CROCODILE CHEMISTRY - AN EASY WAY OF TEACHING CHEMISTRY USING VIRTUAL INSTRUMENTATION

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Abstract:
ICT tools provide many advantages in Sciences teaching by using not only traditional methods but also modern pedagogical approaches. One of the modern technologies that can be used by the Sciences teachers is offered by virtual instrumentation. Using this technology, different virtual experiments or simulations of real processes can be designed. The virtual experiments or simulations can be used by the teachers and students in the classroom in order to assure a logical learning process based on the practical aspects.
Different virtual experiments have been designed and implemented in the classroom by Sciences' teachers enrolled in the Training Modules "Virtual Instrumentation in Science Education" organized in the frame of the three years Socrates – Comenius 2.1. project *„VccSSe – Virtual Community Collaborating Space for Science Education"* (no. 128989-CP-1-2006-1-RO-Comenius-C21), co-funded by the European Commission, Education and Training, Socrates: School Education.
This paper presents the main facilities offered by Crocodile Chemistry software and some virtual experiments designed by the Chemistry teachers from Dambovita County who participated to the mentioned modules. Advantages and possible risks of using virtual experiments in the classroom during their implementation process are also emphasized.

Keywords: Virtual instrumentation; virtual experiment; Crocodile Chemistry; teaching process; learning process

1. Introduction

In the last ten years, it appeared several commercial software products that promoted the use of virtual instrumentation. Many of them are using purely graphical programming methods. Each of these products provide to users - typically including users who are not

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skilled software programmers - a "graphical development environment" which allows to design a custom virtual instrumentation. In this sense, the user can see a "design desktop" environment, generally having the look-and-feel familiar to users of Windows-based graphical applications, in which a variety of software options and "tools" are accessible from toolbars and dialog boxes featuring drop-down menus. All the presented facilities may be accessed by manipulating an on-screen cursor using a computer mouse. [1]

The range of applications that may be made the subject of an instrumentation system spans the range of human activity. Therefore, a software development system that aims to provide a large cross-section of potential users with the tools to design their own customized instrumentation system must provide the user with a large range of development tools and options, including tools and options that may be or are mutually incompatible in a given application. [2]

The introduction of virtual instruments in education has been identified as a necessity at all the educational levels, for illustrating the theoretical and especially the practical aspects. The new pedagogical approaches (like blended learning) are combining the face to face learning with the distance learning. The specific e-learning technologies bring the practical aspects into the didactic process, by defining of different criteria which can be considered in the selection process of a specific software that allow the design of virtual instruments for education. Having in view the particular aspects of training (including the case of distance learning), the most important issue of using virtual instruments is the fact that those instruments can simulate physical phenomena. One of the main advantages of using virtual instruments consists of the fact that the pupils / students can design their own instruments by using different dedicated software. Other advantages of the virtual instruments are: the low cost instrumentation, the portability between different platforms, the easy-user interface and the TCP/IP connectivity.

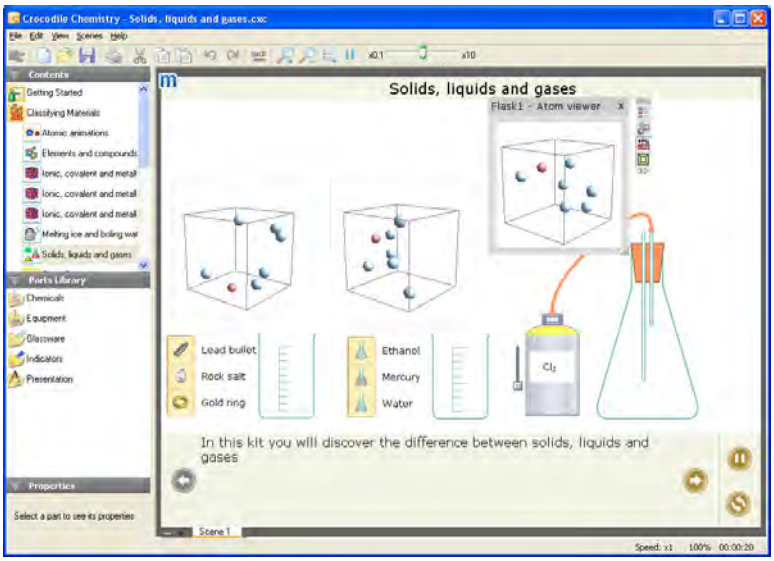
Looking to the diversity of virtual instrumentation software Crocodile Clips software can be mentioned as a very popular one. It is developed specifically for education focused on what teachers and students really need from the packages they are using. Generally, the powerful simulation packages allow students and teachers to recreate experiments, model mathematical theories or simulate real life quickly and easily. [3] In this sense, they are considered as virtual laboratories which are safe and accurate. Crocodile Clips can be easily framed in this category. One of the most useful applications included in the Crocodile Clips software package is Crocodile Chemistry. This application is a simulated chemistry laboratory where experiments and reactions can be modelled safely and easily.

