ISSN 1886-5895
doi.org/ 10.52149/sp21
ENERO 2023 Nº 67
http://usie.es/supervision-21/

FROM SCIENTIFIC KNOWLEDGE TO SCIENTIFIC COMPETENCE, A QUANTUM LEAP

DEL CONOCIMIENTO A LA COMPETENCIA CIENTÍFICA, UN SALTO CUÁNTICO

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Admisión Consejo Editorial: 20/12/2022. Aceptación: 24 /01/2023

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Resumen

El mundo y las sociedades cambian, modificándose el escenario en el que la educación y formación de los futuros ciudadanos también experimentan "revoluciones". La LOMLOE intenta encaminar la transformación educativa que ya se planteó en anteriores leyes de forma menos visible o diferente. Desde el punto de visto pedagógico, se concretan nuevos elementos curriculares centrados en el desarrollo competencial del alumnado. Se establecen los perfiles de salida y sus descriptores, las competencias específicas de cada materia/asignatura o módulo relacionadas con las ahora denominadas competencias clave, los saberes básicos (que no son únicamente contenidos), situaciones de aprendizaje que hay que diseñar y contextualizar para que se ajusten a los criterios de evaluación establecidos en la norma, una evaluación en la que se emplearía una variedad de instrumentos de evaluación para dichas situaciones. Un sinfín de cuestiones que hay que asimilar y procesar.

La materia de Física y Química contribuye, al igual que el resto de las materias, a la adquisición global de las competencias por parte del alumnado, pero principalmente a la competencia matemática y en ciencia, tecnología e ingeniería. Un análisis de las competencias específicas intenta poner luz sobre cuáles son más relevantes. Es obvia la importancia de la ciencia y adquirir una competencia científica para comprender los fenómenos que ocurren en nuestro entorno, y como base para el desarrollo científico, tecnológico y económico. La OCDE, a través de las pruebas PISA,

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sirve de referencia para establecer un marco educativo en la sociedad actual.

La pretendida revolución en el docente pasa, por consiguiente, por un cambio metodológico importante. Hay que ser conscientes de la dificultad que supone la implantación y desarrollo de un modelo centrado en las competencias, de la importancia de tener claro el objetivo de la educación, de la imprescindible formación docente para su desempeño, de la necesidad de un tiempo de reflexión para asimilar y diseñar la nueva arquitectura del currículo a través de las programaciones didácticas.

Palabras claves: LOMLOE, Física y Química, competencia específica, cambio metodológico, evaluación, situaciones de aprendizaje, PISA.

Abstract

The world and societies change, and the scenario in which the education and training of future citizens also undergo "revolutions" is changing. The LOMLOE attempts to set in motion the educational transformation that was already proposed in previous laws in a less visible or different way. From the pedagogical point of view, new curricular elements focused on the development of student competencies are specified. It establishes the exit profiles and their descriptors, the specific competences of each subject or module related to the now called key competences, the basic knowledge (which are not only contents), learning situations that must be designed and contextualized to be adjusted to the evaluation criteria established in the norm, an evaluation in which a variety of evaluation instruments would be used for such situations. A myriad of issues to assimilate and process.

The subject of Physics and Chemistry contributes, like the rest of the subjects, to the global acquisition of competences by the students, but mainly to mathematical competence and competence in science, technology and engineering. An analysis of the specific competences tries

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to shed light on which ones are more relevant. It is obvious the importance of science and acquiring scientific competence to understand the phenomena occurring in our environment, and as a basis for scientific, technological and economic development. The OECD, through the PISA tests, serves as a reference to establish an educational framework in today's society.

The intended revolution in teaching, therefore, requires a major methodological change. We must be aware of the difficulty involved in the implementation and development of a model focused on competencies, of the importance of being clear about the objective of education, of the essential teacher training for its performance, of the need for time for reflection to assimilate and design the new architecture of the curriculum through didactic programs.

Keywords LOMLOE, Physics and Chemistry, specific competence, methodological change, evaluation, learning situations, PISA.

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PROLOGUE: A BEGINNING IS FOREVER

Each course that ends puts a period to what is my professional and almost vital task. The truth be told is that not every year it is a period, but sometimes it is a period that will make the story continue in a new paragraph that is reached with double spacing and indentation. This happens every time there is a change in the Education Law. And that lately, in Spain these laws, and many others, are not new in their entirety, but are modifications of the modification of the last modification, that is, patches to the game and are known by nicknames and / or apocopes.

Between the end of one course and the beginning of the next is the long-awaited summer break, which in its last edition was hot, to the point that it was difficult to fall asleep, the green meadows did not provide the freshness they usually provide, water was scarce, and the color yellow prevailed from very early on. Everything was stormy. Summer, the time of the year when I even feel like thinking about how I will teach next year, was no longer that summer but another one. Another one that was scary because of the uncertainty (Heisenberg's) that accompanied it: when I found the moment, I could not find the position and when I found the position, I could not find the moment, as stated in the famous Principle. The worst of all is that principles like this one, if they give anything, it is the certainty that what they say is true and that no matter how many times we think about it, we will do what we have to do as best we can, but never perfectly.

To the heat was added fever, hot flushes, and vertigo when I became truly aware that in September a new legislative modification was coming into force. A real thermodynamic vessel about to implode (explode inwardly because, outwardly, it is a lot of work) in which temperature was one of the independent variables, together with pressure. This Thermodynamics, of course... what a stepmother it is, but it does not fail, it does not lie. It is pure Science and pure Science.

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I was in the vortex, spinning as the Northern hemisphere corresponds, right-handedly I saw myself with the RD of the LOMLOE curriculum on the computer screen and with the Decree that ultimately affects me, and I said to myself: "the lesser of two evils, read how your discipline and the subjects of 4th ESO and 2nd Baccalaureate are, lest it is not so bad". Precautionary Principle. And I did well. I looked at the contents, or what I usually understand by contents, because between the tiredness and the heat I thought I saw or understood that now we have to call them "knowledge"? And I saw that everything was more or less the same and that if that was the case there would not be many changes. I missed the evaluable learning standards which had served me as a guide in recent courses but I thought it must be up to me and in any case, Markovnikov's Rule in high school you know it or you do not know it, and you learn it as an act of faith because the teacher and the book tell me so, not because halogenations of olefins are made in the high school laboratory and because we have at our disposal the techniques to find out which reaction product is the majority, not even if there is only one reaction product or a hundred. I also missed the concept of evaluation, so, in general. That annoying concept that is so easily eluded, especially if others do it to us (although also if we do it to ourselves, to be honest). But I said to myself... it will be in the general part. I will read it another time with a fresher mind... Instead, I found myself with a forest of general, specific competences and there were no more stages in the competence reaction because the legislator did not think of them, otherwise... more to clear. Entropy, as we know, always increases. The competence forest... oh, how funny, as if we had gone to Narnia, going through a wall or entering that gloomy closet, when physicists and chemists are competent, which is to know how to do, by definition, although we are well aware that, in our disciplines, abstraction and imagination are often the best allies and in some cases the act of faith mentioned above, that is, we were already there when the competences arose like mushrooms with the

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humidity and the warmth. This time the competitions did not come alone. They brought the learning situations, which must be the real situations that we have all experienced, not always observed, before we understand what happens when water does not freeze, but solidifies and does not do so at 0ºC, if we add salt and/or other substances to it. Hence the salt (mixed with sand to increase friction) on the roads of countries like ours, because in others, with salt, the saltshaker, they do not even have to start to prevent us from sliding like skaters on shoes, wheels, or X. In short, I had changed the signifiers, because the signifies were already there, with us Physics and Chemistry students and some others, in the forest of competences.

