

Software For The Implementation Of Virtual Lab For Developing Experimental Skills In Courses Of General Chemistry

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ABSTRACT

This paper describes how the use of a group of Virtual Labs favors the development of the experimental skills, contemplated within the General Chemistry Discipline Program; the software was designed and implemented by a group of undergraduate and graduate students, led by the authors. With them, different Laboratory Practices are simulated; in which, in an interactive way, the student practices what will later be done in the real laboratory. The interface looks like the interior of a real laboratory and it allows controlling the student's interaction with the different equipment and utensils, according to the objectives foreseen in each practice; Thus helping the student to review the operative technique. In addition, self-assessment is provided and instructions for independent study are included.

Keywords: General Chemistry, skill development, teaching-learning, virtual laboratories.

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I. INTRODUCTION

Information and Communication Technologies (ICT) are an increasingly powerful and indispensable tool in educational institutions. They can be used in various ways: source of information; guide for the student learning process; controller of the contents to be taught; means to exercise skills, train what has been learned and motivate the study; among many other applications..

In the case of teaching Chemistry, ICTs allow the use of "virtual laboratories" as computer tools that simulate a chemical testing laboratory. Although they are limited in the teaching of certain aspects related to experimental practice, they offer more flexibility than a real laboratory for teaching, since they make laboratory work a learning option where the student can make mistakes and rectify with an investment that it would not be possible in a real laboratory[1].

As part of the project called "System of computer programs for the university teaching of experimental chemistry", and from the doctoral thesis [2], a group of professors and students of the Central University "Marta Abreu" de Las Villas (UCLV), has been working on the development of computer programs to contribute to the improvement of the teaching-learning process of General Chemistry with the use of ICT [3].

General Chemistry is part of the academic curriculum of the Bachelor's Degree in Chemistry in most of the universities in the world; being the link between the knowledge of chemistry of high

school and university. Internationally appear in this discipline contents related to the atomic structure, chemical periodicity, chemical bonding, states of aggregation, stoichiometry, dissolutions, thermochemistry, chemical kinetics, chemical equilibrium, ionic balance and oxidation reduction reactions; all with a depth and order that depend on the focus of the course.

According to the curriculum, the General Chemistry discipline aims not only to cover traditional content, but to integrate and deepen the knowledge acquired by students at the previous level, about the principles, laws and more general theories of Chemistry, and to study the essential aspects of this science applied to substances, mixtures and chemical reaction. Initially, the structural aspects of the substances are studied, such as the electronic configuration and the link models; subsequently, the transformations of the substances in their thermodynamic, kinetic and equilibrium aspects are analyzed and interpreted for the entire chemical process. In this discipline, skills are developed related to the fundamental operations of the laboratory, which are applied in the solution of simple chemical problems.

The accomplishment of the Laboratory Practices has as one of its general objectives that the student experimentally verifies the principles, laws and theoretical postulates that were received in Conferences and Practical Classes; so it is important that, in addition to correctly developing the experimental operations, the student is able to interpret these results and relate them to the

theoretical contents. The developed virtual laboratories contribute to the fulfillment of this objective; because when interacting with the software, before going to the real laboratory, the student stops at the operations that he does not understand well and can analyze the chemical phenomenon that he is verifying with the experiment; In addition, after performing the practice in the real laboratory, you can return to the virtual laboratory and clarify any doubts you still have.

1. Skills to develop in the Laboratory Practices of the First Year of Degree in Chemistry

In the subject of General Chemistry of the Degree in Chemistry, different Laboratory Practices are carried out, which begin with the basic operations and the familiarization with the equipment and utensils, and they increase their complexity and demand in terms of the skills they must develop. The students experimentally verify the different theoretical aspects dealt with in the subject.

The main skills to achieve are the following:

- To weigh. Determine experimentally the mass of a substance. For this, the student must use the technical balance for approximate weight and the analytic balance for exact weight.
- Levelling. Bring the volume of the liquid to a gauge or measure, being careful not to make the parallax error; that is, consider the meniscus of the liquid.
- Measure volumes. It can be of approximate form, using beakers and test tubes, or with greater precision by means of pipettes and burettes.
- Filter. Separate a solid from a liquid solution, by gravity or vacuum.
- Shake. Mix two or more components in a solution.
- Transfer substances. Transfer a mass, solid, liquid or in solution, from one container to another.
- To use the thermometer. Measure ranges of temperatures or a defined temperature of a sample.
- Use the tweezers. Select the most appropriate to hold the glassware and as an aid to transfer substances.

