Teaching sciences using didactic strategies based in information and communications technologies

Santiago Rojano Ramos¹, Mª Mar López Guerrero²

1. Didactic of Experimental Sciences Faculty of Education University of Málaga
2. Department of Analytical Chemistry Faculty of Sciences University of Málaga

Abstract: Last years, students have presented a low interest to study sciences. In particular, Physics and Chemistry are considerate by students as very difficult subject. Actual teachers have a wide variety of tools to promote the learning of sciences in classrooms. This survey includes the use of virtual applications to understand chemical processes; for example, the redox-reactions. The objective was to carry out a new didactic proposal for teaching the cited reactions. So, it was used a virtual periodic table of chemical elements and an assisted computer simulation to lead students toward the learning of redox chemical reactions and to understand how the reactions occurred into the recipient. Therefore, with the use of videos is possible to watch the chemical reactions in a microscopic level. It represents an important advantage in comparison to conventional teaching of redox reactions in a blackboard. On the other hand, the group filled a questionnaire about the utility of the technique, the advantages or disadvantages and the convenience of using information and communications technologies (ICT) to improve the knowledge in the subject. The results showed that use of ICT allowed them to increase the comprehension of chemical processes as redox reactions. In conclusion, 65% of students group indicated that they preferred multimedia application instead face to face class and 62.5% of students wrote that the use of virtual periodic table and multimedia application are very beneficial to class.

Keywords: ICT; learning sciences; multimedia application; virtual simulation; redox reactions.

1. Introduction

Science in general and Chemistry and Physic in particular are subjects with a high level of difficulty for students. There is a wide variety of reasons to understand that question. In fact, students and citizens are farer than we think. The image of sciences has been decreasing in decades, especially last years. So, teaching of chemistry presents different problems and difficulties such as lack of interest in students, very low motivation, a specific language and nomenclature for chemical compounds … Therefore, chemistry is linked to environmental pollution, products and dangerous industries, toxic compounds and risking activities[1]. For all reasons, the actual image of chemistry is negative; it is well known with the word chemophobia[2]. On the other hand, students know a very few scientists and the important work they had developed in our society. Chemistry is famous as a very difficult subject. It is necessary to practice, review and work hard to understand their topics. The use of ICT could be very beneficial in order to improve the Chemistry learning; ICT can increase participation of students and would improve the direct intervention of the students in classrooms. So ICT could motivate learning of science. Thanks to the rapid advancement of information and communication technology.
they are entering and transforming our educational systems. Consequently, teachers have to face with methods to integrate tools as ITC in classroom. Science teachers and researchers have pointed their worries about the outcomes of science education. George & Kaplan\textsuperscript{[3]} have researched about the lack of interest in science in high school and university. Many students think that science is irrelevant to their personal interest and goals and are unaware of how many jobs require this type of knowledge\textsuperscript{[4]}. In this sense, it has a direct effect on how students perceive the relation to a field such as science. Therefore, such perception influences their career choices as well as their future performance. These reasons are added to the negative public image of chemistry, which origins serious difficulties to students’ attitudes towards chemistry The most of the students’ difficulties in learning chemistry are directly related to the specific nature of chemistry which requires students to move from the macroscopic to the microscopic level, to use chemical symbols and special language and to visualize also abstract concepts such as the shape of a molecule into a two dimensional page\textsuperscript{[5,6]}. Another barrier to chemistry learning, the one related to the formal and abstract nature of the scientific language and the commonly used communication code and nomenclature in standard chemistry or science textbooks\textsuperscript{[7,8]}. Due to every issue exposes previously, the chemistry course seems to be one of the least enjoyed among science subjects\textsuperscript{[9]}. Some of the reasons are related to the content of the chemistry curriculum, the limited amount of time for chemistry lessons, the methods of teaching chemistry and the lack of laboratory experiments. In Spain, chemistry is usually taught in a theory oriented approach without hands on activities and this practice decreases students’ interest for the course. Garcia-Carmona et al.\textsuperscript{[10]} analyzed the science education promoted by the national curriculum of primary education in Spain. The analysis pays attention to different aspects regarding the school science: nature and sociology of science; axiology; psychology in science learning; goals, competences, contents and evaluation criteria; activities, didactic and methodological resources and teaching strategies. Results indicate that primary school science proposed in the national curriculum does not completely adjust with current trends in Science Education. Similar results have obtained in other studies about school science\textsuperscript{[11, 12]}. Consequently in view of the lacks detected in the curriculum, a group of several recommendations were proposed\textsuperscript{[10]}.