I said to myself, under the shade of the hazel tree, "they have already put us in a new labyrinth. They have already changed the exit route and, I'm afraid, the exit will lead to the same place as always, but the road seems to me to have more corners than usual. We will get out, but I don't know how. Well, I do know that I am told that we have to get an exit profile. This is new and daring, like ignorance. We are going to come out profiled and some of us will come out in profile. How elegant and how daring! I have never seen this term before on a resume. This is the lever that this law is going to force you to use so that the can will open and the nice profile you desire will come out. Oh, Archimedes... you are already here. Who will evaluate how we get out of the labyrinth? Who will evaluate the path followed, its efficiency? Surely someone from outside, but not very important, someone from some international organization, some statistics guru, who will pat us on the back and see you next time, but you should know that you have room for improvement".

After this reading, I decided to rest and refused to enter the labyrinth alone. I decided that I would go in with my colleagues in the department and in the faculty. I was very lazy and a little afraid to go in alone, it must be said. I felt again the hot flushes and the cold sweat that follows them, which cooled my skin by evaporation. Blessed thermodynamics and its principles.

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When August comes to an end, I always look back the reasons that led me to teach Physics and Chemistry. I need it, yes no.... Some were purely practical, but very real and related to having a job that would allow me to maintain my physical survival and my dreams of research. And another more idealistic and to which almost all the teachers I know appeal in the first place, the vocation, the so hackneyed I like to teach. The pleasure one feels when showing those who do not know the world we know, while trying to sow in them the seed of curiosity to unveil what is to be known, that is, the curiosity to learn and get to know. The latter is not said, but it is the underlying truth, the unclear image behind the translucent glass that only lets the light pass through and see a blurred object behind it, but so attractive that it makes you devote body and soul to remove the wrinkles from the glass.

And I need to remember and reposition every year this motive, which is more of a purpose, because, although it is the one that underlies the task of the teacher, the professor, the one who teaches, it is generally diluted by a solvent that is increasingly universal and that leaves behind the solutes, the more specific and no less essential ingredients. As I say, it is better not to lose the North. That North that continually hides like the Sun in eclipses and that, as we already know from experience, always comes out again, even if we spend a good while in the twilight, it is always there, and that feeds our hope, illusion and, above all, our patience.

It also comes to my mind that I never wanted to be a teacher, I always wanted to be a researcher. I am curious by nature and I am attracted to find out the why of things; It is an attractive force, at a distance, almost magnetic that leads me to get many times in leafy places where it is better not to be and not to know why you start to get infected with viruses, against which, as we know, especially since COVID-19 came into our lives, you can only overcome them and although, as the song says, what does not kill you makes you stronger, sometimes you are very affected after the journey of

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knowing and having cleared the path that leads to unveil the mystery that attracted me so much at the beginning of each investigative adventure. The mysteries that most attract me are those that are not perceived by the senses, but of which I have evidence, signs, more or less sophisticated that something is happening there, but that it is only "showing its paw".

Then I discovered that unraveling a mystery, a phenomenon, a behavior, is not funny if it is not told and what is more important, it has no value if it is not told by describing the adventure lived to unravel and unravel it, with all the details and data, analyzing the results and obtaining conclusions. Everything so that other curious people can reproduce it, modify it, and improve it. The others are members of an unknown team and that, in many cases, I will never meet, but I know that they exist and will exist, as well as that they existed because they were the ones who inoculated me with the virus.

And of course, I have the last discovery that links with the purpose: we must teach as many as possible, because someone will be infected and will continue with curiosity as a flag, unveiling the mystery and explaining in more depth and detail the why of things. He will continue to improve our lives, even if he leaves his own behind. So, researcher and teacher had to be in the same person and here I am still, researching, learning, and teaching, each time in different subjects, developing new competences in each new mystery and trying to make curious learners more and better, as they say now, more competent. Although I am still waiting for the transcendent evaluation, what fear do we have of the truth and above all of having to react, changing, if the truth tells us that we are not doing well?

To teach academically you have to do it in a formal framework (the informal and if that ...), at least in my environment, it is linked to a branch of knowledge and a curriculum, and within a regulatory framework, not very stable, at least in Spain. I ended up choosing Chemistry and what common mortals know as secondary education (higher education is a hunting and

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fishing preserve in which I did not want, nor do I want, to pay the preserve fee due to personal convictions). As in this educational stage, Chemistry always goes hand in hand with Physics, I found myself teaching Physics and Chemistry in a private school and later in several public high schools, first in Baccalaureate and then in Secondary Education.

1.- INTRODUCTION

According to the RAE, one of the meanings of competence is "expertise, aptitude or suitability to do something or intervene in a given matter". In today's educational environment, the replication of concepts and operations does not imply that a student is capable of performing adequately throughout his or her life.

For this reason, in 2003, the OECD developed the DeSeCo project (Definition and Selection of Competencies), the relevance of which led countries to reformulate their respective school curricula by enacting educational laws adapted to this frame of reference. The Organic Law 2/2006, of May 3, 2006, on Education (LOE) already incorporates key competencies into the educational system. It should be pointed out that the General Organic Law of the Educational System (LOGSE, 1990) already had a precedent when it talked about the skills that students should attain at the end of each stage.

The current Organic Law 3/2020, of 29 December, which amends the Organic Law 2/2006, of 3 May, on Education (LOMLOE) changes and introduces some elements of the curriculum such as the exit profile of students linked to the key competences, the operational descriptors from which the specific competences of each area, subject or field are specified, the basic knowledge corresponding to the knowledge, skills and attitudes of each subject.

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Among the challenges presented in the LOMLOE, among others, are the improvement of the student's level of competence to achieve school success with special emphasis on attention to diversity, reducing the early school dropout rate in Spain to 16.7% in males and 9.7% in females in 2021 (compared to 11, 4% and 7.9% respectively in the EU), increase STEAM vocations, improve the teaching profession through curricular and teaching innovation, achieve an education in civic values so that future citizens acquire a critical and participative spirit in the society in which they live and This law is ambitious in that it develops a pragmatic approach to education in which learning to know and learning to do coexist with a social approach in which learning to live together and learning to be are the result of the attitudes and values that students are expected to reach in their integral education in the complex society they live in today.

That is why, for yet another year, the course has begun with uncertainties (such as the Heisenberg principle mentioned above), learning to teach and reprogram as we go along, with new challenges to face and demands added to those already present in our daily work.