2. Description of the procedure

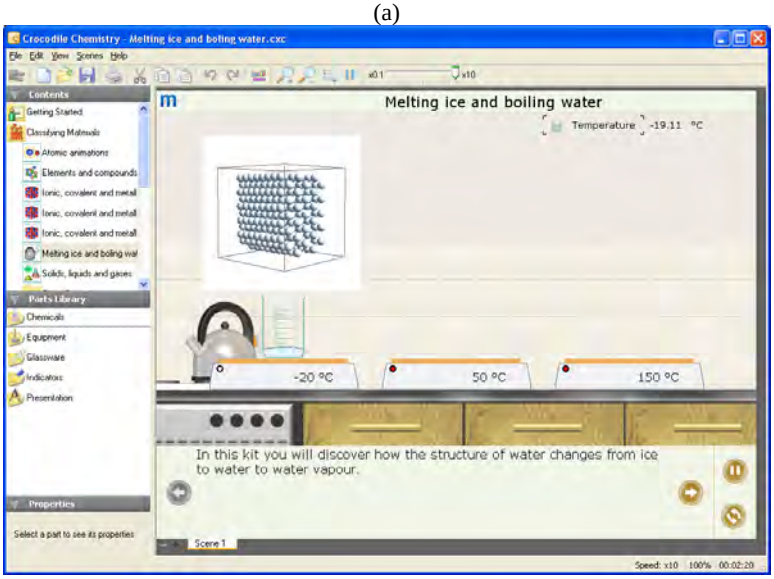
Due to the reason that the virtual instrumentation has proved its power in creating simulation-based learning environments, the partnership of the "*VccSSe – Virtual Community Collaborating Space for Science Education*" European project (no. 128989-CP-1-2006-1-RO-Comenius-C21) tried to introduce this technology at the primary and

mainly secondary educational level. Even that at the university level virtual instrumentation became part of the practical laboratories, not many Sciences teachers know how to create a virtual instrument for their own necessities. During their teaching activities, the teachers are using different ready-made virtual experiments, being kept in the limits of those applications. It is well known that the teacher's activity has to be flexible and folded to the compulsory curricula, level of pupils' understanding and adapted to the material resources which are at their disposal. In many cases, the teachers have to adapt the existing resources to classroom's level. In this way, it is very important for the teachers to have the possibility to design their own virtual experiments and simulations for assuring a logical learning based on the practical aspects. Coming to the teachers' needs, the VccSSe project partnership developed and organized the training modules "Virtual Instrumentation in Science Education" with Sciences teachers from the primary and secondary levels. When preparing the training modules, Crocodile Chemistry was selected as suitable dedicated software with a great potential for being understood and introduced in the classrooms by the teachers. Using the support materials and the examples presented during the training process, the Chemistry teachers designed their own virtual experiments, included them into a learning object and implemented the learning object in their classrooms. During the training process, the teachers identified the advantages proposed by Crocodile Chemistry software and tried to use and adapt them in order to create specific virtual experiments that can be used by the pupils with a view of better understanding of the theoretical concepts.

