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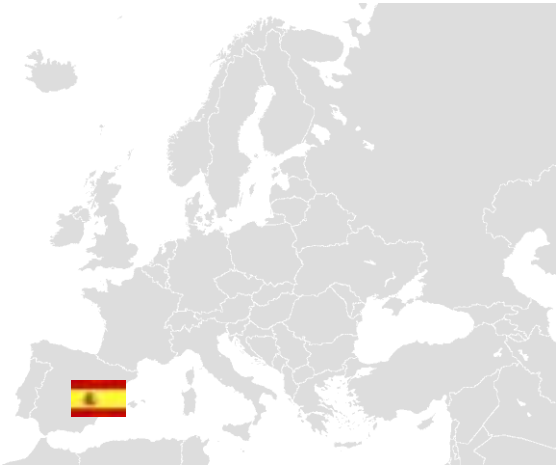

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# SUCCESSFUL EXPERIENCES IN CHEMISTRY TEACHING IN SPAIN

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## Abstract

*Despite the general consensus on the importance that science education is observed a decrease of interest of students in science studies. This has led to seek new methodological approaches to achieve greater motivation of our students, as well as a more effective education. This document is an overview of the most important publications on research into the science of Spanish-speaking education, through which we can see reflected the current state of research in the teaching of Sciences in our country. The following is a review of the minimum skills required of students in our educational system and how through the teaching of chemistry can be achieved most of them. Finally, a brief review of the most relevant methodological guidelines in the teaching of chemistry and some resources found through the realization of the project "Chemistry is all around network".*

## 1. Introduction

In our country, there are difficulties for teachers to applied their research in Didactics at the sciences' classroom [16]. Teachers have little time, classes generally have a strong preparatory character and few resources are available to implement new methodologies in the classroom as teaching by research. Nevertheless, good practices are often reflected in a large number of publications of Spanish-speaking. The magazines where you can find publications on experiments carried out with success in the science education are as follows:


**Teaching Sciences: Journal of research and educational experiences.**
El Institut de Ciències de l'Educació de la Universitat Autònoma de Barcelona and el Vicerectorat d'Investigació de la Universitat de València, they made possible the emergence of this magazine, which is a reference point for all the professionals of research in the teaching of mathematics and experimental sciences in Spain and Latin America since 1983.
http://ensciencias.uab.es/

**Chemical education.**
This quarterly magazine published by the National Autonomous University of Mexico and six professional associations of chemistry of Mexico spreads to all countries of Spanish-speaking, research, and educational contributions in the field of chemistry
.http://www.educacionquimica.info/



**Aula Magazine. Educational innovation**
Magazine in which innovations are reflected in the field of education at
all levels of education. It is published by editorial Grao since 1992.
http://aula.grao.com/

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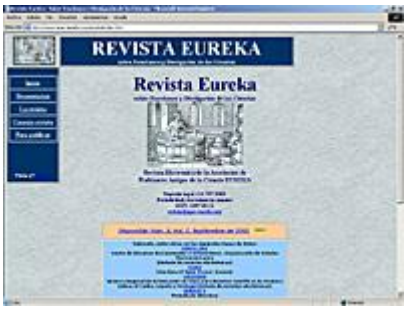
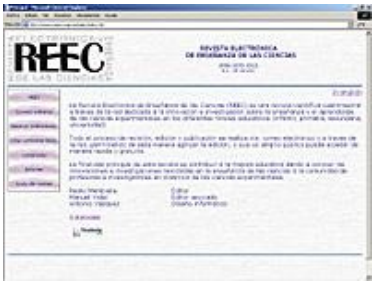
**Alambique Magazine. Didactics of experimental sciences.**
Journal on the science education which includes reflections, experiences, teaching resources and research conducted by teachers and specialists in Didactics of experimental sciences. One of the journals of reference, published by editorial Grao since 1994.
http://alambique.grao.com/




**Eureka Magazine, how to teach and disseminate sciences.**
This electronic journal of the University of Cádiz and the EUREKA Science Teachers Association, has been since 2004, contributing to the development of knowledge in the field of the teaching of science from a theoretical and applied perspective. Its two main orientations are: research and Foundation in teaching Sciences and educational improvement through a more stimulating and informed teaching.
http://reuredc.uca.es/index.php/tavira




