

# EXPLORING CHEMISTRY USING VIRTUAL INSTRUMENTATION - CHALLENGES AND SUCCESSES

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## 1. Introduction

The development of ICT tools offers in present many possibilities of their using in teaching Science and assures a continuous increasing of the quality of the teaching process by the direct advantages related to the logical assimilation of the concepts and phenomena.

About two decades ago, in the information and communication technologies area a new concept appeared - *virtual instrumentation*. This new concept is based on the idea of creating a new and own instrument for user that replaces the traditional adapting of user's needs to the existent instruments. Generally, a virtual instrument (VI) consists of an industry-standard computer or workstation equipped with powerful application software, cost-effective hardware such as plug-in boards, and driver software, which together perform the specific functions of traditional instruments [1].

The most important component of a virtual instrument is the software, with a specific user interface. The areas where virtual instrumentation can be used are covering practically all human activities. That's why a software application that is developed to supply virtual instruments for designing specific user applications have to offer a large number of options and instruments, including some that can look incompatible in a specific application. In the ideal mode, this system has to organise the included software tools in a way that allows the user to easily select the particular options and guides him in the choosing the configuration options [2]. With the right software tool, the users can efficiently create their own applications, by designing and integrating the routines that a particular process requires. They can also create an appropriate user interface that best suits the purpose of the application and those who will interact with it [3].

## 2. Materials and Methods

Science is clearly based on experiences, observations and experimentally found data. Theoretical ideas are very important, but only if their consequences can be verified by observations or experiments. Although some facts were found by chance, most of them resulted from carefully planned experiments. Hence, experiments are an indispensable ingredient in scientific investigations in all Sciences.

Since Science subjects are offered to school children of different ages and backgrounds, they have to be introduced with various degrees of simplification. However, just in scientific research, the experiment retains a central role, and is indispensable indeed in teaching of Science areas, regardless of the degree of rigor.

During the last period, the introduction of virtual instruments in education took place in all the educational levels, not only in teaching different theoretical concepts, but especially in emphasizing of practical aspects of the phenomena. The modern pedagogical approaches, like *Blended-Learning* approach, combine in fact the face-to-face learning methods with the distance-learning ones. Thus, the distance-learning specific technologies bring the physical knowledge close to the process where it is applied, by defining of a criteria collection that can be taking into consideration in the selection of the suitable software that allows the designing of an educational virtual instrument.

From all collection of software that can be used for designing of virtual instruments by presenting of different models and software simulations that assure an easier understanding of different phenomena from the Science areas (Physics, Chemistry, Mathematics and Informatics), *Crocodile Clips* proved to be a suitable and also easier software with a friendly user interface. This is in fact a powerful simulation package, precise and complex, that allows the teachers and students to design experiments, model mathematical theories or simulate real life quickly and easily [4].

## 3. Crocodile Clips Software

*Crocodile Clips* software is developed specifically for educational purposes focused on what teachers and students really need from the packages they use. Software must be installed in each computer to create experimental modules. *Crocodile Clips* is useful either as *Digital Whiteboard* tool or for Computer classroom planning lessons.

For the "Beginner mode" users have just to follow the instructions of the program to interact with ready to use modules. After two or three clicks the users will be running a very visual interactivity. As *Crocodile Clips* contains dozens of examples, this is the best for the first steps with this virtual instrument. For the "Advanced mode" *Crocodile Clips* offers several "Components library" to build its own interactivity. For example, the "Chemicals" library from *Crocodile Chemistry* software contains a great number of chemical reagents classified in the following categories: metals, acids, alkalis, oxides, halides, sulfides, carbonates, nitrates, sulfates, miscellaneous salts and gases. In addition, different graphical representations correlated with the designed experiments can be plotted using "Presentation" library.

*Crocodile Clips* is also a good resource for planning lessons at computer classrooms. Teachers use modules from the program or create themselves their own modules step by step. In both cases, every student needs a copy of the modules and a working sheet with instructions and tasks. At the same time, a collection of explicit video-tutorials are provided by the software company. These tutorials, flash films (no longer than 5 minutes) are helping the users in the self-instruction process. By all its resources, the *Crocodile Clips* package presents a friendly user interface that makes it suitable for using in the secondary educational level and offers the possibility of implementing of some virtual applications even at the primary school level.

In the following parts of the paper, few examples of virtual experiments that are simulating some practical aspects of Chemistry are presented. Those virtual experiments have been produced by in-service teachers who participated at the *Training Modules "Virtual Instrumentation in Science Education"* organized in the frame of *VccSse - Virtual Community Collaborating Space for Science Education* project (code: 128989-CP-1-2006-1-RO-COMENIUS-C21, <http://vccsse.ssa.valahia.ro>) coordinated by Valahia University of Targoviste, Romania.

## 4. Results and discussion

Designing their own virtual experiments and implementing them in the classroom for the first time represented a big challenge for the teachers. But, after the implementation process, analyzing the students' results they discovered that the using of the virtual instrumentation increased the level of students' understanding and lead to a higher motivation of studying Chemistry.

One of the teachers' virtual experiments was proposed for a Chemistry lesson that had in view the teaching of the necessary concepts related to the chemical character of solutions. The level of teaching of the chemical concepts was adapted to the Romanian Chemistry curricula for the 7th grade, the lesson that included the implementation of the above mentioned experiment being entitled *Acid, basic and neutral solutions*.

The experiments designed by the teacher had in view the emphasizing of the chemical character of solutions by using of different indicators. Based on the teacher's virtual experiments the chromatic changes of the chemical indicators in different chemical solutions have been illustrated (Fig. 1).