2.- THE STUDENT FACING THE COMPETENCES

Given the changing nature of life and society, teachers must prepare students to be able to successfully face this society whose speed of change is increasingly frenetic. Students are likely to be professionals in jobs or work environments that are currently unknown, and many students often question the reason for learning certain concepts because they do not see a direct application in their future. For these reasons, it is necessary to motivate the autonomous learning of students in a critical and decisive evolutionary stage for them.

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One of the biggest challenges faced by teachers in developing their work under the umbrella of the LOMLOE is the change in the focus of assessment. It is no longer focused on content, but on the acquisition of the specific competencies of each subject to achieve the key competencies determined in the exit profile of secondary school students. This entails a change in the methodology used so far. Memorization of facts and procedures is important, but not enough to be competent in different aspects.

This classical, magisterial methodology, which society has experienced as students of the 20th century, and with which teachers are familiar and comfortable, must be converted into another methodology focused on the autonomous and responsible learning of 21st century students, with teachers playing a mediating, facilitating, or guiding role through learning situations. The use of active and contextualized methodologies by teachers must facilitate student participation for the acquisition of both knowledge and skills for their use in real situations. Addressing it satisfactorily implies keeping in mind the key pillars of the teaching-learning process: the students and the teachers, without forgetting the third pillar that balances it: the family. For their part, teachers lack the necessary time to get out of their comfort zone, master and apply in the classroom more active and attractive methodologies for students, which are relevant to their training. Although they are familiar with different methodologies, a period of reflection and updating is needed to develop their teaching work with confidence. The haste in the application of the law has led to work with the best intentions, but without knowing exactly how to carry out this methodological change, being advised by what is proposed in different editorials and by what can be interpreted in the legislative framework.

On the other hand, students are accustomed to being passive agents in learning, although attempts are made to the contrary. Internet access "facilitates" the search for information; however, it requires greater maturity

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in selecting reliable sources. Likewise, it is easier to copy and paste information than to write it in one's own way. This immediacy can confuse students, making them mistakenly believe that the learning process has to be just as fast, which leads to demotivation, low self-esteem and abandonment of the subject, which, like everything else in life, requires effort and dedication. The teaching challenge lies in applying a novel and attractive methodology for students, as well as selecting motivating activities that consolidate the necessary knowledge they need to have, being an active element of their own learning.

Last but not least, there is the family. The family environment is key to the good development of the adolescent. Families that understand and value the work and effort students have to make and encourage it at home, as well as the work of teachers, help their children to be more responsible and become better citizens.

3.- PHYSICS AND CHEMISTRY AND THEIR SPECIFIC COMPETENCES

The specific competences of the subject of Physics and Chemistry and their connection with the descriptors of the key competences established to obtain the exit profile of the students in the secondary stage show that the relationship goes far beyond the competence in linguistic communication (CCL) and mathematical competence and competence in science, technology and engineering (STEM). Figure 1 shows that digital competence (CD) and personal, social and learning to learn competence (CPSAA) have almost the same degree of involvement in the achievement of the students' exit profile. This shows that digital competence is key to developing the learning autonomy of students born in this century, the so-called digital natives.

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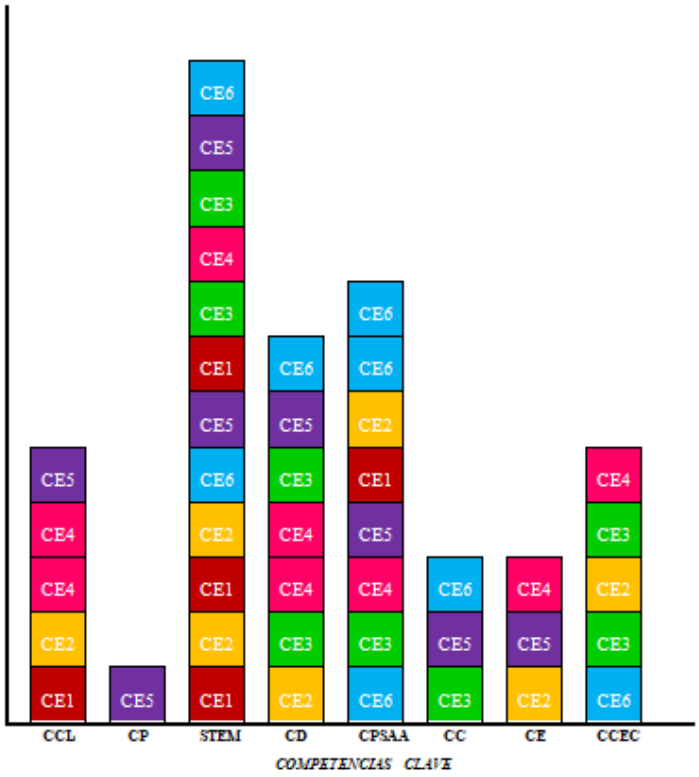
Competencia Específica	Descriptores del Perfil de salida	Competencia Específica	Descriptores del Perfil de salida
CE1	CCL1 STEM1, STEM2, STEM4 CPSAA4	CE4	CCL2, CCL3 STEM4 CD1, CD2 CPSAA3 CE3 CCEC4
CE2	CCL1, CCL3 STEM1, STEM2 CD1	CE5	CCL5 CP3 STEM3, STEM5 CD1



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Graph 1. Connection between the Specific Competences in Physics and Chemistry and the Key Competences.

We should highlight the role of entrepreneurial competence (CE) in the creation of materials and collaborative work among peers to understand the importance of science in the improvement of society and the applications and repercussions of scientific advances, which unfortunately have been and are in the news since the COVID pandemic hit in 2020.

When looking at the connection established by Royal Decree 217/2022, of March 29, establishing the organization and minimum teachings of Compulsory Secondary Education between the Specific Competences of Physics and Chemistry and the descriptors of the Output Profile shown in graph 2, it can be observed that:

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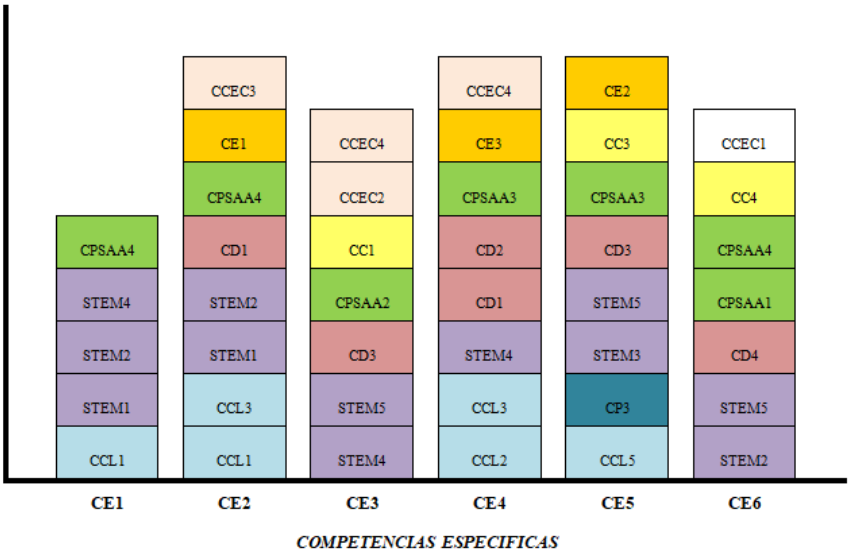
- Mathematical, science, technology, and engineering (STEM) competences are present in all the specific competencies, as would be expected given the nature of the subject of Physics and Chemistry.

