**Key Student Question**	**Key Student Question**	**Key Student Question**	**Key Student Question**
What are the parts of the grape? Which components are the most interesting, and	Which are the steps to follow to obtain white, rosé, red and sparkling wines?	Which are the different stages in a red winemaking process, main chemical reactions	What parameters should be analysed in wines? How are these	Is the consumption of wine harmful or beneficial to the	How would you sort out the information obtained throughout the project?

where are they located? Which are their properties?		and transformations that occur and what parameters should be controlled in the making of a wine?	determinations carried out?	health?	
Formative Assessment(s)	**Formative Assessment(s)**	**Formative Assessment(s)**	**Formative Assessment(s)**	**Formative Assessment(s)**	**Summative Assessment(s)**
• Create a diagram organizing their plan around the central theme of their research.	• Analyse and critique examples of infographics about elaboration of different types of wine. • Summarize the experimental design and student's own specific role in the procedure • Teacher observations	• Experiment report • Notes about research and exit ticket reflections on how it has evolved	• Initial draft of data analysis. • Chemical results analysis	• Journal reflection • Self-assessment	• Portfolio • Peer assessment • Target evaluation (annexe 9). • Rubrics to assess portfolio, oral presentation and peer assessment.

4. Project Calendar

Driving Question: What´s inside a grape?			
SEPTEMBER	**Project Milestone:** Scientific research of the main chemical components of the grape and in which parts are located		
Key Student Question(s): What are the parts of the grape? Which constituents are the most interesting, and where are they located? Which are their properties?			
Day 1:	**Day 2:**	**Day 3:**	**Day 4:**
Introduction of the project and its different parts. Formation of working groups. The teams will be of four people and the roles they will play will be the leader, recorder, presenter and roving reporter. **Scaffolding:** Keywords they will need to use	Brief explanation on the process of obtaining a wine, on the evolution of the grape in the vineyard and on the different varieties that exist. **Scaffolding:** incorporate visual aids and a list of different webpages of regional vineyards.	Beginning of the investigation on the different parts of the grape, on the chemical components that form it and where they are located, as well as on the properties that they present. **Scaffolding**: breaking the topic into parts (analyse it in small groups).	Conclusion of the investigation with the realization of a diagram with all the information extracted. **Scaffolding**: give examples of possible free ICT tools, such as https://www.diagrameditor.com/
Notes: Internet access, Laptop, Literature (books and journals) and the following webpages: https://winefolly.com, https://www.encyclopedia.com/sports-and-everyday-life/food-and-drink/alcoholic-beverages/wine, https://www.winemag.com/2015/01/20/wine-for-beginners/, http://www.wines.com/, www.oiv.int			

<table>
<tr><td colspan="4">Driving Question: What´s the transformation process from a grape to a wine?</td></tr>
<tr><td>OCTOBER</td><td colspan="3">Project Milestone: Elaboration of a flow charts where the different processes of elaboration of the different types of wines that exist are represented (White, rosé and red)</td></tr>
<tr><td colspan="4">Key Student Question(s): Which are the steps to follow to obtain white, rosé and red wines?</td></tr>
<tr><td>Day 1:</td><td>Day 2:</td><td>Day 3:</td><td>Day 4:</td></tr>
<tr><td>Explanation of different types of wines that we can find and their characteristics.
Scaffolding: showing examples.</td><td>Research on the different stages that take place in the production of rosé , red and white wines</td><td>Relationship of the different stages with the chemical compounds and extract.
Scaffolding: breaking the topic into parts (analyse it in small groups).</td><td>Realization of a flow chart of each process</td></tr>
<tr><td colspan="4">Notes: Internet access, Laptop, Literature (books and journals) and the following webpages:
https://winefolly.com, https://www.encyclopedia.com/sports-and-everyday-life/food-and-drink/alcoholic-beverages/wine, https://www.winemag.com/2015/01/20/wine-for-beginners/, http://www.wines.com/, www.oiv.int</td></tr>
</table>

Driving Question: Are you able to make wine?			
NOVEMBER	**Project Milestone:** Elaboration of a red wine, following the fermentation process.		
Key Student Question(s): What are the main reactions and transformations that occur and what parameters should be controlled in the making of a wine?			
Day 1:	**Day 2:**	**Day 3, 4, 5, 6, 7:**	**Day 8:**
Theoretical explanation of the elaboration process that we are going to follow and the parameters that we must control (temperature, evolution of density, Baumé and brix degree and its conversion). **Scaffolding:** Using mind maps (develop timeline for project process).	Beginning of winemaking process. We start to control the temperature, evolution of density, Baumé and brix degree and its conversion (Annexes 8 and 9, as **scaffolding**).	We continue with parameter controls and gathering data	Elaboration of graphs that relate temperature and time, density and time, brix degree and time and baumé degree and time. Graphs interpretation. **Scaffolding:** breaking the topic into parts (analyse it in small groups).
Notes: Remember to create a prior list of Need to Know questions before they begin the elaboration process to facilitate the fermentation process. Include protocols to analyse chemicals.			

Driving Question: How can I define the quality of my wine			
DECEMBER-JANUARY	**Project Milestone:** Analysis of the wines obtained and presentation of the results of the analyses carried out on the wines obtained		
Key Student Question(s): What parameters should be analysed in wines? How are these determinations carried out?			
Day 1:	**Day 2:**	**Day 3:**	**Day 4:**
Explanation of the importance of analysing certain parameters in wines such as acidity through a titration, pH or colour and index of total polyphenols using spectrophotometry (Annexes 10, 11 and 12 as **scaffolding**)	The students will investigate on the different procedures for the determination of these parameters	Laboratory practices related to the determination of acidity (basic-acid volumetric) and alcohol content (distillation) (Annexes 13 and 14, as **scaffolding**)	Presentation of the results obtained in each group and analysis and a work shop on them. Discussion about the quality of the wines obtained based on acidity and alcoholic data. **Scaffold:** teams pair up to analyse one another´s work
Notes: Internet access, Laptop, Literature (books and journals) and the following webpages: https://winefolly.com, https://www.encyclopedia.com/sports-and-everyday-life/food-and-drink/alcoholic-beverages/wine, https://www.winemag.com/2015/01/20/wine-for-beginners/, http://www.wines.com/, www.oiv.int Include protocols to analyse chemicals.			

Driving Question: Is wine a healthy drink?			
FEBRUARY	**Project Milestone:** Research on the influence of wine consumption on health		
Key Student Question(s): Is the consumption of wine in adults harmful or beneficial to the health?			
Day 1:	**Day 2:**	**Day 3:**	**Day 4:**
Explanation of how different drinks can positively or negatively affect our health. **Scaffolding:** give students expert opinions and time talk	Research on the advantages and disadvantages of consuming wine, relating them to the different chemical ingredients that this product possesses (ethanol, polyphenols, etc.)	Talk of a nutrition specialist who will discuss about the importance of wine in the Mediterranean diet.	Oral and written presentations of the research work. **Scaffolding:** BICS for debates/how to conclude
Notes: Internet access, Laptop, Literature (books and journals) and the following webpages: https://winefolly.com, https://www.encyclopedia.com/sports-and-everyday-life/food-and-drink/alcoholic-beverages/wine, https://www.winemag.com/2015/01/20/wine-for-beginners/, http://www.wines.com/, www.oiv.int			

Driving Question: How would you disseminate your findings?				
MARCH	**Project Milestone:** Compilation of the different aspects developed in the project, and a presentation in a document to a real audience.			
Key Student Question(s): How would you sort out the information obtained throughout the project?				
Day 1:	**Day 2:**	**Day 3:**	**Day 4:**	**Day 5:**
The different steps followed in the project will be remembered	All groups will organize the data obtained in the form of tables and graphs and will begin to make the presentation	Continuation of the previous day	Presentation of the projects with the help of an ICT tool (Powerpoint or Prezi, for example). While one team is presenting its results, the rest of the class will take notes to assess the work with the rubric provided by the teacher. The ratings will be written in the portfolio of each team.	Evaluation. This is the last phase of the PBL learning process. Students should present the team portfolio. Learners will evaluate their own team, as well as the rest of the teams and their own individual portfolio (self-evaluation and evaluation of the group) through rubrics.
Notes: Use BIE's presentation rubric teams. Adapt the rubric to fit the needs of this project				

5. Lesson Planner (Supporting Resource)

How to use the document: This planner offers guidance on how you might plan your daily lessons in the project calendar. Pick and choose what feels necessary to achieve the learning outcome and advance product development for all students.