The usability of Crocodile Chemistry proved to be a very good one due to the both ways of its usage which is allowed: "Beginner" and "Advanced". For the "Beginner mode", the users have just to follow the instructions of the program to interact with ready to use modules. After two or three clicks, the users are running a very visual interactivity. As Crocodile Chemistry contains many examples, this is the best for the first step with this virtual instrument. Figure 1 (a, b) presents two examples of ready to use modules provided by the software. For the "Advanced mode", Crocodile Chemistry offers several "Components library" to build its own interactivity (Fig. 2). For example, the "Chemicals library" contains different chemical reagents classified in different categories: metals, acids, alkalis, oxides, halides, sulfides, carbonates, nitrates, sulfates, gases etc. The "Glassware library" offers to the user different chemical utensils like beakers, Erlenmayer flasks, rounded bottomed flasks, baths, evaporating dishes, tubes, burettes, pipettes, graduated cylinders, volumetric flasks etc. Also, the "Equipment library" includes the needed equipments classified in few collections like Apparatus, Electrochemistry, Meters and Probes, Safety Signs and Stoppers. The "Indicators library" includes the charts, solutions and papers of different indicators. One of the most important libraries for designing a new virtual experiment by using the Crocodile Chemistry is "Presentation". This comprises different tools for an easy set-up of the virtual experiment like: Graph, Text, Instructions, Picture, Animation, Drop-down lists, Edit box, Pause button, Reload button, Part tray button.



(a)



(b)

Fig. 1 *Ready to use clips provided by the Crocodile Chemistry software for using virtual instrumentation in the teaching/learning process.*

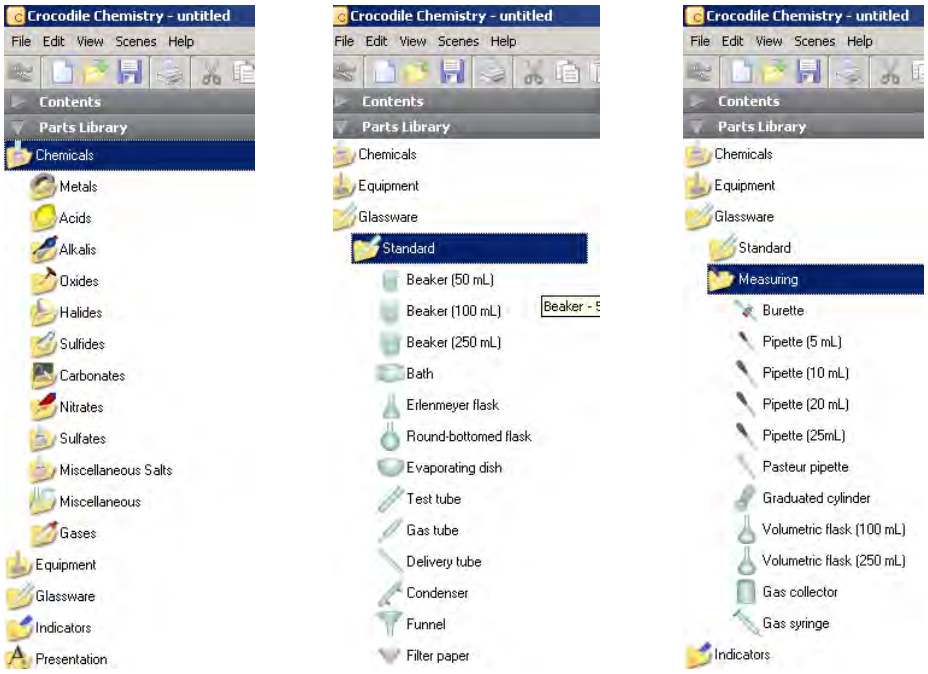


Fig. 2 *Components Libraries included in Crocodile Chemistry for designing a new virtual instrument.*