- The personal, social, and learning to learn competency (CPSAA) is also reflected in the six specific competencies, which underlines the active role of students in their learning that this new law seeks to implement.

- Although the digital competence (CD) is in a greater number of specific competences than the competence in linguistic communication (CCL), the number of descriptors of both competences is the same, so their importance is equal in the development of learning.

- Looking at the number of descriptors for each key competency, we see that far behind the STEM competency are CPSAA together with CCL and CD, which have the same number, which underlines the instrumental nature of the subjects of Language and Technology in the process of autonomous and meaningful learning of the student.



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Graph 2. Connection between the Specific Competences in Physics and Chemistry and the descriptors of the Exit Profile.

The challenge presented by the methodological change focused on the student as the protagonist of his/her learning and evaluating by specific competencies instead of learning standards is the cornerstone of the teaching work. Royal Decree 217/2022, of March 29, clearly states the connection between the specific competences of each subject with the descriptors of the exit profile of secondary school students, that is, the relationship between both types of competences (the specific ones of the subject and the key ones that any student in the Spanish territory must acquire), and it also relates the evaluation criteria with each specific competence. However, it does not establish a clear interrelation between the basic knowledge (the former contents), the specific competences and the evaluation criteria, except for CE3, which is directly related to the IUPAC nomenclature.

On the other hand, article 2 f) defines learning situations ("situations and activities that involve the deployment by students of actions associated with key competencies and specific competencies, and that contribute to the acquisition and development of these"), giving teachers the freedom to establish this association in their teaching activity using more active and innovative methodologies. In this sense, the material provided by publishers is disparate. While some publishers have continued to maintain the format of units or topics that include theoretical content, exercises and, at the end, learning situation activities, others have changed the textbook, dividing it into two distinct blocks: learning situations and basic knowledge. In the learning situations, different activities are collected for students to carry out individually or in groups with reference to the corresponding basic knowledge card. The basic knowledge block consists of theoretical content cards together with consolidation exercises.

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This methodological change using learning situations, although very attractive and promising in black and white, is not so much so in the reality of the classroom. The most relevant advantage is the degree of student satisfaction when they manage to perform a task autonomously and the better acquisition of knowledge. However, the difficulties detected on a daily basis can be summarized as follows:

- More time spent in the execution of the activities by the students, including their subsequent correction and explanation, so the selection of the type of activities is crucial to optimize the session at the school and to address the basic knowledge (contents) set out in the Royal Decree.
- Different pace of work of the students, while some perform the tasks in a reasonable time others need more, so setting an appropriate time for implementation is essential.
- Greater number of students with educational needs, who require highly guided and previously solved activities, which is contradictory to the active methodology that is intended to be implemented.
- A high ratio that hinders greater individualized and mediated attention.
- More time spent by teachers in the preparation of their classroom programming, the choice of activities and their subsequent correction outside school hours, which means an increase in work stress.

Given the nature of the subject of Physics and Chemistry, a greater specification for the realization of laboratory practices is missing, assigning split hours to carry them out safely.

As for the evaluation by competences, the real challenge is how to evaluate correctly and objectively these six specific competences. Bearing in mind that the educational background (as students and as teachers) is the

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evaluation of theoretical and/or practical contents, changing to evaluation by competencies is like being inside a circus tent and trying to jump from one trapeze to another, but without a safety net, especially in those that have a social character or are linked to aspects of the personality or related to emotions. At this point, it is worth reflecting on the tools that would be needed to assess these competencies, since subjectivity underlies these considerations.

The practical nature of the subject of Physics and Chemistry helps in a certain way to evaluate by competences. In fact, in the evaluation of individual or group work on scientists, research topics or laboratory practices, several specific competences are being evaluated globally. Article 2 c) of Royal Decree 217/2022, of March 29, defines specific competencies as "performances that students must be able to display in activities or situations whose approach requires the basic knowledge of each area. The specific competencies constitute an element of connection between, on the one hand, the key competencies, and on the other hand, the basic knowledge of the areas and the evaluation criteria". The teacher's vertigo appears when the legislative framework does not specify a clear interrelation between the different basic knowledge and the specific competencies. The evaluation criteria of each specific competency are the link with the basic knowledge, but in a very open and not very concrete way in comparison with the previous law, as shown in tables 1 and 2.

Royal Decree 1105/2014, of December 26, establishing the basic curriculum for Compulsory Secondary Education and the Baccalaureate (LOMCE)					
Physics and Chemistry for 2nd and 3rd ESO			Physics and Chemistry for 4th ESO		
Contents	Evaluation	Assessabl	Contents	Evaluation	Assessabl

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	criteria	e learning standards		criteria	e learning standards
Block 1. Scientific activity	6	10	Block 1. Scientific activity	8	9
Block 2. Matter	11	24	Block 2. Matter	10	18
Block 3. Changes	7	12	Block 3. Changes	8	14
Block 4. Forces and movements	12	22	Block 4. Forces and movements	15	31
Block 5. Energy	11	25	Block 5. Energy	6	13
Total	***47***	***93***	***Total***	***47***	***85***

Table 1.

Real Decreto 217/2022, de 29 de marzo, por el que se establece la ordenación y las enseñanzas mínimas de la Educación Secundaria Obligatoria. (LOMLOE)					
Physics and Chemistry for 2nd and 3rd ESO			Physics and Chemistry for 4th ESO		
Specific competences	Evaluation criteria	Basic knowledge	Specific competences	Evaluation criteria	Basic knowledge

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CE1	3	A. Basic scientific skills. B. Matter. C. Energy. D. Interaction. E. The change	CE1	3	A. Las A. Basic scientific skills. B. Matter. C. Energy. D. Interactio n. E. The change
CE2	3		CE2	3	
CE3	3		CE3	3	
CE4	2		CE4	2	
CE5	2		CE5	2	
CE6	2		CE6	2	
Total	***15***		***Total***	***15***	

Table 2.

By comparing both tables, we see that not only the number of evaluation criteria has been reduced by 66% (from 47 to 15), but also that the criteria for each content are not specified, the latter being the fundamental change that must be faced, almost on the fly. In a traditional scheme, the evaluation prioritized conceptual contents, and the current shift is directed towards competency criteria encompassing procedures and attitudes.

This freedom that the legislative framework leaves to the professionalism of teachers would be well spent if they had the time to rethink or, rather, reassign the basic knowledge and its activities to the evaluation criteria of each specific competency. This course, in which the subject is being taught according to the LOMLOE, will allow us to reflect and readjust the methodology, and more importantly, to involve students in being active agents of their learning, emphasizing the bases of Cody Blair's learning pyramid. That is, to encourage the student to stop passive learning and become increasingly active, as illustrated in image 1.