I. CHECKING PRIOR KNOWLEDGE Identify how you will inventory student knowledge ahead of the task, lesson, or activity. (e.g., previous day's exit tickets, warm-up activity, need to know list review, quiz, class discussion, etc.)

II. LEARNING OUTCOME These can be related to success skills or standards. If your district uses a graduate profile or career pathway outcomes, include relevant outcomes here as well.

III. KEY VOCABULARY Note which terms or academic vocabulary will be essential to this lesson. If you serve English language learners, consider what additional vocabulary might be necessary for them to access the content/skills during the instructional activities.

IV. FORMATIVE ASSESSMENT For each lesson, consider which assessment type best measures the learning outcome. For example, a quiz may be the best way to check for understanding of key terms while an annotated sketch might be best for determining student understanding of how the key terms fit together. In some cases, your assessment may be informal, such as an exit ticket, or more formal, as in a rough draft. Finally, when planning your formative assessment, diversify who is doing the assessment. Include self, peer, and teacher assessment opportunities, as appropriate for the age group. When possible, have external partners or end users provide feedback to improve or guide the work.

V. MAJOR INSTRUCTIONAL ACTIVITIES This can include lessons, tasks, activities, or learning experiences. Choose the instructional method that will best help students achieve the learning outcome. For example, a direct instruction lesson may be appropriate for introducing the key players in World War II while an artifact inquiry activity during which students examine primary source documents would be better suited for them to understand the impact of those key players on the pivotal events during the war. This would also be the space to include teaching and learning related to classroom culture, student collaboration, and/or project management tools or skills, as appropriate for students or project milestone needs. Included links show examples of such activities.

VI. SCAFFOLDS Scaffolds are intended to be temporary supports that are removed when students no longer need them. These scaffolds can be used to support either content or the project process (e.g., need to know questions). Leverage "checking prior knowledge" to ensure you are offering the right scaffolds to the students who need them. Be sure to consider a wide range of needs, such as literacy skills, language acquisition levels, auditory/visual

processing, building schema, learning style preferences, academic performance levels, etc.

VII. REFLECTION How will students reflect on their thinking, process, or learning?

VIII. STUDENT NEED TO KNOW QUESTIONS ADDRESSED Which student questions will be answered, or are you aiming to answer, during this instructional activity?

IX. TOOLS/RESOURCES Student-facing tools, human resources such as experts or community members, teacher tools, equipment, etc.

TABLE 6: PBL project planner (PBLWorks, 2019)

5.4. The Project Assessment Map

Assessment within a PBL and CLIL framework encompasses both formative and summative types. Summative assessments indicate whether students have demonstrated skills and knowledge from the project's learning objectives. In PBL, summative assessment usually takes the form of students' final products and/or presentations, as it is represented in fig. 5

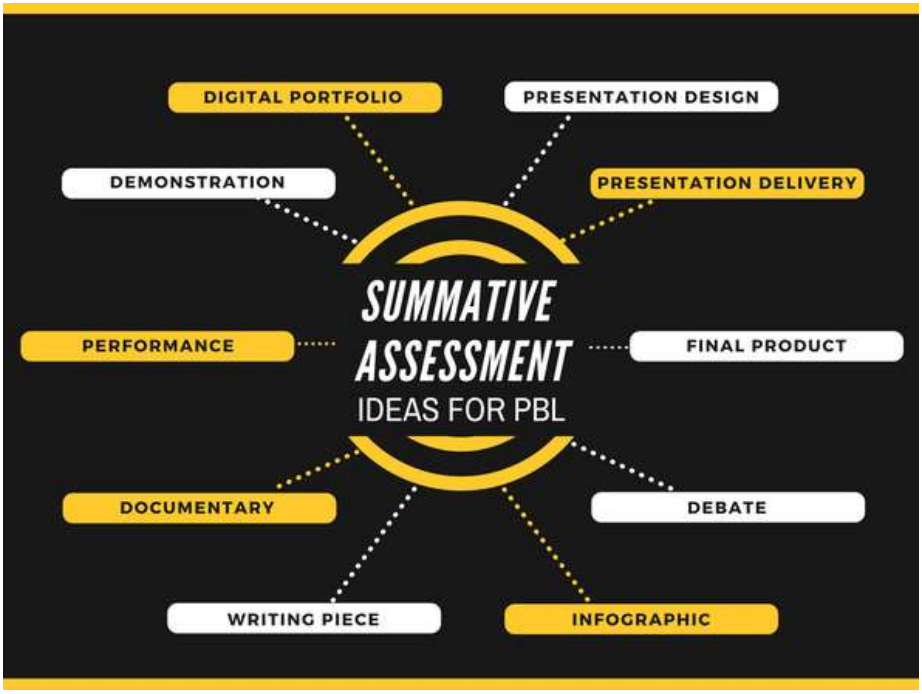


Figure 5. Summative assessment. Ideas for PBL. Northern, Sam (n.d.)

In this project our final product is the presentation to a real audience of a poster and video with the stages of the wine making process together with the main data obtained during the process which will have a summative assessment through different tools such as rubrics, Portfolio, Peer assessment and Target evaluation.

Formative assessments are monitoring tools between the pre and post (summative) assessments. Formative assessments provide feedback and adjust ongoing teaching and learning. For this, the teacher will use especially the active observation during the execution of the activities carried out in working groups. Besides, the teacher will assess the team portfolio that each group should complete and deliver the day of the oral presentations with the proposed activities (see Table 6) during the blocks and the procedures that they have carried out weekly in this project. Throughout this project,

different assessment tools will be used such as rubrics (see annexes 1-6), target evaluation (annexe 7) as a self-assessment strategy and peer-assessment (annexe 5) which allows students to develop self-criticism and be aware of their performance, judging themselves. In addition, the evaluation criteria will be as follows in table 7:

	Evaluable Learning Standards	Project Milestone	Formative Assessment(s)	Tools	Summative Assessment(s)
September	**BLOCK 1. SCIENTIFIC ACTIVITY** **EA.1.1.1.** Apply necessary skills for scientific research. **EA.1.1.6.** From a scientific text, extract and interpret the information, argue with rigor and precision using the appropriate terminology.	Scientific research of the main chemical components of the grape and in which parts are located	• Create a diagram organizing their plan around the central theme of their research.	• Rubric to assess the writing skill **(9.5%)**	
October	**BLOCK 5. CARBON CHEMISTRY** **EA.5.6.2** It relates the organic reactions with processes that occur at the biological level.	Elaboration of a flow charts where the different processes of elaboration of the different types of wines that exist are represented (White, rosé and red)	• Analyse and critique examples of infographics about elaboration of different types of wine. • Summarize the experimental design and student's own specific role in the procedure	• Rubric to assess an infography **(9.5%)** • Teacher observations **(5%)**	
November	**BLOCK 3. CHEMICAL REACTIONS** **EA.3.1.1.** Write and adjust chemical equations of biochemical or industrial interest. **EA.3.2.2.** Perform the stoichiometric calculations in different reactions. **BLOCK 4. ENERGY TRANSFORMATIONS AND SPONTANEITY OF CHEMICAL REACTIONS.**	Elaboration of a red wine, following the fermentation process. Record a video during the process.	• Experiment report • Notes about research and exit ticket reflections on how it has evolved	• Rubric to assess the collaborative work **(9.5%)** • Rubric to assess the lab report. **(9.5%)** • Teacher observations **(5%)** • Exit ticket **(9.5%)**	

	EA.4.6.2. Justify the spontaneity of a chemical reaction based on enthalpic, entropic and temperature factors.				
December-January	**BLOCK 2. QUANTITATIVE ASPECTS OF CHEMISTRY** **EA.2.4.1.** Express the concentration of a solution in different ways and describe the procedure of preparation in the laboratory and perform the necessary calculations.	Analysis of the wines obtained and presentation of the results of the analyses carried out on the wines obtained	• Initial draft of data analysis. • Brainstorms	• Rubric to assess the collaborative work **(9.5%)** • Teacher observations **(5%)**	• Rubric to assess the oral presentation **(9.5%)**
February	**BLOCK 1. SCIENTIFIC ACTIVITY** **EA.1.1.1.** Apply necessary skills for scientific research. **EA.1.1.6.** From a scientific text, extract and interpret the information, argue with rigor and precision using the appropriate terminology.	Research on the influence of wine consumption on health	• Journal reflection	• Rubric to assess the writing skill **(9.5%)** • Self- assessment **(9.5%)**	• Rubric to assess the oral presentation **(9.5%)**
March (Final product)		Compilation of the different aspects developed in the project, and a presentation in a document to a real audience.			• Rubric to assess portfolio **(9.5%)** • Rubric to peer assessment **(9.5%)** • Target evaluation **(9.5%)**

Table 7: Project assessment & evaluation criteria

6. REFLECTIONS AND FINAL CONSIDERATIONS

A problem that exists nowadays in secondary education and especially in the 1st year of post-compulsory education is the requirement of a strict and broad curriculum, well adapted to the available school time. Therefore, it is not usual to bring experiences of educational innovation to the classroom that agglutinate and relate knowledge acquired throughout this stage. However, we consider that it is a very suitable course to carry out this type of experience since it is important to leave the strictly educational context, bringing it closer to reality and relating acquired knowledge with situations that surround us.