**E-Magazine about teaching Sciences**.
Quarterly scientific journal dedicated to the innovation and research on the teaching and learning of experimental sciences from different educational levels. In operation since 2003.
http://reec.uvigo.es/

All items of educational research, educational experiences and evaluations of the same and proposals of new methodological approaches can be found to apply in the classroom. Most of the authors are professors and researchers of recognised prestige in the teaching of Sciences both at the University level and at the level of secondary education and are the main source of resources and experiences related to the implementation in the classroom teaching of experimental sciences.

## 2. Key Competences and their development in chemistry education

Following the recommendations of the OECD and the European Union, has been extended in our educational system the concept of competence in accordance with the achievement by our students a well-rounded education. The concept of competence as capabilities, knowledge and attitudes that allow effective participation in the political, economic, social and cultural life of our society, leads to an idea of teaching based on real-life problems and which attends to the diversity of the student body. It is away from the traditional teaching learning and methodological strategies with a global focus. Within this framework, the educational system Spanish introduces eight core competencies aimed at forming a common European framework [20]:

- Competence in linguistic communication.
- Mathematical competence.
- Competence in knowledge and interaction with the physical world.
- Processing the information and digital competence.
- Social competence and civic.
- Cultural and artistic competition.
- Competence for learning to learn.
- Autonomy and personal initiative.

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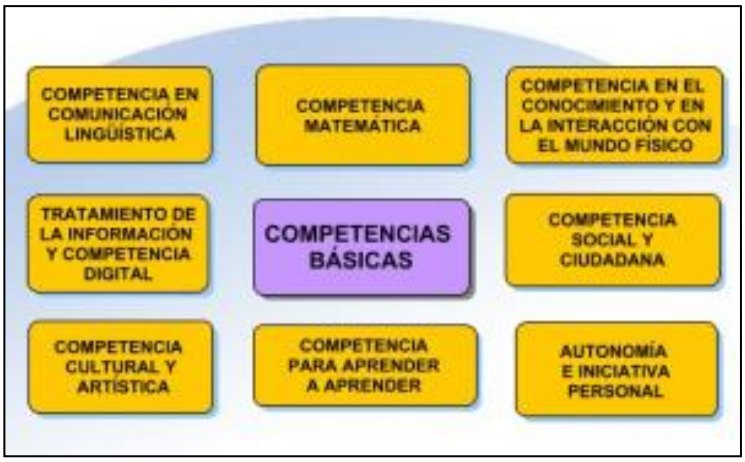


Fig. 1: Basic competences schedule (http://competenciasbasicas.webnode.es/)

The competence that is more developed in chemistry learning is knowledge competition and interaction with the physical world. This competence is defined in annex I to the Decree of minimum teachings of the ESO (RD 1631/2006) as:
*The ability to interact with the physical world, both in the natural aspects generated by human action, thereby allowing the understanding of events, predicting consequences and the activity aimed at the improvement and preservation of the conditions of life of their own, other people and the rest of living beings* [15].

In the LOE and the PISA report are specified within the scientific competence four kinds of capacities or dimensions:

1. Identification of scientific issues. This dimension includes the recognition of issues that can be investigated in a scientific way, the use of strategies or search and understanding of scientific information and the selection and recognition of the key research features, such as the formulation of hypotheses, design of experiments, the matching of data, etc.
2. Scientific explanation of phenomena. This dimension includes the understanding of basic principles and scientific concepts and their interrelationships, the description of phenomena through scientific explanatory models and the application of science to everyday life situations.
3. Use of scientific evidence. In this dimension is intended that students learn how to interpret data and scientific evidence, alleged reason its findings, communicate them properly and know reflect on the implications on human activity and the environment.
4. Attitudes towards science and scientific attitudes. This dimension tries to develop responsibility for oneself and the environment, decision making around local and global problems and consider the different perspectives that presents a problem.

However, the competence from interaction with the physical world is not the only one that its developed in the learning chemistry process [7].