3. Results and discussion

Using Crocodile Chemistry software, four teachers from Dambovita County, who achieved the training modules "Virtual Instrumentation in Science Education" organized in the frame of VccSSe project, designed several new virtual experiments adapted to the Chemistry curricula scheduled for Romanian lower and upper secondary school. All the teachers discovered a lot of instruments provided by the software and found it very useful not only for the upper secondary school but especially for the lower secondary school. They appreciated the easy way of designing of virtual experiments which illustrate different theoretical concepts covered from the first year of learning Chemistry (during the 7^{th} grade). Topics like "Chemical character of solutions", "Substitution Reaction", "Electrolysis", "Galvanic Elements" or "Chemical properties of organic acids" were chosen by the teachers for different learning Chemistry levels. Figure 3 illustrates the 4^{th} Scene of the virtual experiment "Chemical character of solutions" designed for the 7^{th} grade (1^{st} year of learning Chemistry) dedicated to the identifying of the acid or alkali character of a solution by using the pH paper dipped in the universal indicator solution and the universal indicator chart. [4-6]

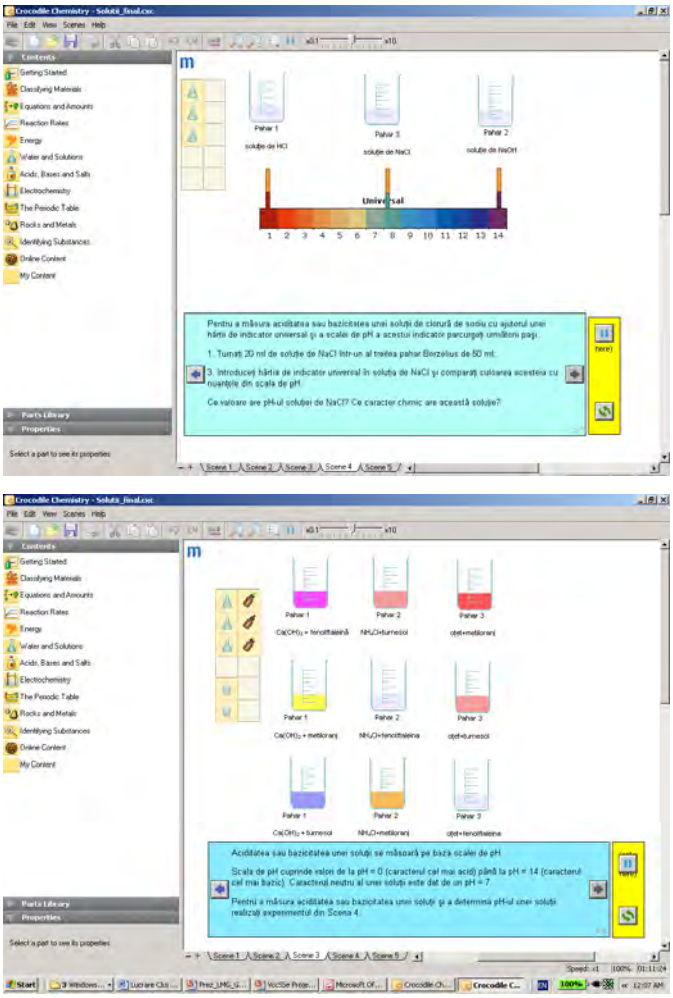


Fig. 3 *Identifying the chemical character of HCl, NaOH and NaCl, $Ca(OH)_2$, NH_4Cl and CH_3COOH by using the virtual instruments designed with Crocodile Chemistry.*

Using the successive steps of the 4th scene, the pupils determined the chemical character of HCl, NaOH and NaCl solutions. Following the same succession of steps and the same tools provided by the software, the pupils could find also the chemical character and the pH of different solutions of calcium chloride, ammonium chloride and acetic acid.