In this work, the proposal focuses on a commercial winery process, but there are many other possible projects of interest in which the same project format could be applied to different subjects. Through this project we intend that students break their learning routine by carrying out activities that also create a link to the culture of the area, in particular to the wine culture, but in general, students do not know how the processes take place despite the fact that the students of the science and technology branch in post-secondary have acquired sufficient basic knowledge for their knowledge and understanding.

In addition, it seems an appropriate time to address real problems such as alcoholism, because in the society in which we live it is a problem that should not be overlooked and solving it should be an important task both in teaching and in society.

Finally, I have prepared a SWOT matrix, which is shown in the table 8 that represents the weaknesses, strengths, threats and opportunities that we could find during the implementation of the project we present.

Strengths	Weaknesses
Teaching staff interested in innovation Integral education Participatory project	Students have no previous knowledge of viticulture. The teacher is not an oenology expert Lack of time in the school hours Lack of resources
Opportunities	**Threats**
Incentive to improve the educational quality trough active methodologies Learning by doing	School timetable Teaching staff and students poorly engaged Lack of support

Table 8. SWOT matrix of the project

Although the weaknesses and threats are many, they could be solved, since the strengths and opportunities of the project are also many and very strong.

7. CONCLUSIONS

During elaboration of this proposal, I have tried to plan dynamic sessions to favour the learning of Physics and Chemistry taking into account the 4Cs framework, as we can see in the table 9:

Content (subject and linguistics)**:** it includes key concepts • Different parts of grapes. Main Chemical compounds • Types of wines and their characteristics • Elaboration of a red wine, following the fermentation process • Parameter controls in the making of a wine (temperature, evolution of density, Baumé and brix degree, acidity through a titration, pH, colour and index of total polyphenols using spectrophotometry) • The problems derived from alcoholism	**Cognition:** it involves thinking skills. • Identify the different types of winemaking. • Design the flow diagrams of the different vinifications. • Discuss the optimal moment of grape ripening • Describe the processes that the grapes go through until they become must • Analyse the fermentation process • Recognise the different preferred operations

• Use the correct vocabulary to express themselves. • Present Simple, past simple and conditionals • Connectors, comparatives	• Evaluate the problems of alcoholism. Advantages and disadvantages of wine consumption
Culture: also called citizenship and community. • Working in groups and in the lab in a healthy and safe way. • Resolution of real problems • Knowledge of the viticulture of our region.	**Communication:** it includes key language and language functions • Relate different phenomena that might have an explanation based on something common. • Discuss, argue and synthesize opinions and ideas • Present their lab report in front of peers and before an external audience.

TABLE 9: 4Cs framework of our PBL

the CLIL principles, the five skills (listening, reading, spoken production, spoken interaction and writing) and the PBL phases, while the teacher acts as a facilitator of knowledge. Students are expected to increase their motivation through the different activities, and as a result, they will improve the learning of content and language.

Although the work is limited to a didactic proposal whose results could not be contrasted due to the impossibility to implement it, the bibliography consulted regarding project-based learning indicates that this methodology can be effective to obtain the proposed objectives (Alvarez Sanchez, 2016 , Crane, 2015, Holubova, 2008).

It is essential to be aware of the innumerable advantages of teaching a non-linguistic area (such as Physics and Chemistry) in bilingual programmes. After the implementation of this didactic proposal in a future, it is expected to conclude that, this methodology offers a more flexible, visual and closer approach to the student. It advocates more interactive and autonomous learning, focused on solving tasks and inquiry. Undoubtedly, the improvement is visible in students' language skills, verbal and written communication skills, teamwork, creative thinking, personal development and problem solving. It also

improves communication between teachers and students, while improving the coordination of teachers´collaboration.

In conclusion, PBL is an ideal methodology to enhance CLIL learning, connecting previous knowledge to new knowledge through cooperative work while teaching students how to promote lifelong learning and help to develop the 21st century skills (digital competence, cooperative skills, autonomy and creativity, among others).

Finally, I would like to say that a self-evaluation of the project has been made. For this, we have used the following review sheet for projects involving ELL (English language learning) (Gottlieb, 2016) Table 10.

Common Instructional Products: A Review Sheet for Projects Involving English Language Learners

Name of project: _____

Grade level(s) or departments: _____

Teachers involved: _____

The Project	*YES*	*NO**
Covers a representative sample of grade-level college and career readiness standards and language proficiency/development standards		
Makes provision for multiple levels of language proficiency for ELLs		
Insists on demonstration of oral language in two languages and biliteracy development for students in dual language settings		
Is linguistically and culturally responsive		
Requires student work samples or products for the designated language domains and content area(s)		
Covers grade-level curriculum yet is authentic, relevant, and of interest to students		
Relies on multiple resources, including those in the students' home languages		
Follows a logical sequence of scaffolded activities and tasks		
Contains visual, graphic, and interactive supports		
Allows students to follow different pathways, such as using multiliteracies, to meeting learning targets and standards		

*For every NO response, offer a suggestion on how to enhance the project.

Table 10: A Review Sheet for Projects Involving English Language Learners. (Gottlieb, 2016)

According to this, our project:

- Covers a representative sample of physical and chemical subject learning standards and language proficiency / development standards.
- Insists on demonstration of oral language in two languages and biliteracy development for students in dual language settings
- Is linguistically and culturally responsive

- Requires student work samples or products for the designated language domains and content area(s)
- Covers grade-level curriculum yet is authentic, relevant, and of interest to students
- Relies on multiple resources, including those in the students' home languages
- Follows a logical sequence of scaffold activities and tasks.
- Contains visual, graphic, and interactive supports

In addition, The Framework for High Quality Project Based Learning (HQPBL,2018) describes six criteria, each of which must be at least minimally present in a project in order for it to be judged "high quality." If we analyse our project, we can find these criteria:

- It makes our students think critically about the different phases to follow in winemaking, learning at the same time important academic concepts related to physics, chemistry and wine.
- It reflects what happens in the world outside of school, therefore it connects to the interests and concerns of young people
- Students make their work public by sharing it not only with the teacher but also with each other, experts, and other people beyond the classroom. This public process and final presentation encourages students to improve the quality of their work and demonstrates what students know and can do.
- In it, students collaborate between themselves, sharing talents and skills.
- Students not only learn and make use of project management processes, tools, and strategies similar to those used in the world beyond school but they also learn to assess the quality of their work and think about how to make it better. By reflecting on what they have accomplished, students retain project content and skills longer, develop a greater sense of control over their own education, and build confidence in themselves.

Finally, I would like to say that with this project I have tried to demonstrate that PBL and CLIL are two complementary and beneficial approaches to learning a second language and to teaching the subject of Physics and Chemistry, since both methodologies allow the teacher to get students' attention and to motivate them by working on projects, developing

creative skills, critical reasoning, collaboration and autonomy that allow them to face the problems of real life.

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9. ANNEXES

Annexe 1: Rubric to assess the oral presentation

	Low (5)	Medium (6)	High (7-8)	Very high (9-10)
Body posture and eye contact	The student has poor posture and / or does not look at people during the presentation.	The student sometimes has good posture and makes eye contact.	The student has good posture and establishes eye contact with everyone in the room during the presentation.	The student has good posture, looks relaxed and confident. Make eye contact with everyone in the classroom during the presentation.
Fluency and pronunciation	The student is not understood or has poor pronunciation most of the time.	The student speaks clearly and distinctly all the time, but with a bad pronunciation	The student speaks clearly and distinctly most of the time. It has no bad pronunciation.	The student speaks clearly and distinctly all the time and has no bad pronunciation.
Content	The student does not seem to understand the subject very well.	The student shows a good understanding of parts of the subject.	The student demonstrates a good understanding of the subject.	The student shows a complete understanding of the subject.
Comprehension	The student cannot answer the questions.	The student can accurately answer a few questions.	The student can accurately answer most of the questions.	The student can accurately answer almost all the questions.