- Understanding of basic principles and scientific concepts, the issuance of hypothesis, interpretation of data, drawing conclusions and discussion of results are clearly related competence in linguistic communication.
- The control variables and make necessary calculations in any scientific investigation develop mathematical competition and if performed with the help of the information and communication technologies, develop digital competence.
- Information search, your understanding and your selection strategies correspond both to digital competence and autonomy and personal initiative.
- The dimension of the scientific authority collecting the attitudes toward science and decision making, can be directly related social competence and civic, it includes aspects such as the

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recognition of health and personal habits and the study of the relationships of science with society and the environment.

- Finally, the issuance of hypothesis, interpretation of data, drawing conclusions and discussion of results and ultimately all learning by research and any application of the principles of the scientific method in the classroom to develop competition to learn how to learn.

## 3. Examples of successful experiences

### 3.1 Experience description

Experiences on teaching of physics and chemistry carried out successfully in recent years in our country include the following methodological guidelines:

**Learning by research**

Given the recommendations made in the official studies of 6 European countries one methodological approach having more success in recent years is the teaching by research. This approach, related to constructivism argues that the conceptual changes must occur in the students by placing them in a context similar to the scientists. These investigations can be routed to solve both theoretical issues and practical problems, and always would be the phases of scientific research in their development: emission scenarios, planning, verification of hypotheses and evaluation of results [4].

However, this methodological approach differs from learning by discovery in which the teacher must be present as a guide of the process. To make learning effective you must have a guide to learning to overcome difficulties that are in the process [12].

While this type of learning can find obstacles in its implementation underway, has shown that students who work in the lab show a significant improvement in their scientific competences [2].

**Contextual Science**

There are two modes within the science through the context: one on the basis of the concepts explained the context and another from the context develops the concepts. The latter is traditionally called contextual science [5].

Contextual teaching is primarily based on the transfer of school knowledge to the real world. This is usually done through the everyday science, thus increasing the motivation of students. Some Spanish authors have studied everyday chemistry teaching [9]. Others have promoted outside the school laboratory experiments making use of materials that are around us [3],[10]. Thus, they desmitificado science and shown that chemistry is not as mysterious or science something that should be limited to the laboratory or scientists. .In parallel to the contextual teaching we find the CTS movement, which aims to train students as citizens so that they make informed decisions and to carry out actions responsible for reaching the critical thinking and intellectual independence. This movement claims the incorporation into the school curriculum of the cultural dimension of science in society, their relationships with the technological advances, the social, political and economic context and environment [1].

One of the applications carried out in Europe and applied in Spain since 1995 is the project "Salters advanced Chemistry". The objectives of this project, presenting the chemistry in a way that is contextualized to a level equivalent to our high school, include the following: show the methods used by science and the most important areas of research, emphasize the relationship of chemistry to our daily lives, and expand the range of learning activities that are used in the teaching of physics and chemistry, always with a rigorous treatment that provide sufficient basis to pursue future university studies [17].

**Cooperative work**

Cooperative work is considered an essential instrument for a constructivist orientation of the science learning and is an approach to learning with a long tradition among the movements of educational renewal. Cooperative work is based on the formation of heterogeneous groups, the positive interdependence between the members of the Group and individual responsibility that requires that the work of the group depends on the individual work of all its members [11]. In the field of science, this work is usually based on the study of problematic situations, issuance of hypothesis, test making and subsequent discussion of the results obtained. This approach to the work of the students allows you to approach the activity of students scientific

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activity, achieve meaningful learning and enhance the interest of students in scientific culture [19]. Cooperative work also contributes to the self-regulation of learning and the improvement of communication skills [18]. However, to get a cooperative work that allows you to build the scientific knowledge a careful design of the work plan is needed. Teacher should assume its role determines the proper achievement of the objectives and the functioning of the group. Therefore, an adequate training of future teachers including the methodological basis of the cooperative learning in the contents of their initial training is required [13].