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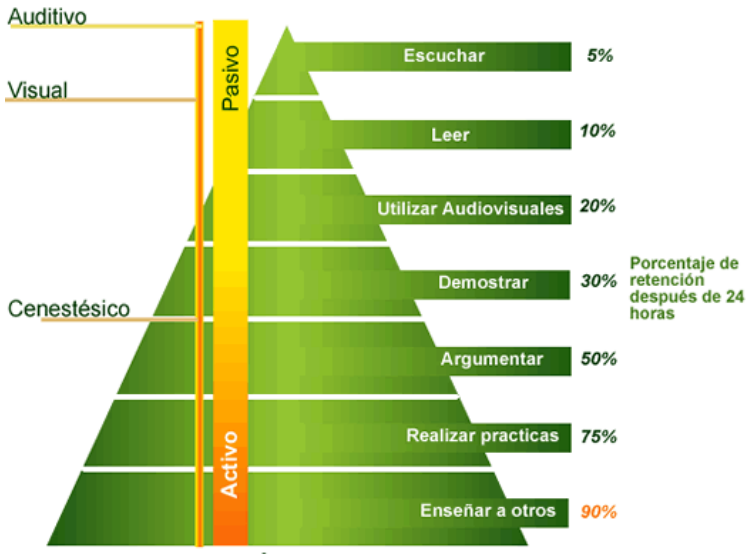

Image 1. The learning pyramid.

Source: Cody Blair. *Cómo aprenden y recuerdan los estudiantes de manera más efectiva.*

An approach to concretize teaching practice would be to relate each core knowledge activity to the corresponding evaluation criteria and specific competencies, to ensure that all six are evaluated in an equitable manner. Table 3 is a suggestion, by way of example, that helps to mark the evaluation criteria that are assessed with the realization of the activities proposed for a given basic knowledge. In this graphic way, it will be easy to visualize the close relationship between the specific competencies (with the evaluation criteria) and the basic knowledge on which they are based (with the activities/learning situations proposed by each teacher).

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	Specific Comp.	CE1			CE2			CE3			CE4		CE5		CE6	
		Eval. Crit.			Eval. Crit.			Eval. Crit.			Eval. Crit.		Eval. Crit.		Eval. Crit.	
Basic knowledge	Activities	1.1	1.2.	1.3.	2.1.	2.2.	2.3.	3.1.	3.2.	3.3.	4.1.	4.2.	5.1.	5.2.	6.1.	6.2.
A	Elaboration of a scientific report after carrying out a simple experimental work at home and its subsequent oral presentation (e.g.: how to know if a bottle is really empty).	X			X		X	X				X	X			
B	Elaboration of an infographic or timeline, by groups, with the different atomic models that have emerged throughout history.	X			X								X		X	
C	Verification of the factors that influence the speed of a reaction (e.g.: oxidation of fruit).	X			X	X						X				X
D	Analysis of different routes and means of transport to travel in a sustainable way.		X			X		X				X				
E	Analysis of the energy consumption of various household appliances and		X	X				X	X			X				

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	the economic cost.															
E	Elaboration of a report with the improvements that could be made to reduce energy consumption at the domestic level, in the school and in society.			X				X					X	X		X

Table 3. Example of relationship between learning situations and specific competencies through their corresponding evaluation criteria.

Detailing the activities proposed in the table should not be understood as a rigid and restricted way of carrying out the teaching task, but as an aid to carry out this task within the new law and to facilitate the change of approach that is intended to be achieved. As with everything else, this should be done in a calm and reflective manner, incorporating small but subtle changes that favor this transition.

The mere fact of considering how to deal with competency-based assessment and trying to find some light to illuminate the right path is already a decisive step towards building the foundations for the changing future that lies ahead.

One of the biggest rejections that usually produces so many legislative changes in education is the accelerated manner in which the different laws are applied and their subsequent modifications in short periods of time. Although each law tries to improve aspects of the previous one, the speed with which the reforms follow one after the other (image 2) means that they are not received with the welcome they deserve. In the same way that infrastructure improvement works are carried out and all citizens assume the discomfort that this entails due to the progress and comfort it will bring,

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teachers can also assume these legislative changes, if it were known that several years (more than a decade) will pass until the next reform, that is, enough time to not have the feeling of being installed in the drastic, continuous and permanent change, with the labor and personal wear that this entails. We hope that this law will be long enough for all the effort and dedication that is being put into it to be rewarded and for the methodological change to be implemented with enthusiasm and confidence. Our students, in particular, and society, in general, will be grateful.

CHRONOLOGICAL AXIS OF THE LAWS REGULATING THE EDUCATION SYSTEM							
Pre-constitutional		Post-constitutional					
Moyano Law **LIP** Law of Public Instruction (1857)	*Villar Palasi Law* **LGE** General Education Law (1970)	**LODE** (1980)	**LOGSE** (1990)	**LOCE** (2002)	**LOE** (2006)	**LOMCE** (2013)	**LOMLOE** (2020)

Image 2.

Source: taken as a reference from the document:
http://www.usie.es/SUPERVISION21/2015_38/SP_21_38_Articulo_Leyes_educacion_ultimos_200_anyos_Berengueras_y_Pont.pdf

4.- COMPETENCE TO COMPETENCE

Specific competence 1: Understand and relate the reasons why the main physicochemical phenomena of the environment occur, explaining them in terms of the appropriate scientific laws and theories, to solve problems to apply them to improve the nearby reality and the quality of human life.

Exit profile descriptors: CCL1, STEM1, STEM2, STEM4, CPSAA4.

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This competence is fundamental in the development of scientific thinking and its contextualization with the phenomena that occur around us. Understanding, relating, and explaining are cognitive actions of different complexity applicable to any subject. Among the descriptors associated with this competency, CPSAA4 ("performs self-evaluations on his/her learning process, seeking reliable sources to validate, support and contrast information and to obtain relevant conclusions") stands out, since the self-evaluative process in the acquisition of true knowledge through reliable sources should be carried out through methodological strategies that also include co-evaluation and heteroevaluation.

Specific competence 2: Express the observations made by students as questions, formulating hypotheses to explain them and demonstrating these hypotheses through scientific experimentation, inquiry and the search for evidence, in order to develop the reasoning of scientific thinking and improve skills in the use of scientific methodologies.

Exit profile descriptors: CCL1, CCL3, STEM1, STEM2, CD1, CPSAA4, CE1, CCEC3.

The application of the scientific method is present not only in scientific-technological areas/subjects, but it is also extensible to other educational, personal, social, and professional fields. The selection and treatment of information obtained nowadays, mainly through the Internet, must be carried out with a critical spirit to differentiate between reliable and unreliable sources. This aspect is important in a world where fake news, disinformation and pseudoscientific knowledge are the order of the day.

Descriptor CCEC3 ("expresses ideas, opinions, feelings and emotions through cultural and artistic productions, integrating their own body and developing self-esteem, creativity and a sense of their place in society, with an empathetic, open and collaborative attitude") is included in parallel to other descriptors more related to the subject of Physics and Chemistry. One

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might think that it is decontextualized in relation to the rest of the descriptors. In his talk "Schools kill creativity", Sir Ken Robinson advocates a change in an obsolete academicist and limiting education system. Encouraging the expression of ideas, creativity and innovation should begin with a self-reflection of our teaching work in the classroom. It is necessary for teachers to get out of their comfort zone, taking small steps, being creative and innovating to encourage our students to be creative and innovative as well.