2. Virtual laboratories to enhance the development of the skills

To simulate the realization of practices, and enhance the development of skills in students, were developed the following Virtual Laboratories:

- Hardness of water[4]
- Properties of substances [5]
- Purification of commercial sodium chloride [6]
- Redox trials [7]

- Purification of benzoic acid [8]
- Preparation of solutions [9]
- Basic operations [10]
- Electrolysis and Daniell Cell [11]

For the design and implementation of these virtual laboratories, a study was made of how each practice is performed in the laboratory [12]; its development was filmed in the real laboratory; a bank of representations and images of utensils and laboratory equipment was elaborated; the necessary theoretical information was collected and the different help and evaluation systems were elaborated on each subject in question [13].

Below are images of some of the operations that are performed in the laboratory practices. First, photos taken in the real laboratory and then images of how these operations are performed in the virtual laboratory.

The images that make up Fig. 1 show a sequence of two of the most important operations, which are carried out very frequently in a chemical laboratory: weigh and transfer. These operations are the first skills that the student must overcome; since weighing a substance is carried out in all the laboratory practices, both in this discipline and in the rest that are included in the Curriculum.



Figure 1. Sequence of actions to weigh and transfer a solid

Measuring volumes is another of the necessary skills for a chemist. In his actions, many mistakes can be made; so, it is very difficult to execute correctly. Something that happens frequently is the so-called parallax error, when the view is not at the correct height.

The upper part of Fig. 2 shows the actions that must be followed, and the position that the technician must assume, to check the correct height of the liquid in the container. On the other hand, the lower images show how, in the user's interaction with the virtual laboratory, an extension of the test piece is presented so that the student can click on the quantity of liquid that it wishes to measure and, if the selected quantity is correct, the liquid rise is

simulated until the meniscus reaches the line of sight. Subsequently, the operation of transferring the liquid to the beaker is performed.



Figure 2. Sequence of actions to measure with a test tube and transfer for a beaker

Some substances become contaminated and change their coloration; it is necessary, then, to complete its purification by adding a reagent, for example activated carbon, so that it adsorbs the impurities that cause that coloration. After adding the activated carbon, it is necessary to heat so that the substance dissolves and the reagent is separated and, finally, paper is used to filter the solution with the sample by gravity.

Fig. 3 shows, at the top, photos of the process sequence in the laboratory; while in the lower part it is possible to appreciate the sequence of user actions by adding the reagent to the container, containing the substance of the experiment; place it on the heating plate; take the filter paper and place it in the funnel; select the appropriate clamp to remove the Erlenmeyer from the heat source, once it has reached the right temperature, and take it to the support to pour it into the funnel and collect the filtered substance.



Figure 3. Sequence of actions to purify with activated coal and to filter for gravness

Some experiments require that the filtration process be carried out under vacuum. In this case, the order in which the different operations for the assembly of the equipment, the placement of the Buchner funnel and the filter paper are executed is very important; as well as the use of a stove, with the right temperature, to complete the drying process up to constant weight. This is achieved in the software, as shown in the sequence of images in Figure 4, since the student has to "take" each of the parts that make up the equipment, mount it, place the filter paper, add the substance and turn it on.



Figure 4. Sequence of actions to filter under vacuum

After filtering the sample, the student selects the container, which must have previously tared, and moves the sample to the right side of the lab where the stove is located (Fig. 5), selects the appropriate temperature and, when it is reached,

remove the sample, return to the balance and check that the substance is completely dry.



Figure 5. Sequence of actions to dry in the oven

In a manner analogous to those described all the skills, which need to be developed in the different laboratory practices, have been conceived in virtual laboratories. When the student makes an error, there is shown warning messages and is not allowed continuing, as long as does not perform the operation correctly. All the software have their support systems, which include the Operative Technique, a video and photos of the development of the practice in the real laboratory and the User Manual of the application.

II. CONCLUSIONS

It has been illustrated, through these images, the student's interaction with the software and how these facilitate the preparation to face the real practices, enabling the student to acquire a better preparation before performing the practice in the real laboratory. With them, the student can put into practice, in an interactive way and in an environment very close to reality, the knowledge acquired in Conferences, Practical Classes and Seminars. The software allows, in an efficient and fast way, to simulate and analyze many variants of the phenomenon under study.

Despite the undeniable advantages that all this implies, it should be noted that it is impossible to simulate all the possibilities of errors or bad operations that the student may commit. For all these reasons, its use is insisted on as part of a methodological strategy that must be adapted to the characteristics of each career and of each group of students, without losing sight of the study objective of a bachelor's in chemistry. During several courses, these software have been used with very

good results. Its use has also been extended to other universities in the country.

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