In recent years, this kind of methodologies found in ICT a new learning environment. On the one hand, the virtual classroom based on blabla as Moodle, facilitate the availability of information in different media and the collaborative work of the students, who are actively involved in the construction of their knowledge [8]. On the other hand, the increasingly more common deployment in the classrooms of social networks is becoming a new opportunity for learning that is both known and familiar to them. Projects at the college level as the "University 2.0 GNOSS" offer the possibility of applying methodologies of collaborative learning, the generation of knowledge sharing and the application of active methods of teaching and learning as the participation of the students in the preparation of the contents and evaluation of resources contributed by the rest of the companions [14].

## 4. The impact of the project on successful experiences

### 4.1 Workshop

The workshop on Teacher training under the Chemistry is all around Network Project was held on (the 1st of april, 2014) 01.04.2014 in Santo Tomás de Villanueva School in Granada. Twelve people, among them teachers (9) from various school levels and experts (3) were present.

During the meeting, participants were asked to discuss the following topics:

- Teachers' and experts' personal successful experiences
- Analysis of international papers and publications on successful experiences and good practices
- Analysis of testing of teaching resources made by partners (uploaded on the project portal)
- Discussion on teaching resources tested at national level (if already done)
- Planning of future/possible testing.

They came to a variety of conclusions:

#### 4.1.1. Teachers' and experts' personal successful experiences

During the meeting university teachers and secondary teachers showed us educational experiences that have helped to improve students' motivation and meaningful learning. Some of these experiences were: cooperative learning based methodologies, laboratory experiences, organization and participation in science fairs, and the use of ICT resources in the classroom. The use of ICT resources in some schools has been in using electronic devices like digital tablets. These devices make digital textbooks and educational multimedia applications directly accessible to students. We looked at applications like 3D "Molecules Edit&Drill", designed to enable students to build, construct, modify and examine molecules in 3D. This application fosters learning experiences about chemical structures and isomers, and the students used it to create a databank of molecules.

Some teachers have been using social networks like Twitter as an instrument for motivating their students. Pupils and teachers have been publishing photos of their educational activities and laboratory experiences, as well as links to webs and videos about chemistry. Also, there is a facebook site about the project "Chemistry is all around network in Spain" that lets us share information among teachers about successful experiences and educational resources.

Some teachers are beginning to experiment a new teaching model named "the flipped classroom" that inverts traditional teaching methods, delivering instruction online outside of class and moving "homework" into the classroom. In this model, students watch lectures at home at their own pace, communicating with peers and teachers via online discussions and concept engagement takes place in the classroom with the help of the teacher. The traditional role of the teacher changes and the teacher turns into

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a guide of students learning. Some examples of brief explanations that have been used within this approach can be found in some videoblogs like “Veritasium”, “Minute Physics” and “Minute Earth”.
Teaching of inorganic chemical nomenclature was one of the main topics of discussion during the meeting. One of the experts, Manuel Fernández, whose research is about Science Education, has recently written a paper about the teaching of inorganic chemical nomenclature. This expert supports a reduction of learning contents, teaching only familiar and everyday compounds to avoid pupils' demotivation and overall rejection of chemical contents. Teachers felt that it was an interesting paper and suggested including it in the publications section of the project portal.

#### 4.1.2. Analysis of international papers and publications on successful experiences and good practices

Most of the papers and publications commented on by teachers and experts were those that were written in Spanish. These publications dealt with use of ICT resources in the classroom and educational approaches based on a constructivist interpretation of teaching and learning: contextual science, STS contents, inquiry and argumentation in the classroom, experiments about everyday chemistry and recreational chemistry, cooperative learning, etc.
All the teachers and experts agreed on the importance of ICT resources. We can find ICT resources in virtual labs in applications about visualization of molecules and videos about chemistry lectures. There was unanimity on the need for laboratory experiences, but they are not effective under all circumstances, because it is necessary to prepare such experiences by giving the students a conceptual basis that link to science laboratory instruction.
University and secondary teachers agreed that a methodological change must be accompanied by a lower teacher-student ratio, given that nowadays all of them have too many students and they can´t apply non-traditional teaching approaches. Furthermore, the university admission tests are designed with a traditional approach that does not promote new teaching methodologies.