Specific competence 3: Be fluent in the basic rules and norms of physics and chemistry in terms of IUPAC language, mathematical language, the use of correct units of measurement, the safe use of the laboratory, and the interpretation and production of data and information in different formats and sources, to recognize the universal and transversal character of scientific language and the need for reliable communication in research and science between different countries and cultures.

Exit profile descriptors: STEM4, STEM5, CD3, CPSAA2, CC1, CCEC2, CCEC4.

It is fundamental in Physics and Chemistry the correct use of scientific-mathematical language as another way of transmitting information that avoids ambiguities that may appear in colloquial expressions.

The descriptor CPSAA2 ("understands health risks related to social factors, consolidates healthy lifestyles at physical and mental level, recognizes behaviors contrary to coexistence and applies strategies to address them") is closely related to transversal elements and, of course, applicable to personal and social spheres. According to the text of this specific competence, it can be considered that this descriptor is not framed in such competence. While it is true that the "safe use of the laboratory" is a requirement and a need that we can contextualize in a personal and professional future. The curriculum of this subject lacks a real presence of

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experimental practices in which some of the competences indicated here can be embodied and evaluated.

Finally, the acquisition of a minimum scientific culture necessary to be useful in everyday situations is defined by means of the descriptors CCEC2 y CCEC4.

Specific competence 4: Use digital platforms and varied resources critically, efficiently, and safely, individually and in teamwork, to foster creativity, personal development, and individual and social learning, by consulting information, creating materials and communicating effectively in different learning environments.

Exit profile descriptors: CCL2, CCL3, STEM4, CD1, CD2, CPSAA3, CE3, CCEC4.

In the information society in which we find ourselves, it is important that students acquire a critical and efficient spirit in relation to information sources, social networks, and virtual learning environments. This competence is not exclusive to the subject of Physics and Chemistry and could be exportable to any other subject/educational field. Our students need to develop skills to be able to relate in an increasingly digitized society where communications, management, information are made through various platforms and networks.

Specific competence 5: Use the strategies of collaborative work, fostering growth among equals as the entrepreneurial basis of a critical, ethical and efficient scientific community, to understand the importance of science in the improvement of society, the applications and repercussions of scientific advances, the preservation of health and the sustainable conservation of the environment.

Exit profile descriptors: CCL5, CP3, STEM3, STEM5, CD3, CPSAA3, CC3, CE2.

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Knowledge has no borders; it is interdisciplinary as it is not exclusive to one area or subject. Likewise, collaboration between people and teams is necessary to achieve greater efficiency and effectiveness in obtaining results.

This competence is mainly focused on learning teamwork strategies necessary for the development of activities that can also be applied in a professional and labor future (CE2). Respect for diversity, collaboration and cooperation, equity and equality are values that are implicit in this competency and serve to promote social cohesion.

In conclusion, this competence could be perfectly applicable to any area/subject/field, simply by contextualizing it together with the basic knowledge of the same area/subject/field.

Specific competence 6: Understand and value science as a collective construction in continuous change and evolution, in which not only the people dedicated to it participate, but also requires interaction with the rest of society to obtain results that have an impact on technological, economic, environmental, and social progress.

Exit profile descriptors: STEM2, STEM5, CD4, CPSAA1, CPSAA4, CC4, CCEC1.

The impact that scientific and technological development has on society is unquestionable, both for actions that improve the quality of life of its citizens and for those that have a negative and counterproductive effect on health and the environment. This bi-directional science-society relationship is increasingly evident in a globalized world. It should not be forgotten that science is at the service of society to provide solutions to the challenges of everyday life and that it involves being aware and assuming a personal and social commitment. In this regard, it is worth mentioning the SDGs of the 2030 Agenda.

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In this competence, the descriptor CPSAA1 ("regulates and expresses their emotions, strengthening optimism, resilience, self-efficacy and the search for purpose and motivation towards learning, to manage challenges and changes and harmonize them with their own objectives") where the emotional sphere of the individual is added as a basis to achieve the objectives proposed in their personal and formative development. However, none of the evaluation criteria associated with this competence is directly related to this descriptor.

5.- FROM PISA TESTS TO SCIENTIFIC COMPETENCE

The OECD's Programme for International Student Assessment (PISA) began its journey in 2000, assessing reading literacy, in the following call the mathematical competence and in 2006 the scientific competence was evaluated, incorporating, as a novelty, the evaluation of students' attitudes towards science, with questions integrated into the cognitive test. In the 2015 edition, the digital format was used, so that, for the first time, it was possible to evaluate the students' ability to carry out a scientific investigation through the design (simulation) of experiments, and to interpret the resulting evidence.

PISA establishes a baseline level (level 2, on a scale where 6 represents the maximum level and 1b the minimum) at which participants begin to demonstrate skills that will enable them to participate effectively and productively in their lives as learners, workers, and citizens. The extensions incorporated into the PISA for Development (PISA-D) science framework represent an attempt to obtain more information on students whose performance is currently at or below level 1 (1a, 1b, 1c), to contribute to the monitoring and achievement of the education-related SDG, with an emphasis on leaving no one behind. PISA-D is based on the PISA 2015 science framework.

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Science literacy is defined in PISA 2015 as "the ability to engage with issues related to science and scientific ideas as a reflective citizen. A scientifically literate person is willing to engage in reasoned discourse about science and technology, which requires competencies to explain phenomena scientifically, evaluate and design a scientific investigation, and interpret scientific data and evidence." And student performance in science is assessed through questions related to contexts, knowledge, and skills.

The contexts that are used to provide meaning and usefulness to students' learning as well as to engage them emotionally and cognitively are classified as:

- Quotidian: situations that occur in the daily life of students.
- Utilitarian: situations that are not in their daily life but are likely to occur.
- Hobbies and leisure: contexts related to activities that students can perform as a means of distraction or enjoyment.
- Fantasy: contexts that are the product of imagination, which do not correspond to real or plausible situations.
- Academic: evaluation contexts that do not make sense outside the school environment.

The same test can exhibit several contexts at the same time, so they are not mutually exclusive. In the article published by Rosales et al. (2020), the percentage of contexts in the PISA Biology and Geology tests from 2000 to 2015 is observed, with utilitarian (48%) and everyday (26%) being the most frequent, followed by academic (14%) and hobby and leisure context (12%). They conclude that the high percentage of everyday and utilitarian context is consistent with the recommendations that have been given to obtain meaningful learning and foster general interest in science learning. Ideally,

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the context of hobbies and leisure should surpass the academic context due to its high motivational potential, since it would allow students to see how what they do in their free time is related to what they learn at school. Although there are numerous references to science content in movies, books or comics, the fantasy context has not been detected in any of the tests reviewed, increasing it would mean providing students with a critical spirit in the face of science fiction series.