Table 1. Rubric to assess the oral presentation.
Adapted from Sánchez Palacios M.C. (2017)

Annexe 2: Rubric to assess the writing skill

	Low (5)	Medium (6)	High (7-8)	Very high (9-10)
Coherency/ Consistency	Piece was incoherent. It lacked focus. it was obvious the student did not put enough time or effort into the piece.	Piece was not very easy to read and understand because it either lacked a clear focus, consistency, build or some combination thereof.	Piece was basically easy to read and understand. it moved fairly well from point to point and it has a clear emphasis, but lacked focus	Piece was easy to read and understand. it moved well from point to point and it has a clear emphasis
Relevancy	Students did not display understanding of the assigment. Piece was not relevant to the topic	Not sure if students understood the point of the assigment. their piece was severely lacking in relevant details	Students demostrated understanding of the topic, but was lacking in amount of relevant details	Students demostrated understanding by writing a piece that included relevant information and examples
Vocabulary/ Syntax	It was obvious the student did not put enough time or effort into the writing of the piece	Sentence structure and vocabulary were too simple given grade level	Sentence structures could have been more varied and vocabulary could have displayed more sophistication	Vocabulary and sentence structure are commensurate with grade level. Sentences were varied and vocabulary was sophisticated
Convections	It was obvious the student did not put enough time or effort into the writing of the piece	The piece contained several grammatical errors and spelling errors	The piece contained one glaring grammatical error or more than one spelling error	The piece was completed with no glaring grammatical errors or spelling errors

Table 2. Rubric to assess the writing skill. Retrieved from irubric[tm] : https://www.rcampus.com/rubricshowc.cfm?sp=yes&code=E6436W& (accessed Jul 03 2019).

Annexe 3: Rubric to assess portfolio

	Low (5)	Medium (6)	High (7-8)	Very high (9-10)
Organisation	The organisation was not clear or logical.	Most of the content is logically organised.	Use of lists to organise, but the overall organization seems weak.	Well-organised content using titles and lists to group related material.
Quantity of work	Several people in the group did not do their part of the work.	One person in the group did not do his part of the work.	Most of the work is divided and shared equally among the team members.	All the work is divided equally and shared by all members of the group
Quality of work	The work usually needs to be checked by the teacher or redone to ensure their quality.	The work occasionally needs to be checked by the teacher or redone to ensure its quality.	The work is quality.	The work is of the highest quality.
Language	There are more than four spelling mistakes and grammar mistakes.	There are four spelling mistakes and / or grammatical errors.	There are three or fewer spelling mistakes and / or punctuation errors.	There is not spelling mistakes or grammatical errors.
Problem resolution	Students does not try to solve problems or help others. Let others do the work.	Students does not suggest or refine solutions, but is willing to try solutions proposed by others.	Students refine solutions suggested by others.	Students search and suggest solutions to problems.

Table 3. Rubric to assess portfolio.
Adapted from Sánchez Palacios M.C. (2017)

Annexe 4: Rubric to assess the collaborative work

	Low (5)	Medium (6)	High (7-8)	Very high (9-10)
Control of group effectiveness	Rarely controls the effectiveness of the group and does not work for the group to be more effective	Occasionally controls the effectiveness of the group and works to make the group more effective	Repeatedly controls the effectiveness of the group and works to make the group more effective	Repeatedly controls the effectiveness of the group and makes suggestions to make it more effective
Work quality	It provides work that, in general, needs to be checked or redone by other members of the group.	It provides work that occasionally needs to be checked or redone by other group members.	Provides quality work	Provides work of the highest quality
Work with others	He or she rarely listens, shares and supports the work of others. Fundamentally he or she is not a good member of the group.	Sometimes he or she listens, shares and supports the work of others, but sometimes he or she is not a good member of the group.	He or she usually listens, shares and supports the work of others. It does not cause problems in the group.	Almost always listens, shares and supports the work of others. Try to keep the union of the members working in groups.
Contributions	Rarely provides useful ideas when participating in the group and the discussion in class. You can refuse to participate.	Sometimes it provides useful ideas when participating in the group and the class discussion. A successful member of the group who does what is asked of them.	It usually provides useful ideas when participating in the group and the class discussion. A strong member of the group that strives.	It always provides useful ideas when participating in the group and the discussion in class. He is a definite leader who contributes with a lot of effort.

Table 4. Rubric to assess the collaborative work.
Adapted from Calduch, P. A. (2018).

Annexe 5: Rubric to peer assessment

Peer Evaluation Form for Group Work Peer Evaluation Form for Group Work

Your name _____

Write the name of each of your group members in a separate column. For each person, indicate the extent to which you agree with the statement on the left, using a scale of 1-4 (1=strongly disagree; 2=disagree; 3=agree; 4=strongly agree). Total the numbers in each column.

Evaluation Criteria	Group member:	Group member:	Group member:	Group member:
Attends group meetings regularly and arrives on time.				
Contributes meaningfully to group discussions.				
Completes group assignments on time.				
Prepares work in a quality manner.				
Demonstrates a cooperative and supportive attitude.				
Contributes significantly to the success of the project.				
TOTALS				

Feedback on team dynamics:

1. How effectively did your group work?
2. Were the behaviors of any of your team members particularly valuable or detrimental to the team? Explain.
3. What did you learn about working in a group from this project that you will carry into your next group experience?

Table 5. Rubric to peer assessment.

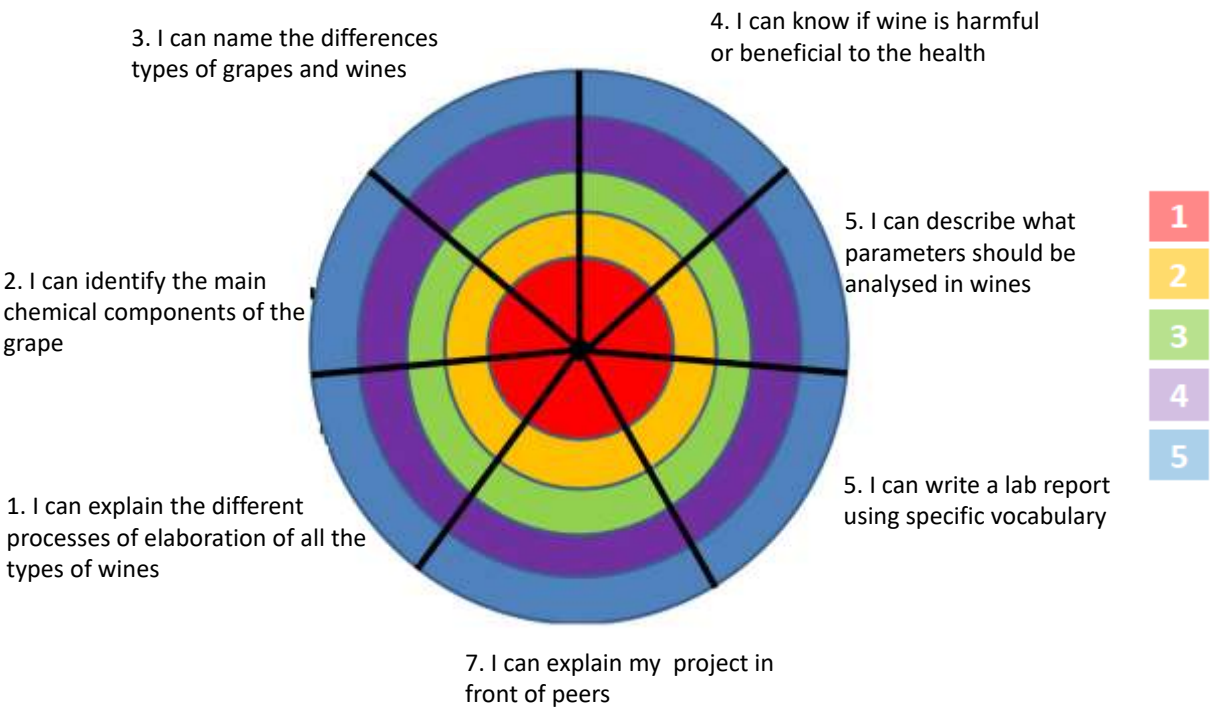
Adapted by Robin Cresiski at Goucher College from a peer evaluation form developed at Johns Hopkins University (October, 2006). Retrieved from: https://blogs.goucher.edu/cast/files/2019/03/Sample-Peer-Evaluation.pdf (accessed Jul 03 2019)