In a subject as Chemistry, concepts often present under three levels of representation: macroscopic, microscopic and symbolic levels\textsuperscript{[13]}. The most of phenomena are available to direct experience (macroscopic level), but in their explanation is necessary a little of knowledge about molecular structure and the interaction between atoms and molecules (called as microscopic level). To represent this phenomenon, chemists have designed specialized symbol systems like molecular formulas, which help them to communicate and visualize chemistry concepts\textsuperscript{[14]}. In the present study, the experience is developed of using a virtual application to understand chemical processes. It was identified student misconceptions and misinterpretation for Mechanical Engineering students as they are attempting to interpret and explain the chemical processes. Oxidation-reduction reactions were identified as one of the most difficult concept to teach and learn for students. Therefore, it is necessary an interesting tool or ICT application to get a good comprehension of the redox processes in students. In this study, the main objective was to develop and carry out a didactic proposal for teaching chemistry topics using didactic resources as virtual environment and the use of a simulation that lets students to construct useful mental models. On the other hand, the use of videos in which could be possible to watch the reactions represents an excellent opportunity to understand better the redox processes. After it was identified and understood student misconceptions and misinterpretation in Chemistry for engineering students, they are attempting to interpret and explain the chemical processes at macroscopic level. So, at the beginning, we worked at level microscopic with the application or simulation. After, the level macroscopic arrives to achieve a good comprehension of redox reactions in solution. With the rapid advancement of information and communication technology, teachers are faced with the challenge of integrating ITC tools into de classroom setting for effective
teaching and learning. These changes could be influencing the educational systems in general and instructional methods in particular. The use of computers in instructional lessons computers can be used on their own or along with other instructional tools in order to ameliorate learning practices\cite{15}. In general, it is observed that face-to-face instruction is the most commonly used instructional practice for teachers in class. These types of strategies have already been used not only in the field of science. They have also been used in teaching other disciplines and there are numerous studies on the importance of ICT in school learning. An extensive study on the incidence of multimedia applications and their perspective was made by several authors\cite{16,17}. They carried out certain tests for the teaching of different representations of chemical phenomena through multimedia. Also, in general, Lopez et al.\cite{18} has studied ICT and its impact in the socio-educational field and in our particular case, in the field of experimental sciences, have designed and applied various multimedia materials for learning science\cite{19}. Other authors have worked with other ICT to teach and learn science. For examples, there are particular cases of using blog to teach chemistry at the University. Rojano and Lopez\cite{20} designed a blog to teach a group or scientific concepts at university level, in particular the Grade of Primary Education in the University of Malaga. The blog as a strategy allows us to encourage the learning of students and their participation in the course. The study developed contains information about the use of the blog and its positive influence to improve the perception of students towards Chemistry. In quantitative terms, it was found that this tool increases the students’ academic performance thanks to better assimilation of concepts\cite{20}. On the other hand, Marin and Donoso\cite{21} also worked with a blog in order to improve the learning of Chemistry. Cited authors designed a blog which is integrated in the subject “Chemistry II” in the first year of chemistry studies at the University of the Balearic Islands in order to build a communication and collaborative knowledge space around chemistry between professors and students.