These contexts are related to the learning situations that are defined in article 2f) of Royal Decree 217/2022, of March 29, as "situations and activities that involve the deployment by the students of actions associated with key competences and specific competences, and that contribute to the acquisition and development of them". Therefore, teachers must make an effort to use an increasing number of contexts that motivate and capture the students' interest in the subject of Physics and Chemistry, especially in the fantasy context.

The different types of knowledge assessed in the PISA tests are threefold:

- Content knowledge: knowledge of facts, concepts, ideas, theories about the natural world established by science.
- Procedural knowledge: knowledge of practices and concepts on which empirical investigations are based (repetition of measurements, control of variables and procedures to represent and communicate data).
- Epistemic knowledge: involves understanding the role of questions, observations, theories, hypotheses, models, and arguments in science; recognizing the variety of forms of scientific inquiry and understanding the role of peer review in establishing reliable knowledge.

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People need all three forms of scientific knowledge to perform the three competencies of scientific competence. It is not based on content knowledge alone, but encompasses a broader view of the kind of science knowledge required of fully engaged citizens.

Scientific competence is broken down into three:

- Explain phenomena scientifically.
- Interpret data and evidence scientifically.
- Evaluate and design scientific investigations.

These three competencies require knowledge. The first competency requires content knowledge, the last two require procedural knowledge, and all three competencies require epistemic knowledge.

The procedural and epistemic knowledge are both needed to identify questions that are amenable to scientific inquiry, to judge whether appropriate procedures have been used to ensure that claims are justified, and to distinguish scientific issues from matters related to values or economic considerations. This definition of scientific competence assumes that, throughout their lives, individuals will have to acquire knowledge, not through scientific inquiry, but using resources such as libraries and the Internet. Procedural and epistemic knowledge are essential in deciding whether the many demands for knowledge and understanding that pervade contemporary media are based on the use of appropriate procedures and are justified.

In addition, the competency-based perspective also recognizes that there is an affective element to the student's demonstration of these competencies: students' attitudes or disposition toward science will determine their level of interest, sustain their engagement, and may motivate them to take action (Schibeci, 1984). Thus, the scientifically literate person would typically have an interest in scientific topics; be engaged in science-related issues; be

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concerned with issues of technology, resources, and the environment; and reflect on the importance of science from a personal and societal perspective. This requirement does not mean that these individuals are necessarily willing to become scientists but rather that these individuals recognize that science, technology, and research in this field are an essential element of contemporary culture that frames much of our thinking.

Therefore, the PISA 2015 science competency used in PISA-D consists of four related aspects: contexts, skills, knowledge, and attitudes, as shown in Figure 3.

Image 3. Interrelationships among the four aspects of the PISA 2015 science literacy assessment framework.

Source: OCDE (2016a), *Marco y pruebas de evaluación de PISA 2015*, http://dx.doi.org/10.1787/9789264255425-en.

In the PISA-D report (OECD, 2017) and in the PISA 2018 report (OECD, 2019), a tool is shown that allows collecting test information in terms of two dimensions: knowledge and skills, as illustrated in image 4. In addition, each item can be tracked by employing a third dimension based on depth or level of knowledge. This last dimension allows the cognitive demand of the items to be categorized as low, medium, or high. This provides a means to operationalize cognitive demand, as each question can be categorized based on the realization of demands of the following types:

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- Lows. Carrying out a one-step procedure, for example, recalling a fact, word, principle, or concept, or locating a single point of information in a graph or table.

- Mediums. Use and apply conceptual knowledge to describe or explain phenomena, select appropriate procedures involving two or more stages, organize data/visualization, interpret, or use simple data sets or graphs.

- Highs. Analyze complex information and data; synthesize and evaluate evidence; justify; reason; provide multiple sources; develop a plan or sequence of steps to address a problem.

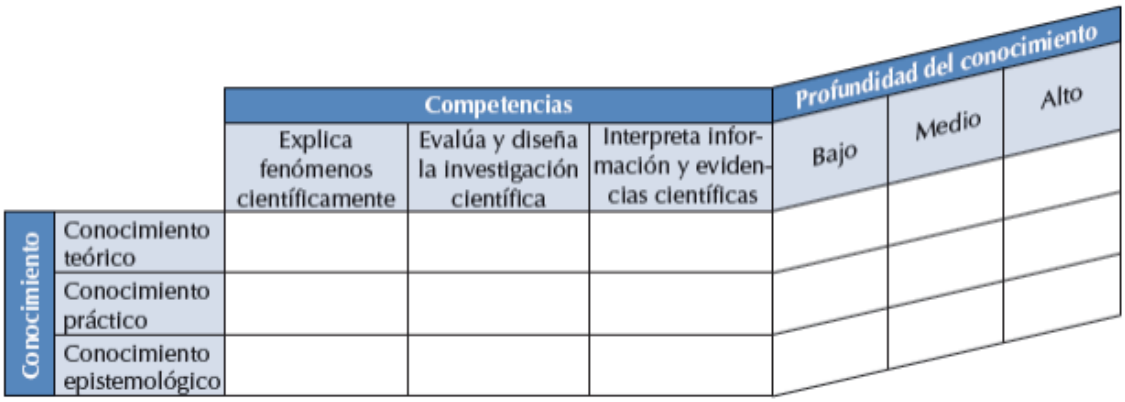

Image 4. Framework of cognitive requirements.

Source: OCDE (2017), *Marco de evaluación y de análisis de PISA 2015 para el desarrollo.*

Table 4 shows the relationship between the different types of knowledge with the scientific competences addressed in the PISA tests and the specific competences in Physics and Chemistry established in the current legislative framework and that teachers must address so that students acquire a scientific literacy that will enable them to become responsible citizens committed to sustainability.

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Knowledge	Scientific Competence PISA	Physics and Chemistry Specific Competences (LOMLOE)
Content	Explain phenomena scientifically	CE1, CE4
Procedural	Interpret data and evidence scientifically	CE3
Procedural	Evaluate and design a scientific investigation	CE2, CE5. CE6

Table 4. Relationship between types of knowledge, scientific competence (PISA) and specific competences.

6.- COMPETENCY-BASED ASSESSMENT

The PISA test sample study has been exploring various competencies through its different editions.

In the latest PISA 2018 report, it states that global competence aims to provide a comprehensive view of education systems' efforts to create learning environments that invite young people to understand the world beyond their immediate environment, interact with others with respect for their rights and dignity, and take steps toward building sustainable and thriving communities. Global competence education builds on the ideas of different models of global education, such as intercultural education, global citizenship education, and democratic citizenship education (UNESCO 2014b, Council of Europe 2016a). Despite differences in their approach and scope, these models share a common goal to foster students' understanding of the world and empower them to express their views and participate in society (Global Competence Framework, PISA 2018).

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Within the framework of global competencies, the aim is for people to be able to apply them in their daily lives in different areas:

1) the ability to analyze problems and situations of local, global and cultural significance (e.g. poverty, economic interdependence, migration, inequality, environmental risks, conflicts, cultural differences and stereotypes);

2) the ability to understand and appreciate different perspectives and worldviews;

3) the ability to establish positive interactions with people from different national, ethnic, religious, social or cultural backgrounds, or of different gender;

4) the ability and willingness to take constructive action towards sustainable development and collective well-being.