Annexe 6: Rubric to assess an infography

	Very high (9-10)	High (7-8)	Medium (6)	Low (5)
Use of Class Time	Used time well during each class period. Focused on getting the project done. Never distracted others.	Used time well during each class period. Usually focused on getting the project done and never distracted others.	Used some of the time well during each class period. There was some focus on getting the project done but occasionally distracted others.	Did not use class time to focus on the project or often distracted others.
Graphics - Relevance	All graphics are related to the topic and make it easier to understand.	All graphics are related to the topic and most make it easier to understand.	All graphics relate to the topic.	Graphics do not relate to the topic.
Required Elements	The infographic includes all required elements as well as additional information.	All required elements are included on the infographic.	All but 1 of the required elements are included on the infographic.	Several required elements were missing.
Content - Accuracy	At least 4 accurate facts are displayed on the infographic.	3 accurate facts are displayed on the infographic.	2 accurate facts are displayed on the infographic.	Less than 2 accurate facts are displayed on the infographic.
Attractiveness	The infographic is Exceptionally attractive in terms of design, layout, and neatness.	The infographic is attractive in terms of design, layout and neatness.	The infographic is acceptably attractive though it may be a bit messy.	The infographic is distractingly messy or very poorly designed. It is not attractive.
Mechanics	Capitalization and punctuation are correct throughout the infographic.	There is 1 error in capitalization or punctuation.	There are 2 errors in capitalization or punctuation.	There are more than 2 errors in capitalization or punctuation.
Grammar	There are no grammatical mistakes on the infographic.	There is 1 grammatical mistake on the infographic.	There are 2 grammatical mistakes on the infographic.	There are more than 2 grammatical mistakes on the infographic.

Table 6 Infographic rubric.
Adapted from Urich (2005) Retrieved from: http://www.truwebs.com/csu/ete567/webquest/ (accessed Jul 03 2019)

Annexe 7: Target evaluation



Annexe 8: Density measurement protocol

Method OIV-MA-AS2-01B Type IV method

Density and Specific Gravity at 20°C

1. Definition

Density is the mass per unit volume of wine or must at 20°C. It is expressed in grams per milliliter, and denoted by the symbol $\rho_{20°C}$.

Specific gravity at 20°C (or 2°C/2°C relative density) is the ratio, expressed as a decimal number, of the density of the wine or must at 20°C to the density of water at the same temperature, and is denoted by the symbol d^{20}_{20}

2. Principle

Density and specific gravity at 20°C are determined on the sample for testing:
- by ebullometry (hydrometry)

Note: For very accurate measurement, the density and relative density must be corrected for the presence of sulfur dioxide.

ρ_{20} = $\rho'_{20} - 0.0006 \times S$
ρ_{20} = the corrected density
ρ'_{20} = the observed density
S = total sulfur dioxide in g/L

3. Preliminary treatment of sample

If the wine or the must contains appreciable quantities of carbon dioxide, remove most of this by agitating 250 mL of wine in a 1000 mL flask, or by filtering under reduced pressure through 2 g of cotton wool placed in an extension tube.

4. Working Methods

4.1. Hydrometry

4..1.1 *Apparatus*

4..1.1.1 Hydrometer

Hydrometers must meet the AFNOR requirements regarding their dimensions and graduations.

They must have a cylindrical body, a stem of circular cross-section not less than 3 mm in diameter. For dry wines, they must be graduated from 0.983 to

1.003 with graduation marks every 0.0010 and 0.0002; each mark at 0.0010 must be separated from the next corresponding mark by at least 5 mm. For measuring the density of non-alcoholic wines, sweet wines and musts, a set of five hydrometers are to be used, graduated from 1.000 to 1.030, from 1.030 to 1.060, from 1.060 to 1.090, from 1.090 to 1.120 and from 1.120 to 1.150. These hydrometers shall be graduated for density at 20°C by marks every 0.0010 and 0.0005, with each 0.0010 being separated from the next corresponding mark by at least 3 mm. These hydrometers are to be graduated so they are read "at the top of the meniscus". The indication of the graduation in density or specific gravity at 20°C, and of the reading of the top of the meniscus, is to be carried either on the graduated scale or on a strip of paper enclosed in the bulb.

These hydrometers must be checked by an official authority.

4..1.1.2 Thermometer, in intervals of not less than 0.5°C.

4..1.1.3 A measuring cylinder with internal diameter 36 mm and height 320 mm, held vertical by supporting leveling screws.

4.1.2 *Procedure*

Place 250 mL of the prepared sample (3.) in the measuring cylinder 4..1.1.3, insert the hydrometer and thermometer. Mix the sample and wait one minute to allow temperature equilibration; read the thermometer. Remove the thermometer and after a further one minute read the apparent density at t°C on the stem of the hydrometer.

Correct the apparent density (as read at t°C) for the effect of temperature, using the tables for dry wines (Table V), for musts (Table VI) or for wines containing sugar (Table VII).

The 20°C/20°C specific gravity is obtained by dividing the density at 20°C by 0.998203.

Table VI

Temperature corrections c required for the density of natural or concentrated musts, measured with an *ordinary glass* pycnometer or hydrometer at t °C, to correct to 20 °C.

$\rho_{20} = \rho_t \pm \frac{c}{1000}$ - if t° is less than 20 °C; + if t° is more than 20 °C

Temperature en °C	Masses volumiques																					
	1.05	1.06	1.07	1.08	1.09	1.10	1.11	1.12	1.13	1.14	1.15	1.16	1.18	1.20	1.22	1.24	1.26	1.28	1.30	1.32	1.34	1.36
10°	2.17	2.34	2.52	2.68	2.85	2.99	3.16	3.28	3.44	3.58	3.73	3.86	4.13	4.36	4.60	4.82	5.02	5.25	5.39	5.56	-5.73	5.87
11°	2.00	2.16	2.29	2.46	2.59	2.73	2.86	2.99	3.12	3.24	3.37	3.48	3.71	3.94	4.15	4.33	4.52	4.69	4.85	5.01	5.15	5.29
12°	1.81	1.95	2.08	2.21	2.34	2.47	2.58	2.70	2.82	2.92	3.03	3.14	3.35	3.55	3.72	3.90	4.07	4.23	4.37	4.52	4.64	4.77
13°	1.62	1.74	1.85	1.96	2.07	2.17	2.28	2.38	2.48	2.59	2.68	2.77	2.94	3.11	3.28	3.44	3.54	3.72	3.86	3.99	4.12	4.24
14°	1.44	1.54	1.64	1.75	1.82	1.92	2.00	2.08	2.17	2.25	2.34	2.42	2.57	2.78	2.86	2.99	3.12	3.24	3.35	3.46	3.57	3.65
15°	1.21	1.29	1.37	1.45	1.53	1.60	1.68	1.75	1.82	1.89	1.97	2.03	2.16	2.28	2.40	2.51	2.61	2.71	2.80	2.89	2.94	3.01
16°	1.00	1.06	1.12	1.19	1.25	1.31	1.37	1.43	1.49	1.54	1.60	1.65	1.75	1.84	1.94	2.03	2.09	2.17	2.23	2.30	2.36	2.42
17°	0.76	0.82	0.88	0.91	0.96	1.00	1.05	1.09	1.14	1.18	1.22	1.25	1.32	1.39	1.48	1.52	1.57	1.63	1.67	1.71	1.75	1.79
18°	0.53	0.56	0.59	0.63	0.65	0.69	0.72	0.74	0.77	0.80	0.82	0.85	0.90	0.95	0.99	1.02	1.05	1.09	1.13	1.16	1.18	1.20
19°	0.28	0.30	0.31	0.33	0.35	0.36	0.38	0.39	0.41	0.42	0.43	0.43	0.46	0.48	0.50	0.52	0.54	0.55	0.57	0.58	0.59	0.60
20°																						
21°	0.28	0.29	0.31	0.33	0.34	0.36	0.37	0.39	0.40	0.41	0.43	0.44	0.46	0.48	0.51	0.54	0.56	0.57	0.58	0.59	0.60	0.60
22°	0.55	0.58	0.61	0.64	0.67	0.70	0.73	0.76	0.78	0.81	0.84	0.87	0.93	0.97	1.02	1.06	1.09	1.12	1.15	1.17	1.19	1.19
23°	0.85	0.90	0.95	0.99	1.04	1.08	1.12	1.16	1.21	1.25	1.29	1.32	1.39	1.46	1.52	1.58	1.62	1.68	1.72	1.75	1.77	1.79
24°	1.15	1.19	1.25	1.31	1.37	1.43	1.48	1.54	1.60	1.65	1.71	1.76	1.86	1.95	2.04	2.11	2.17	2.23	2.29	2.33	2.35	2.37
25°	1.44	1.52	1.59	1.67	1.74	1.81	1.88	1.95	2.02	2.09	2.16	2.22	2.34	2.45	2.55	2.64	2.74	2.83	2.87	2.90	2.92	2.96
26°	1.76	1.84	1.93	2.02	2.10	2.18	2.25	2.33	2.41	2.49	2.56	2.64	2.78	2.91	3.03	3.13	3.26	3.37	3.47	3.55	3.62	3.66
27°	2.07	2.16	2.26	2.36	2.46	2.56	2.65	2.74	2.83	2.91	3.00	3.07	3.24	3.39	3.55	3.69	3.82	3.94	4.04	4.14	4.23	4.30
28°	2.39	2.51	2.63	2.74	2.85	2.98	3.06	3.16	3.28	3.38	3.48	3.57	3.75	3.92	4.08	4.23	4.37	4.53	4.62	4.73	4.80	4.86
29°	2.74	2.86	2.97	3.09	3.22	3.34	3.46	3.57	3.69	3.90	3.90	4.00	4.20	4.39	4.58	4.74	4.90	5.05	5.19	5.31	5.40	5.48
30°	3.06	3.21	3.35	3.50	3.63	3.77	3.91	4.02	4.15	4.28	4.40	4.52	4.75	4.96	5.16	5.35	5.52	5.67	5.79	5.91	6.00	6.04