2. Methodology

Thus, it was thought that the use of ICT could be very beneficial for students in order to achieve an adequate learning about this subject and this type of processes. We are sure that ICT could increase participation and motivation of the students in the development of the subject. So, in order to remove the barriers stemming from the abundance of abstract knowledge, several cognitive strategies are assumed. In this respect, computer assisted instruction can be considered as a fruitful endeavor to integrate science and technology and improve the quality of learning experiences\cite{22}. This allows learners to progress at their own pace, control their learning, participate in the learning endeavors more willingly, learn more effectively, get a richer variety of instructional materials, keep track of the learning experiences, get direct answers for their unique questions, get instant feedback regarding their strengths and weaknesses, conduct experiments which are hard to realize in real-life or in laboratory class, and learn at a shorter time in a systematic way. Computers are usually much more enjoyable and always more patient than classrooms teachers\cite{23,24,25,26}. It represents a factor that we could to take advantage. Firstly, with the help of a virtual periodic table (Figure 1), students can learn the principal characteristics of elements participating in the reactions, such as electronic configuration, place in periodic table, reactivity of them, orbitals, behavior respect to loose or gain electrons and other very important properties of them, as oxidation states and chemical compounds.

One of the main advantages of the ITC use is that we can increase the motivation in students. In this survey, in the interactive multimedia field, learning objects are digital assets, for instance, animations, in context. In this case, the learning process will be improved because this learning experience would involve student to observe a chemical phenomenon as a lecture demonstrations and then, it will be viewed an animation multimedia application about the phenomenon at the molecular and atomic level, which will be explained by a narrator. And eventually, the students will adapt their mental model to explain a similar phenomenon with an analogous substance or reactions about other topics in Chemistry. The most important thing for the success of this multimedia application would be to promote visualization
as a learning strategy is the practice and application of the visualization skills developed. And with this type of learning we obtain some advantages as construct scientifically acceptable new ideas about reactions at the molecular level which will be able to apply in other new models or topics or new substances in chemical reactions. Furthermore, it will be possible that the student use their models to understand new chemistry concepts that require an atomic/molecular level at the beginning. The experience consists of using a virtual application to understand chemical processes. It was identified student misconceptions and misinterpretation for Mechanical Engineering students as they are attempting to interpret and explain the chemical processes. Oxidation-reduction reactions were identified as one of the most difficult concept to learn. So we have to look for an application in order to get a better comprehension of redox reactions in students. The objective has been to carry out a proposal for teaching contents of chemistry using didactic resources for virtual environment, the use of a simulation that lets students to construct useful models. The application must to explain the reaction redox under microscopic level, as we can see next image. Regarding to computer assisted instruction, a simulation using a multimedia application, an obvious advantage is the ability to concurrently present multiple representations to visualize chemical phenomena\textsuperscript{[27]}. The materials can provide logical links between various representations to aid students’ understanding. These materials can help students to build mental links to strengthen their logical framework of conceptual understanding and to achieve mastery level understanding of chemical concepts, contributing to learner motivation and active engagement. A high level of intrinsic motivation and active engagement are essential to the success of a project based learning lesson\textsuperscript{[28]}.

Figure 1. Virtual periodic table (www.Ptable.com/?lange.es) designed by Michael Dayah

The animation started with several zinc atom circles in an organized patter placed against a grey background (water). Floating freely in the water were some copper atoms with a “2+” symbol on them (cation of copper) and the double number of atom clusters containing atom with a “-” symbol on it surrounded by nitrate ions. The reaction occurs when one copper atom approach one zinc atom and the electrons are transferred from zinc to copper. And now, the zinc atoms have “2+” symbol on it and become smaller and at the same time, each copper atom becomes larger and loses its “2+” symbol. With this example, the students are able to see how the micro level works as a macro level, and how some changes occur in the atom structures. This design described below it can be used for any chemistry topic that will require a scientifically acceptable mental model of the molecular world. In this case, the learning process will be
improved because this learning experience would involve student to observe a chemical phenomenon, in particularly, a chemical reaction as a lecture demonstrations and then, it will be viewed an animation multimedia application about the phenomenon at the molecular level, which will be explained by a narrator. Before, students have analyzed the participating atoms, their electronic configuration and properties to combine with other atoms by a reaction.