#### 4.1.3. Analysis of testing of teaching resources

Some teaching resources in the Chemistry is all Around Network portal have been used by some teachers and some group of students. Three of the most useful resources suggested are:

- FQ-Experimentos (FQ-experiments), by Fernando Díaz Escalera.
  This resource proposes activities about problem based learning and propose simple experiments that pupils can watch in video-records.This resource has been used to support physics and chemistry learning in 4º course of compulsory secondary education, with very satisfactory results. The use of this resource in particular improved student motivation.
- Iniciación interactiva a la materia (interactive incitation to matter), by Mariano Gaite Cuesta.
  This resource has been applied in 1º course of baccalaureate during the didactic unit about atomic models and elemental particles. Its application in the classroom has been developed with the use of digital tablets and the students evaluation has been positive.
- Tabla periódica de los elementos (periodic table of elements), by Benito Navarro.
  This resource has been applied in some schools by a cooperative learning activity which consisted in building a giant periodic table during the science fair in the shool. It is a resource that has been valued positively by teachers and students. This website shows us several ways to classify chemical elements depending on different criteria.

We have planned the future evaluation of portal resources in several schools. This evaluation is still pending and it will be organized in the near future, and the schools involved will communicate with each other by email.

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## 4.2 Testing of ICTs

### 4.2.1. Teaching resource 1

**Iniciación Interactiva a la Materia**

(Interactive Introduction to the Matter)

http://concurso.cnice.mec.es/cnice2005/93_iniciacion_interactiva_materia/curso/

Tested by Antonio Jesús Torres Gil (Teacher). Colegio Santo Tomás de Villanueva. Granada.

Asessment made with 30 students from 1º Bachillerato (16-17 of age) in the subject Physics and Chemistry.

The Topics related to the resource are:

- Behavior of matter.
- Atomic Models: Thomson, Rutherford, Bohr.
- Atomic an nuclear structure.

Main learning objectives:

- To have the student appreciate, learn and understand chemistry's basic concepts through computer models.
- Develop a historical perspective of science.

Our methodology was this:

Our students studied the didactic unit “the atom”, using the resources in this web. They worked interactive exercises that appear in the website. The students used their Ipads during the learning sessions. The activity was very well received by the students, who very positively evaluated their work in this unit.

Conclusions:

- This resource enhances motivation of students.
- This resource enhances scientific competences of students.
- It complements textbook contents.

### 4.2.2. Teaching resource 2

**Periodic table of elements.**

**http://www.xtec.cat/~bnavarr1/Tabla/castellano/indice.htm**

Tested by Lorenza Madrid Villar (Teacher). Colegio Cristo de la Yedra. Granada.

Asessment made with 24 students from 4º ESO (15-16 of age) in the subject Physics and Chemistry.

The Topics related to the resource are:

- Periodic table of the elements.
- Classification and properties of the elements.
- History of Chemistry

Main learning objectives were:

- Develop and facilitate ICT-based learning activities in the context of teaching chemistry.
- Develop an appreciation of how science has contributed to the historical and cultural development of our society.

The methodology was this:

Work in classroom by preparing a list of home experiments and distributing them to students. They have to do a report of their experiment with an explanation, comments, difficulty, etc. This resource was applied in the development of a science fair during a year by working in science projects.

Conclusions:

- This resource was very well received by the students, who very positively evaluated their work in this unit.
- The resource helped students in their experimental work for their science fair.
- This resource enhances motivation of students.
- This resource enhances scientific competences of students.
- This resource showed the work of scientist to students.
- This is a good resource in contextual an everyday science.

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## 5. Conclusions

Despite the difficulties encountered to involve faculty in the teaching of sciences research, a good number of teachers seeking new methodological approaches and ways of teaching to increase students motivation and meaningful learning of physics and chemistry, which is reflected in numerous publications related to educational research. methodological approaches based on context science, learning by research and collaborative learning have shown some clues about the way forward in the methodological change that is needed in Europe to overcome the current crisis in the teaching of science. on the other hand, to provide teachers a source of resources such as available on the website of "chemistry is all around network" promotes good practice in the teaching of chemistry as they show some of the assessments to the resources available in the network. it is the appropriate combination of approaches cited along with the proper use of the resources of education through ICT where probably find the way to achieve the conceptual change from the constructivist view of teaching, a positive attitude of the students towards science and a proper scientific literacy of our future citizens.

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