The experiments were presented step by step for an easier understanding of the chemical concepts. Another sequence of the same virtual experiment was dedicated to the determination of the acid or basic character of a solution by using the pH paper impregnated with universal indicator. In this sequence the teacher used the chromatic pH scale provided by the software for the using of the universal indicator. The pH values and different colours of the pH-paper introduced in HCl, NaOH and NaCl solutions can be easily illustrated with the help of the virtual experiment (Fig. 2).

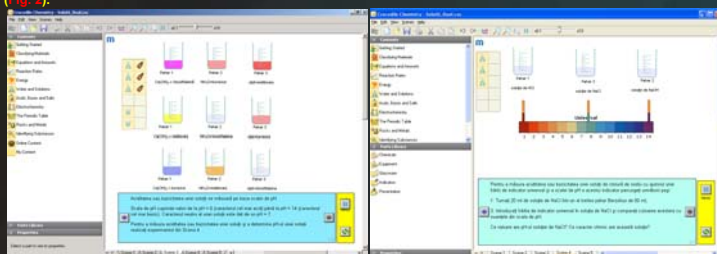


Fig. 1 Determination of the chemical character of solutions by using a VI created with Crocodile Chemistry

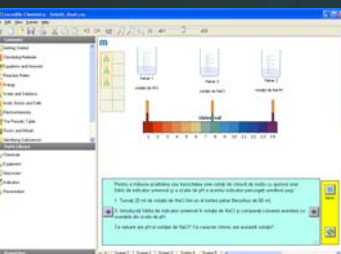


Fig. 2 Identification of pH value of a solution by using a VI created with Crocodile Chemistry

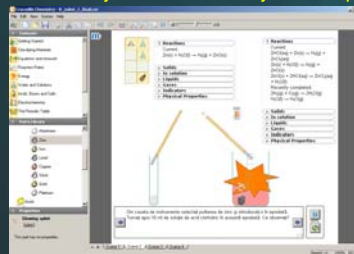


Fig. 3 Simulation of chemical reaction of Zn with HCl solution by using a VI created with Crocodile Chemistry

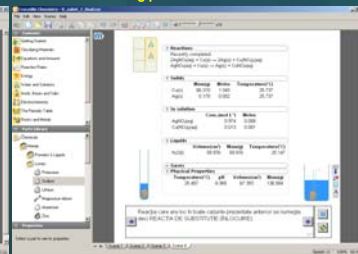


Fig. 4 Simulation of reaction between Cu and AgNO<sub>3</sub> solution by using a VI created with Crocodile Chemistry

Based on the aspects mentioned above it can be emphasized that one of the great advantages of the Crocodile Chemistry software is given by the fact that in the frame of the same virtual experiments the teacher can design different sequences focused on different simulations. In addition, in the frame of each sequence the teacher can create different successive steps, with gradual difficulty levels. On the other hand, the pupils have also the possibility to design new experiments on their own, as complementary steps of the lesson.

Designing of virtual experiments by the Chemistry in-service teachers after participation to about 40 hours of training sessions was a real challenge from their point of view. However, some of the teachers found very interesting the ways and moments to implement those virtual experiments in their lessons. One of the most important aspects emphasized by the teachers as a strong point of the *Crocodile Chemistry* was the availability of the software for producing new virtual experiments that allow the teacher to be creative. In this way the teacher can design different experiments focused to illustrate the theoretical concepts and adapt the experiments to the background of a specific classroom of students.

Analyzing the teachers' opinions after the implementing of their virtual experiments in the classroom, it was emphasized that the using of virtual instrumentation - in this case, the tools provided by *Crocodile Chemistry* software - for designing of virtual experiments for teaching Chemistry present the following advantages: a) offers to the teacher and students the possibility to design quickly, easy and safely different virtual experiments necessary to a proper understanding of the chemical processes; b) skips the effective consuming of chemical substances, and no equipment damages are produced; c) avoids the possible accidents that can take place when real experiments with high level of danger are carried out; d) saves the time of their presentation in comparison with the real experiments; e) allows the learning autonomy due to specific tools for the solving of tasks that can be easily controlled.

Last, but not least, the teacher and students are not working anymore in a toxic atmosphere like in the real Chemistry laboratory.

## 5. Conclusion

In a lesson without simulations or VIs, the learner deals with the lesson and the real world in two separate moments and the lesson can just present a picture of the real world. On the opposite, according to the VI model, the learner can deal directly with the real world. The main goals of the lesson become to guide the execution of the experiment, to give on-line instructions and information about the involved subjects and to stimulate the participation of the student. The execution of virtual experiments requires the creation of interfaces which, in the case of Science applications, consist of multimedia simulation for the communication between the learners' commands and the target system. The software applications like *Crocodile Clips* provide their own interface, where simulations can be easily created.

Based on the implementation process of virtual experiments in teaching Chemistry at different levels, the teachers identified a lot of advantages of using virtual instrumentation in Chemistry lessons that have been mentioned above. Those advantages prove that using of virtual instrumentation in teaching Chemistry can be a very good solution for a deeper understanding of theoretical concepts, a confirmation of a model or hypothesis or just increasing the learners' motivation. On the other hand, the excessive use of Chemistry virtual experiments in the detriment of real ones present the risk that the students do not acquire the necessary skills for using the chemical utensils and laboratory equipment, manipulation of chemical reagents and the careful observation of a chemical phenomena.

The teacher - who designs all process of teaching, learning and evaluation - is the person who has to decide how to combine all the suitable methods and the specific tools that he disposes in order to achieve all the objectives proposed at the required level.

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