Different examples of substitution reactions were emphasized by another teacher inside a virtual experiment entitled "Substitution reaction" dedicated also for 7th grade pupils. For example, the reaction between sodium and water (fig. 4) which is one of the dangerous reactions that the teacher has to show to the pupils for explaining the substitution reaction concept can be understood very well when showing the related virtual experiment. [4-6]

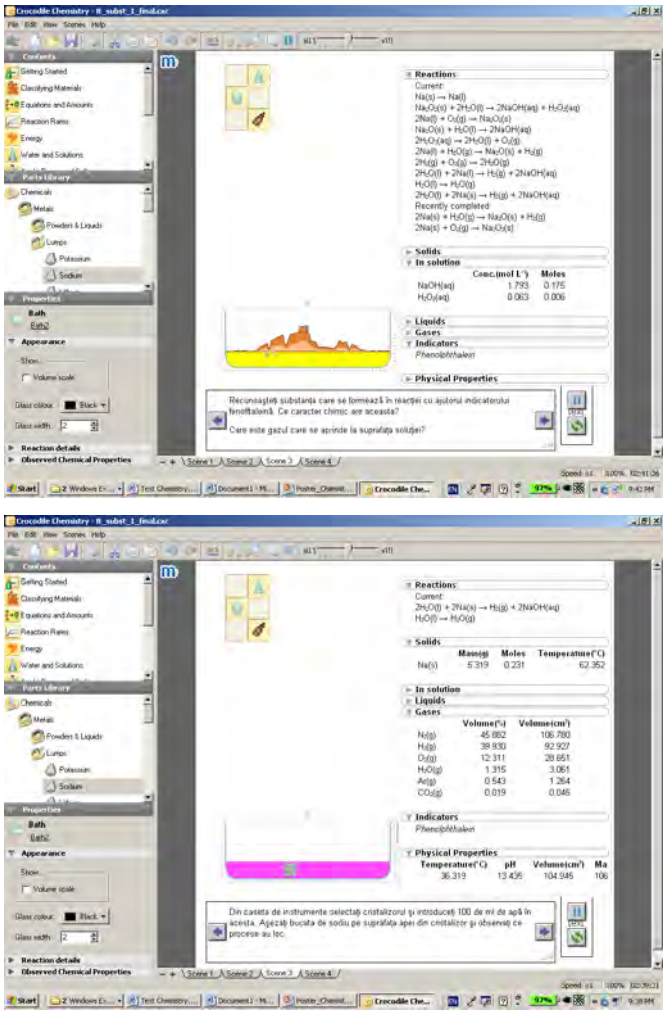


Fig. 4 *Successive steps emphasized by a virtual experiment designed with Crocodile Chemistry during the chemical reaction between sodium and water.*

In the second scene of the same virtual experiment, the teacher proposed to students to simulate the reaction between zinc and a hydrochloric acid solution. It was requested to emphasize the gas that evolves during the experiment and to identify the chemical character of the products. The comparison between the cases when a powder or a lump of zinc is used was accomplished (fig. 5).