Figure 2. Redox reaction Cu/Zn (from http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/electroChem/voltaicCell20.html)

Figure 3. Redox reactions simulation (provided from http://highered.mheducation.com/)

3. Results And Discussion Of Results

The studies are designed as a quantitative research, which uses the pre-test and post-test control group design and a questionnaire to know what they think about the utility of these ITC tool in order to improve the teaching and learning process. It aims to investigate whether computer assisted instruction realized through simulation is more effective than face-to-face classrooms in increasing student success in Science, and if they think that computer assisted is useful to learn more easily the subject and the chemical concepts studied. Each student did one questionnaire, a pre-test and a post-test. The two groups, which participated, had the same experience in working with chemicals in laboratory, attended the same computer simulations, in simulation study. The questionnaire consists of several items and it is a five point Likert type scale. Students’ questionnaire responses were analyzed using a Likert scale, and they were referred to
the utility of this computer assisted instruction and their thoughts. The scale of the test was a five point Likert type scale with a range of five options. The positive items range from 1 = Certainly Disagree to 5= Certainly Agree. Thus for questions positively, a value closer to 5 is always positive. The values are averaged by the number of students, for values between 1 and 5. The value 3 as neutral, values 2-3 moderately positive attitudes and values 4-5 represent very positive attitudes are defined. The surveys were validated by three experts in the field of Educational Science, before passing them into the classroom. The internal consistency of the test was estimated with Cronbach's alpha using the formula of the variance of the items, giving a value of 0.366; indicating that the acts are reliable. According to the results obtained from the assessments, the qualification starting in both groups is very low; however, no significant differences are obtained between the two groups. As for the final outcome it is observed that the group that started from a lower rating scored a 7.45, while the other group reached 5.71. However, no significant differences had been founded between groups for a confidence level of 95%.

Figure 4. Results of use of application multimedia in front to face to face class

Regarding the use of multimedia application and the advantages/disadvantages about them, students showed the next opinions respect utility, affectivity and benefices of use of virtual periodic table and multimedia application. In the next lines, we can observe the results that students showed in the questionnaire. Firstly, they were questioned if they had preferred the application multimedia regarding face to face classroom when it was used in classroom. The data can be seen in Figure 4. Data showed that a high percent of students, 56 and 9%, reflected that they agree or certainly agree with the use of virtual periodic table or multimedia application, but the fact is that there is also an important percent which opinion is negative regarding to the methodology used by the teacher.

Secondly, students were questioned if they considered that multimedia application should be a benefit for the class. The results can be seen in Figure 5.

Figure 5: Results the application represents a benefit for the class
On the other hand, students were questioned if they had considerate that multimedia application showed the interest of teacher about the learning of redox processes. The results can observe in Figure 6.

Figure 6. Results if multimedia application shows interest of teacher about learning

Finally, students were questioned about multimedia application helped them to understand better the redox reactions. Figure 7 shows the obtained results.

Figure 7. Results if multimedia application helped students

4. Conclusions

From the obtained results, it showed that the study population considered useful the multimedia application. The utility does not transcend the interest in studying because the difficulty is seen as an attitudinal obstacle to face to the subject of chemistry. This is an important fact, an attention call for teachers to reflect on the need to revise teaching methodologies and evaluation, because while learning requires effort, indicated difficulty goes beyond the lack of interest.

Regarding the results obtained in reference to the utility of the media application, the vast majority of the responses between are above 3, which can be considered as a positive treatment to the use of the application. A value of 3 would indicate that students do not observe improvement or worsening when using this application. However, virtually all the answers to positive questions show a value greater than 3, and those with a negative nature samples a value less than 3. It would indicate that the multimedia application is evaluated positively in general. Students have considered that multimedia application supposed an example of good ITC tool in order to achieve the comprehension of the redox reactions. Students wrote that they would have preferred the multimedia application instead of traditional face to face classic. Therefore, student showed that application multimedia is more effective than traditional class.

The used ITC demonstrated that students significantly increased the number scientifically acceptable ideas in student’s conceptions of science due to the fact that the use of ITC have demonstrated that allows them to practise and improve their knowledge.
The use of the virtual periodic table, multimedia application simulation and videos could be helpful in improving problem solving. This encourages students to develop new ideas about science and chemistry, and allows them to create a memory from viewing animations, leading to confirmation or modification of the existing mental model. Furthermore, it will be possible that the student can use the created models in redox process to understand new chemistry concepts that require a molecular level.

References


www.Ptable.com/?lange.es
http://group.chem.iastate.edu/Greenbowe/sections/projectfolder/flashfiles/electroChem/