Adapted from International organisation of Vine and Wine (OIV). *Compendium of international methods of wine* and must analysis (2019) Volume 1.

Annexe 9: BRIX and BAUMÉ degree protocol

Method OIV-MA-AS2-02 Type I method

Evaluation by refractometry of the sugar concentration in grape musts, concentrated grape musts and rectified concentrated grape musts

(Oeno 21/2004)
(Revised per Oeno 466/2012)

1 Principle

The refractive index at 20°C, expressed either as an absolute value or as a percentage by mass of sucrose, is given in the appropriate table to provide a means of obtaining the sugar concentration in grams per liter and in grams per kilogram for grape musts, concentrated grape musts and rectified concentrated grape musts.

2 Apparatus

Abbe refractometer

The refractometer used must be fitted with a scale giving:
- either percentage by mass of sucrose to 0.1%;
- or refractive indices to four decimal places.

The refractometer must be equipped with a thermometer having a scale extending at least from +15°C to +25°C and with a system for circulating water that will enable measurements to be made at a temperature of 20 ± 5°C. The operating instructions for this instrument must be strictly adhered to, particularly with regard to calibration and the light source.

3 Preparation of the sample

3.1 Must and concentrated must

Pass the must, if necessary, through a dry gauze folded into four and, after discarding the first drops of the filtrate, carry out the determination on the filtered product.

3.2 Rectified concentrated must

Depending on the concentration, use either the rectified concentrated must itself or a solution obtained by making up 200 g of rectified concentrated must to 500 g with water, all weighings being carried out accurately.

4 Procedure

Bring the sample to a temperature close to 20°C.

Place a small test sample on the lower prism of the refractometer, taking care (because the prisms are pressed firmly against each other) that this test sample covers the glass surface uniformly. Carry out the measurement in accordance with the operating instructions of the instrument used.

Read the percentage by mass of sucrose to within 0.1 or read the refractive index to four decimal places.

Carry out at least two determinations on the same prepared sample. Note the temperature *t*°C.

5 Calculation

5.1 Temperature correction

- Instruments graduated in percentage by mass of sucrose: use Table I to obtain the temperature correction.
- Instruments graduated in refractive index: find the index measured at *t*°C in Table II to obtain (column 1) the corresponding value of the percentage by mass of sucrose at *t*°C. This value is corrected for temperature and expressed as a concentration at 20°C by means of Table I.

5.2 Sugar concentration in must and concentrated must

Find the percentage by mass of sucrose at 20°C in Table II and read from the same row the sugar concentration in grams per liter and grams per kilogram. The sugar concentration is expressed in terms of invert sugar to one decimal place.

5.3 Sugar concentration in rectified concentrated must

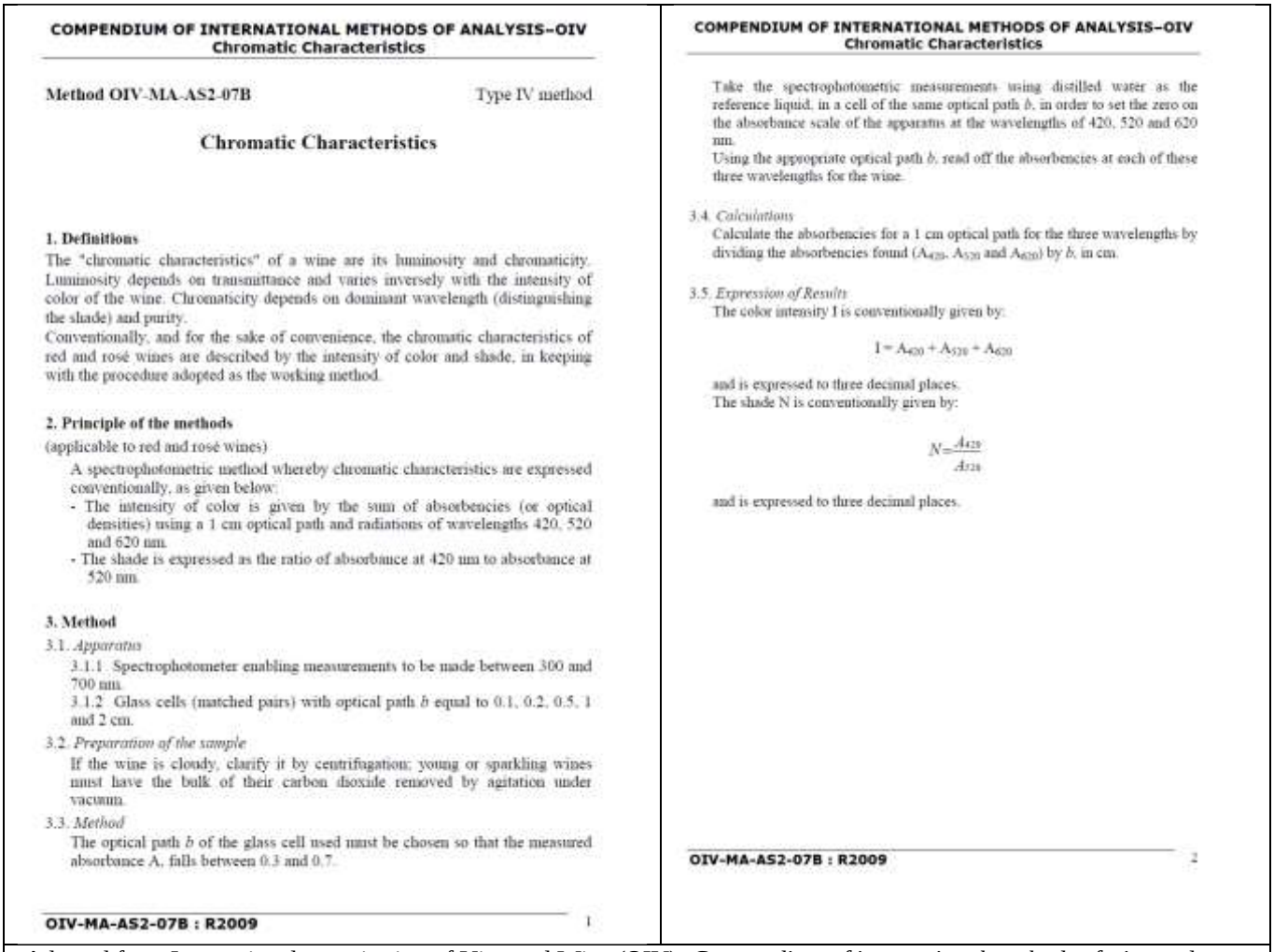
Find the percentage by mass of sucrose at 20°C in Table III and read from the same row the sugar concentration in grams per liter and grams per kilogram. The sugar concentration is expressed in terms of invert sugar to one decimal place. If the measurement was made on diluted rectified concentrated must, multiply the result by the dilution factor.