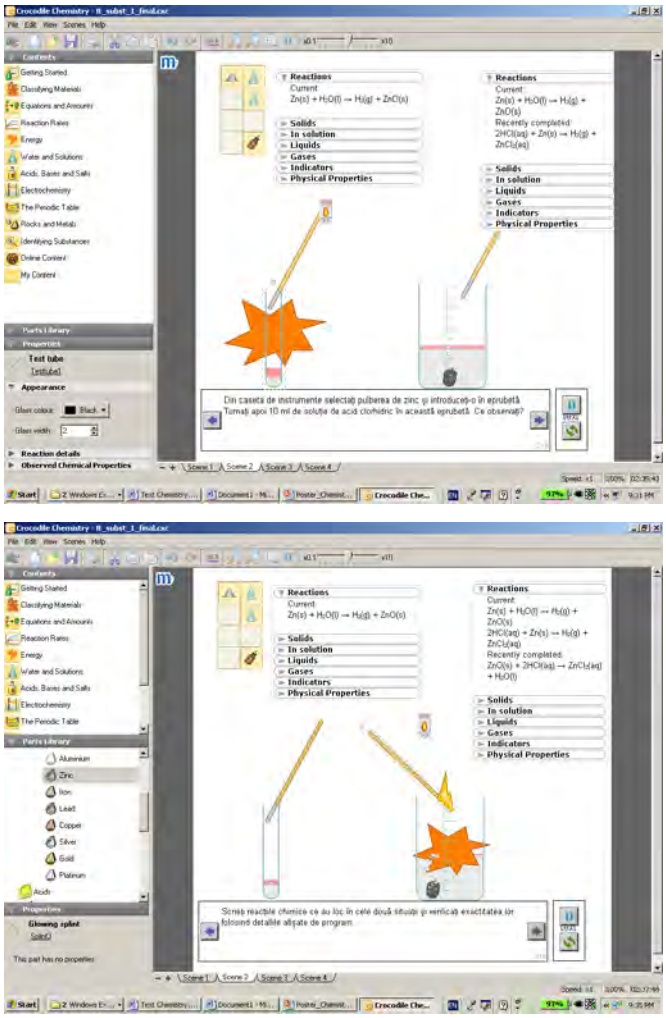


Fig. 5 *Successive steps followed during the virtual experiment designed for the substitution reaction between a powder or a lump of zinc and hydrochloric acid solution.*

For the upper secondary school pupils other advanced theoretical contents were treated by the teachers like the electrolysis process or the functioning of galvanic elements. The electrolysis of different solutions and the processes which are taking place function of different electrodes were illustrated in the "Electrolysis" virtual instrument created by a teacher for the 12th grade students. Figure 6 illustrates the electrolysis of copper sulphate performed with inert electrodes (platinum).

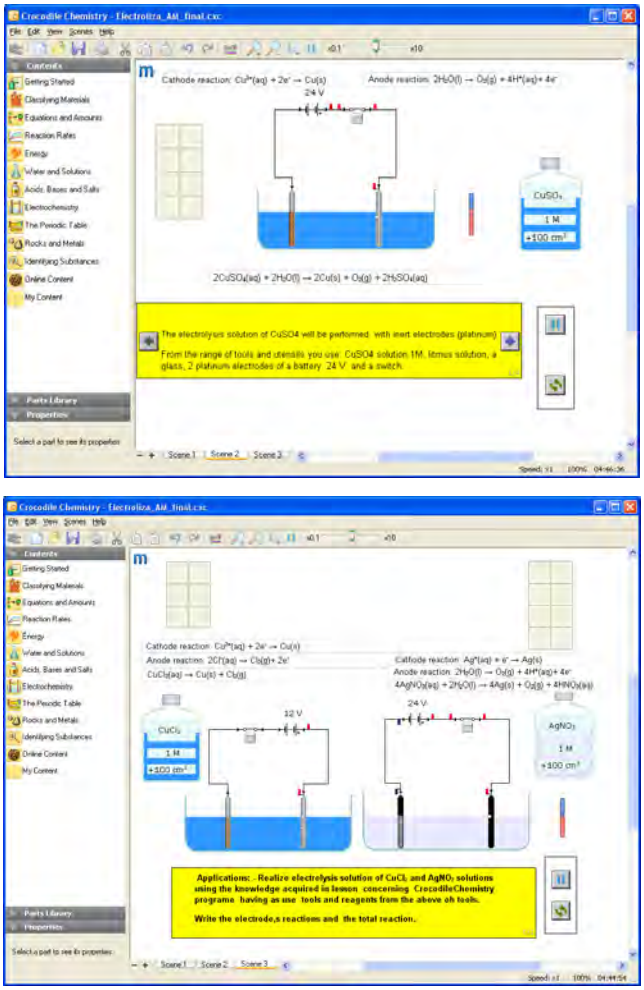


Fig. 6 *Learning the electrolysis of copper sulphate, copper chloride and silver nitrate using the designed virtual experiments.*

Using the knowledge related to the activity series of metals activity, the pupils can identify which are the ions that discharge to the electrodes, being able to write the oxidation reaction that takes place to the anode, the reduction reaction from the cathode, which is the gas that evolves in the anodic space as well as the reaction developed in the electrolytic bath. All of these details can be checked by pupils through the additional tools of the virtual instrument designed with Crocodile Chemistry.