Education systems have been adapting to the current educational framework so that present and future citizens acquire democratic values of equality and social cohesion, participate actively in different areas, prosper in a sustainable economy and achieve personal, social and professional fulfillment.

This is the challenge added to the implementation of the current law and which is linked to the competency-based curriculum. In addition to the cognitive area, it is in the competences related to social, emotional, and civic aspects where we face an added difficulty due to the lack of elements or tools necessary to assess them (*El enfoque del currículo por competencias. Un análisis de la LOMLOE*. Dr. Francisco López Rupérez, 2022).

Its effective application in the teaching task is not being reflected now since we are still immersed in a model in which the evaluation of knowledge has a

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specific predominant weight over these other aspects. It could even be said that at some point an evaluation by competencies has been carried out surreptitiously, but without being explicitly or concretely included in the didactic programs.

The lack of training and information for teachers, the high dose of bureaucracy, the ratios of students in the classrooms and the haste to carry out the preparation of the corresponding programs based on the current regulations are some of the difficulties for its implementation. Added to this is how to carry out the evaluation of the criteria according to each subject using different evaluation instruments through learning situations that need to be designed appropriately according to the context of the center, classroom or student. An immense task in every sense.

It would be a mistake in this process to take as a starting point the basic knowledge to be imparted and obtained by the students, since we would continue working in an obsolete and incomplete cognitive model. Considering the evaluation criteria associated with the specific competencies of the subject, the appropriate learning situations must be proposed in order to observe the evidence of learning that will be evaluated by means of the aforementioned varied instruments (rubrics, objective tests, checklists, etc.). Here it should be noted that in the subject of Physics and Chemistry there is basic knowledge in which such situations are more easily elaborated, such as energy, interaction and change as they can be related to environmental issues, sustainable and technological development, while other blocks may be somewhat more complex as in the block of the subject where some concepts are more abstract and less visible especially for students at lower levels.

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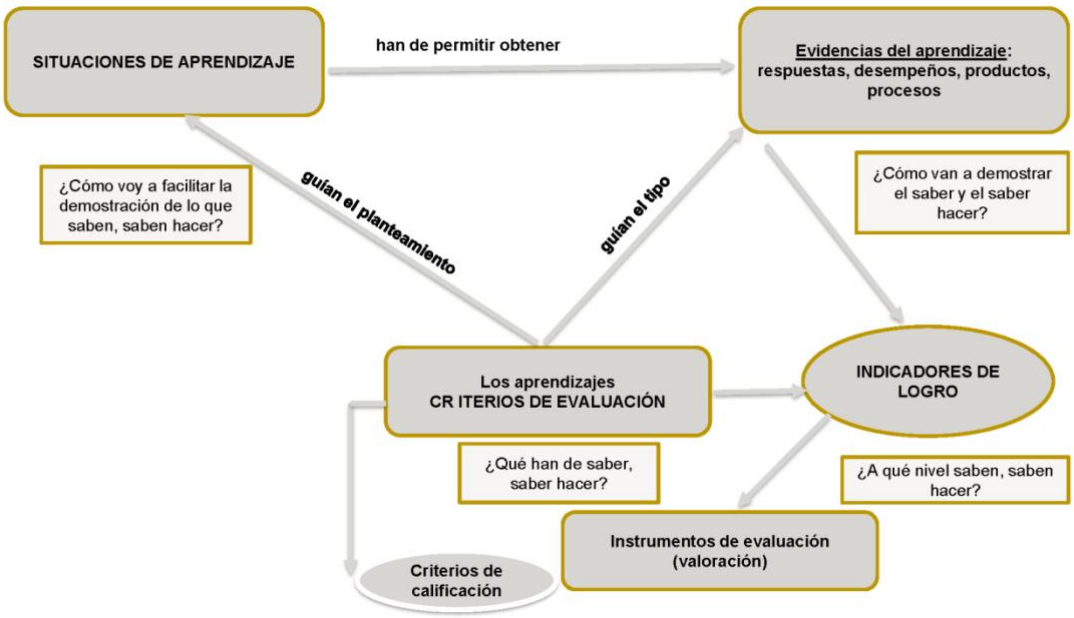

Image 5. Relationship between curricular elements.

Source: Educastur "Orientaciones para la elaboración de las concreciones curriculares y programaciones docentes de educación secundaria obligatoria y bachillerato".

To sum up, it is necessary to reflect deeply, calmly and with time to concretize the different programmable elements of the curriculum. A great deal of creativity and innovation on the part of the teacher is required to design the contextualized learning situations together with the different tables to later evaluate/grade objectively according to the established evaluation criteria with their corresponding achievement indicators.

The changes to be made to the teaching-learning model used up to now should be a challenge for teachers to try to improve the quality of education and should not prevent them from taking the first steps to achieve the fundamental objective of training citizens for a globalized, changing, technological, diverse, democratic, and sustainable society.

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EPILOGUE: AS CARBON, C, DIAMOND, DOES NOT FAIL

In the professional career of many teachers, there have been many "flying goals" and attempts to change routes, many labyrinths, many legislative and regulatory changes, perhaps too many, and in the end, tired, fed up with so much dizziness, we are left with "I'll see how my subjects are with the new law-regulations whatever". With so many new signifiers there are times when we feel like the particle in the box that is so much talked about in Quantum Chemistry, going from one place to another with unlikely chances of getting out. We wish they would let us be dual, like light sometimes wave and sometimes corpuscle and let us travel at higher and better speeds without asking us to do color magic to achieve ends that shape us. They induce in us, as the field theory says, methodological changes that nothing and nobody wants to evaluate, measure, or analyze, if only to learn what not to do.

What will we contribute to the competent citizen of the 21st century from our areas of knowledge? Well, it will surely be more criteria and values than competences; more character traits and skills related to the advancement of knowledge than knowledge; more taste for doing things well and doing good than knowing if everything is all right, although we will also try to do so. And above all and what may be really important: what is neither true nor valid nor necessary. We do not know all the above is classified in general, specific or subspecies competences, but they are necessary. But what I would like at least is that the virus of curiosity and the machete to clear the forest or jungle and to be able to see what is behind stays with some of our students and continues to advance the knowledge to live every day more and better and the more, the better.

Thus, most probably, as I said before, we will come out of this in profile, and we will all do what our best understanding allows us to do. In the end, as no one is going to tell us if we are doing well, badly or regularly... only the next

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generations and what they are capable of performing throughout their lives, will prove us right or take it away. We will adapt to evolve and survive in a new labyrinth, but with more and more uncertainties.

Reviewing my science mater, Chemistry, I always find answers and once again it is so. This time they are in what is known as Le Châtelier's Principle: any modification in a chemical equilibrium causes it to react to recover the equilibrium it has lost.

With how well Le Châtelier says it, let's trust and not succumb because I don't want me or my students to come out profiled or in profile. A Principle is forever, like a Theorem, like Carbon, C, diamond, pure carbon, crystallized at high pressure and temperature, hard as no one. It does not fail.

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