5.4 Refractive index of must, concentrated must and rectified concentrated must

Find the percentage by mass of sucrose at 20°C in Table II and read from the same row the refractive index at 20°C. This index is expressed to four decimal places.

Adapted from International organisation of Vine and Wine (OIV). *Compendium of international methods of wine* and must analysis (2019) Volume 1.

Annexe 10: Chromatic characteristics protocol



Method OIV-MA-AS2-07B Type IV method

Chromatic Characteristics

1. Definitions

The "chromatic characteristics" of a wine are its luminosity and chromaticity. Luminosity depends on transmittance and varies inversely with the intensity of color of the wine. Chromaticity depends on dominant wavelength (distinguishing the shade) and purity.

Conventionally, and for the sake of convenience, the chromatic characteristics of red and rosé wines are described by the intensity of color and shade, in keeping with the procedure adopted as the working method.

2. Principle of the methods

(applicable to red and rosé wines)

A spectrophotometric method whereby chromatic characteristics are expressed conventionally, as given below:

- The intensity of color is given by the sum of absorbencies (or optical densities) using a 1 cm optical path and radiations of wavelengths 420, 520 and 620 nm.
- The shade is expressed as the ratio of absorbance at 420 nm to absorbance at 520 nm.

3. Method

3.1. *Apparatus*

3.1.1. Spectrophotometer enabling measurements to be made between 300 and 700 nm.

3.1.2. Glass cells (matched pairs) with optical path b equal to 0.1, 0.2, 0.5, 1 and 2 cm.

3.2. *Preparation of the sample*

If the wine is cloudy, clarify it by centrifugation; young or sparkling wines must have the bulk of their carbon dioxide removed by agitation under vacuum.

3.3. *Method*

The optical path b of the glass cell used must be chosen so that the measured absorbance A, falls between 0.3 and 0.7.

Take the spectrophotometric measurements using distilled water as the reference liquid, in a cell of the same optical path b, in order to set the zero on the absorbance scale of the apparatus at the wavelengths of 420, 520 and 620 nm.

Using the appropriate optical path b, read off the absorbencies at each of these three wavelengths for the wine.

3.4. *Calculations*

Calculate the absorbencies for a 1 cm optical path for the three wavelengths by dividing the absorbencies found (A_{420}, A_{520} and A_{620}) by b, in cm.

3.5. *Expression of Results*

The color intensity I is conventionally given by:

$$I = A_{420} + A_{520} + A_{620}$$

and is expressed to three decimal places.

The shade N is conventionally given by:

$$N = \frac{A_{420}}{A_{520}}$$

and is expressed to three decimal places.

Adapted from International organisation of Vine and Wine (OIV). *Compendium of international methods of wine* and must analysis (2019) Volume 1.

Annexe 11: pH protocol

Method OIV-MA-AS313-15 Type I method

pH
(A31, Oeno 438-2011)

1. Principle
The difference in potential between two electrodes immersed in the liquid under test is measured. One of these two electrodes has a potential that is a function of the pH of the liquid, while the other has a fixed and known potential and constitutes the reference electrode.

2. Apparatus
2.1 pH meter with a scale calibrated in pH units and enabling measurements to be made to at least ±0.01 pH units.

2.2 Electrodes:

- glass electrode, kept in distilled water;
- calomel-saturated potassium chloride reference electrode, kept in a saturated solution of potassium chloride; or,
- a combined electrode, kept in distilled water.

3. Reagents
– Buffer solutions:

- Saturated potassium hydrogen tartrate solution, containing 5.7 g/L potassium hydrogen tartrate ($CO_2HC_2H_4O_2CO_2K$) at 20°C. (This solution may be kept for up to two months by adding 0.1 g of thymol per 200 mL.)

pH { 3.57 at 20 °C; 3.56 at 25 °C; 3.55 at 30 °C

- Potassium hydrogen phthalate solution, 0.05 M, containing 10.211 g/L potassium hydrogen phthalate, $CO_2HC_6H_4CO_2K$, at 20°C. (This solution may be kept for up to two months.)

pH { 3.999 at 15 °C; 4.003 at 20 °C; 4.008 at 25 °C; 4.015 at 30 °C

Solution containing:
potassium *di*-hydrogen phosphate, KH_2PO_4 ..... 3.402 g
di-potassium hydrogen phosphate, K_2HPO_4 ..... 4.354 g
water to ...../..... 1 litre
(This solution may be kept for up to two months)

pH { 6.90 at 15 °C; 6.88 at 20 °C; 6.86 at 25 °C; 6.85 at 30 °C

Note: commercial reference buffer solutions traceable to the SI may be used.

For example: pH 1.679 ±0.01 at 25°C
pH 4.005 ±0.01 at 25°C
pH 7.000 ±0.01 at 25°C

4. Procedure
4.1 *Zeroing of the apparatus*

Zeroing is carried out before any measurement is made, according to the instructions provided with the apparatus used.

4.2 *Calibration of the pH meter*

The pH meter must be calibrated at 20°C using standard buffer solutions connected to the SI. The pH values selected must encompass the range of values that may be encountered in musts and wines. If the pH meter used is not compatible with calibration at sufficiently low values, a verification using a standard buffer solution linked to the SI and which has a pH value close to the values encountered in the musts and wines may be used.

4.3 *Determination*

Dip the electrode into the sample to be analyzed, the temperature of which should be between 20 and 25°C and as close as possible to 20°C. Read the pH value directly off the scale.

Carry out at least two determinations on the same sample.

The final result is taken to be the arithmetic mean of two determinations.

Adapted from International organisation of Vine and Wine (OIV). *Compendium of international methods of wine* and must analysis (2019) Volume 1.

Annexe 12: Index of total polyphenols protocol

Method OIV-MA-AS2-10 Type IV method

Folin-Ciocalteu Index

1. Definition

The Folin-Ciocalteu index is the result obtained by applying the method described below.

2. Principle

All phenolic compounds contained in wine are oxidized by Folin-Ciocalteu reagent. This reagent is formed from a mixture of phosphotungstic acid, $H_3PW_{12}O_{40}$, and phosphomolybdic acid, $H_3PMo_{12}O_{40}$, which, after oxidation of the phenols, is reduced to a mixture of blue oxides of tungsten, W_8O_{23}, and molybdenum, Mo_8O_{23}. The blue coloration produced has a maximum absorption in the region of 750 nm, and is proportional to the total quantity of phenolic compounds originally present.

3. Apparatus

Normal laboratory apparatus, in particular:

3.1 100 mL volumetric flasks.

3.2 Spectrophotometer capable of operating at 750 nm.

4. Reagents

4.1 Folin-Ciocalteu reagent

This reagent is available commercially in a form ready for use.

Alternatively it may be prepared as follows: dissolve 100 g of sodium tungstate, $Na_2WO_4.2H_2O$, and 25 g of sodium molybdate, $Na_2MoO_4.2H_2O$, in 700 mL of distilled water. Add 50 mL phosphoric acid 85% (ρ_{20} = 1.71 g/mL), and 100 mL of concentrated hydrochloric acid (ρ_{20} = 1.19 g/mL). Bring to the boil and reflux for 10 hours. Then add 150 g of lithium sulfate, $Li_2SO_4.H_2O$, and a few drops of bromine and boil for 15 minutes. Allow to cool and make up to one liter with distilled water.

4.2 Anhydrous sodium carbonate, Na_2CO_3, made up into a 20% (*m/v*) solution.

5. Procedure

5.1 *Red wine*

Introduce the following into a 100 mL volumetric flask (3.1) strictly in the following order:

COMPENDIUM OF INTERNATIONAL METHODS OF ANALYSIS - OIV
Folin-Ciocalteu Index

1 mL of the wine, previously diluted 1/5,
50 mL of distilled water,
5 mL of Folin-Ciocalteu reagent (4.1),
20 mL of sodium carbonate solution (4.2).

Bring to 100 mL with distilled water.

Mix to dissolve. Leave for 30 minutes for the reaction to stabilize. Determine the absorbance at 750 nm through a path length of 1 cm with respect to a blank prepared with distilled water in place of the wine.

If the absorbance is not in the region of 0.3 appropriate dilution should be made.

5.2 *White wine*

Carry out the same procedure with 1 mL of undiluted wine.

6. Expression of results

6.1 *Calculation*

The result is expressed in the form of an index obtained by multiplying the absorbance by 100 for red wines diluted 1/5 (or by the corresponding factor for other dilutions) and by 20 for white wines.

6.2 *Precision*

The difference between the results of two determinations carried out simultaneously or very quickly one after the other by the same analyst must not be greater than 1. Good precision of results is aided by using scrupulously clean apparatus (volumetric flasks and spectrophotometer cells).

Adapted from International organisation of Vine and Wine (OIV). *Compendium of international methods of wine* and must analysis (2019) Volume 1.

Annexe 13: Total acidity protocol

Method OIV-MA-AS313-01 Type I method

Total acidity

1. Definition

The total acidity of the wine is the sum of its titratable acidities when it is titrated to pH 7 against a standard alkaline solution. Carbon dioxide is not included in the total acidity.

2. Principle

Potentiometric titration or titration with bromothymol blue as indicator and comparison with an end-point color standard.

3. Apparatus

3.1 *Water vacuum pump.*

3.2 *Vacuum flask, 500 mL.*

3.3 *Potentiometer* with scale graduated in pH values, and electrodes. The glass electrode must be kept in distilled water. The calomel/saturated potassium chloride electrode must be kept in a saturated potassium chloride solution.

3.4 *Beakers of 12 cm diameter or any appropriate recipient*

4. Reagents

4.1 *Buffer solution pH 7.0:*

potassium *di*-hydrogen phosphate, KH_2PO_4	107.3 g
sodium hydroxide solution, NaOH, 1 mol/L	500 mL
water to	1000 mL

Alternatively, ready-made buffer solutions are available commercially.

4.2 Sodium hydroxide solution, NaOH, 0.1 mol/L.

4.3 Bromothymol blue indicator solution, 4 g/L.

bromothymol blue	4 g
neutral ethanol, 96% (*v/v*)	200 mL

Dissolve and add:

water free of CO_2	200 mL

sodium hydroxide solution, 1 mol/L, sufficient to produce

blue green color (pH 7)	7.5 mL
water to	1000 mL

5. Procedure

5.1 *Preparation of sample:* elimination of carbon dioxide.

Place approximately 50 mL of wine in a vacuum flask; apply vacuum to the flask using a water pump for one to two min, while shaking continuously. Other CO2 elimination systems may be used if the CO2 elimination is guaranteed.

5.2 *Potentiometric titration*

5.2.1 Calibration of pH meter

The pH meter is calibrated for use at 20°C, according to the manufacturer's instructions, with the pH 7 buffer solution at 20°C.

5.2.2 Method of measurement

Into a beaker, introduce a volume of the sample, prepared as described in 5.1, equal to 10 mL in the case of wine and 50 mL in the case of rectified concentrated must. Add about 10 mL of distilled water and then add sodium hydroxide solution, 0.1 mol/L, from a burette until the pH is equal to 7 at 20°C. The sodium hydroxide must be added slowly and the solution stirred continuously. Let *n* mL be the volume of sodium hydroxide, 0.1 mol/L, added.

5.3 *Titration with indicator (bromothymol blue)*

5.3.1 Preliminary test: end-point color determination.

Into a beaker (3.4) place 25 mL of boiled distilled water, 1 mL of bromothymol blue solution and a volume prepared as in 5.1 equal to 10 mL in the case of wine and 50 mL in the case of rectified concentrated must. Add sodium hydroxide solution, 0.1 mol/L, until the color changes to blue-green. Then add 5 mL of the pH 7 buffer solution.

5.3.2 Measurement

Into a beaker (3.4) place 30 mL of boiled distilled water, 1 mL of bromothymol blue solution and a volume of the sample, prepared as described in 5.1, equal to 10 mL in the case of wine and 50 mL in the case of rectified concentrated must. Add sodium hydroxide solution, 0.1 mol/L, until the same color is obtained as in the preliminary test above (5.3.1). Let *n* mL be the volume of sodium hydroxide solution, 0.1 mol/L, added.

6. Expression of results

6.1 *Method of calculation*

- The total acidity expressed in milliequivalents per liter is given by:

$$A = 10\,n$$

It is recorded to one decimal place.

- The total acidity expressed in grams of tartaric acid per liter is given by:

$$A' = 0.075 \times A$$

The result is quoted to two decimal places.

- The total acidity expressed in grams of sulfuric acid per liter is given by:

$$A' = 0.049 \times A$$

The result is quoted to two decimal places.

6.2 *Repeatability (r)* for titration with the indicator (5.3):

$r = 0.9$ meq/L
$r = 0.04$ g sulfuric acid/L
$r = 0.07$ g tartaric acid/L

6.3 *Reproducibility (R)* for titration with the indicator (5.3):

For white and rosé wines:

$R = 3.6$ meq/L
$R = 0.2$ g sulfuric acid/L
$R = 0.3$ g tartaric acid/L

For red wines:

$R = 5.1$ meq/L
$R = 0.3$ g sulfuric acid/L
$R = 0.4$ g tartaric acid/L

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Adapted from International organisation of Vine and Wine (OIV). *Compendium of international methods of wine* and must analysis (2019) Volume 1.

Annexe 14: Alcohol content protocol

3. METHOD OF OBTAINING DISTILLATE

3.1. Apparatus

3.1.1 Distillation apparatus, consisting of:
- a round-bottomed 1-liter flask with ground-glass joints.
- a rectifying column about 20 cm in height or any similar condenser.
- a source of heat; any pyrolysis of extracted matter must be prevented by a suitable arrangement.
- a condenser terminated by a drawn-out tube taking the distillate to the bottom of a graduated receiving flask containing several mL of water.

3.1.2 Steam distillation apparatus consisting of:
- a steam generator
- a steam pipe
- a rectifying column
- a condenser.

Any type of distillation or steam distillation apparatus may be used provided that it satisfies the following test:
Distil an ethanol-water mixture with an alcoholic strength of 10% vol. five times in succession. The distillate should have an alcoholic strength of at least 9.9% vol. after the fifth distillation; i.e. the loss of alcohol during each distillation should not be more than 0.02% vol.

3.2. Reagents

Suspension of calcium hydroxide, 2 M

Obtain by carefully pouring 1 liter of water at 60 to 70°C on to 120 g of quicklime, CaO.

3.3. Preparation of sample

Remove the bulk of any carbon dioxide from young and sparkling wines by stirring 250 to 300 mL of the wine in a 1000 mL flask.

3.4. Procedure

Measure out 200 mL of the wine using a volumetric flask. Record the temperature of the wine.

Transfer the wine to the distillation flask and introduce the steam-pipe of the steam distillation apparatus. Rinse the volumetric flask four times with successive 5 mL washings of water added to the flask or the steam-pipe. Add

10 mL of calcium hydroxide 2 mol/L and several pieces of inert porous material (pumice etc).

Collect the distillate in the 200 mL graduated flask used to measure the wine.

Collect a volume of about three-quarters of the initial volume if distillation is used and a volume of 198 to 199 mL of distillate if steam distillation is used. Make up to 200 mL with distilled water, keeping the distillate at a temperature within 2°C of the initial temperature.

Mix carefully, using a circular motion.

Note: In the case of wines containing particularly large concentrations of ammonium ions, the distillate may be redistilled under the conditions described above, but replacing the suspension of calcium hydroxide with 1 mL sulfuric acid diluted 10 /100.

Precautionary safety measures

Respect the safety guidelines for the usage of distillation apparatuses, the manipulation of hydro-alcoholic and cleaning solutions.

4. Measurement of the alcoholic strength of the distillate with a hydrometer or by refractometry (Type IV Methods)

4.1. ***Hydrometer***

4.1.1 Apparatus

- Alcoholmeter

The alcoholmeter must conform to the specification for class I or class II equipment defined in International Recommendation No 44. *Alcoholmeters and Alcohol Hydrometers*, of the OIML (Organisation Internationale de Métrologie Légale).
- Thermometer graduated in degrees and in 0.1°C from 0 to 40°C certified to within 1/20th degree.
- Measuring cylinder. 36 mm diameter and 320 mm height, held vertically by supporting leveling screws.

4.1.2 Procedure

Pour the distillate (3.4) into the measuring cylinder. Ensure that the cylinder is kept vertical. Insert the thermometer and alcoholmeter. Read the temperature on the thermometer one minute after stirring to equilibrate the temperature of the measuring cylinder, the thermometer, the alcoholmeter and the distillate. Remove the thermometer and read the apparent alcoholic strength after one minute. Take at least three readings using a magnifying glass. Correct the apparent strength measure at *t*°C for the effect of temperature using Table II.

The temperature of the liquid must differ very little from ambient temperature (at most, by 5°C).

Adapted from International organisation of Vine and Wine (OIV). *Compendium of international methods of wine* and must analysis (2019) Volume 1.