The possibilities of visualizing in real time of what is happening inside the chemical system, which are the microscopic components, what chemical processes are taking place in every moment, how many grams of each substance are in different moments of the chemical reactions, the possibility of seeing which are the simultaneous reactions that are taking place in the system, represent powerful facilities that were used by the Chemistry teachers in their virtual experiments implemented in the classroom. However, some limits of the software were discovered by the teachers during the designing process. For example, trying to create a virtual instrument for learning the separation methods of the mixture compounds, some of the teachers reported that in the case of separating the components of mixtures of different solid and liquid reagents, the software couldn't make the difference between the densities of the system solids. Thus all the solids that are not reacting with the liquids are deposed on the bottom of the beaker. In this way, the solids can't be separated each other after their separation by liquid through the filtration process. During the real experiments, when a mixture of water, sand and chalk powder is prepared, the pupils can see that the sand is deposed on the bottom of the beaker while the chalk powder remains on the water surface due to its lower density. The sand can be separated by decantation and the chalk powder can be separated by filtration. This fact lead to the conclusion that teacher has an extremely important role when using those kind of experiments. He / she must know very well the software facilities and skip the possibilities to create some virtual experiments that emphasize something wrong from the scientific point of view during the simulation.

4. Conclusions

The training modules *"Virtual Instrumentation in Science Education"* organized in the frame of VccSSe project proved to be a great opportunity for the Science teachers (in general) and Chemistry teachers (in special) to discover the advantages of using virtual instrumentation in order to improve the logical thinking and learning of the theoretical concepts through the practical aspects. One of the main gains of the training modules was the teachers' ability to design new virtual experiments adapted to the national curricula, their technical possibilities and the level of pupils' knowledge.

During the designing process of the virtual experiments teachers discovered the facilities offered by the Crocodile Chemistry, being able to identify the main advantages of the software that can be used during the implementation process. These can be the following:

- the possibility to present gradually the theoretical concepts, for an easier and deeper understanding of the chemical processes which are taking place in different environments;
- the opportunity to repeat measurements many times and run experiments at convenient time;
- the facility to design quickly, easy and safely virtual experiments and simulations necessary to a proper understanding of the chemical processes;
- the removal of consuming the chemical reagents like in the real experiments;
- the avoiding of all equipment damages and accidents that can take place during the real and dangerous experiments;
- the working in the absence of toxic atmosphere present always in a real Chemistry laboratory.

Some limits of Crocodile Chemistry were also reported. Even some of them proved to be real limits, few of those reported were fixed through other facilities offered by the software. This emphasizes that designing the virtual experiments with Crocodile Chemistry requires an initial preparation and also good teachers' ICT skills.

However, the role of the teacher is very important when using virtual experiments in the classroom. He / she has to design logical successive steps in the virtual experiment application in order to assure the easier and deeper understanding of the chemical processes. On the other hand, he / she has to be able to skip the possibilities for creating virtual experiments that can include scientific mistakes during their simulation.

Emphasizing the main advantages and possible risks of using virtual experiments in the classroom during their implementation process, it can be concluded that virtual instrumentation can be a complementary method of teaching Chemistry that together with the traditional experimental methods allows a deep and logical understanding of the chemical environments.

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References

[1] http://www.datx.com/solution_center_data_acq/Evolution-of-Virtual-Instrumentation.pdf
[2] G. Gorghiu (coord.), *Applications of Virtual Instrumentation in Education*, Bibliotheca Publishing House, Targoviste, 2007.
[3] ***, About Crocodile Clips, http://www.crocodile-clips.com/
[4] L. M. Gorghiu, G. Gorghiu, T. Alexandrescu, Utilizarea experimentelor virtuale în predarea noțiunilor de chimie, *Tradiții, valori şi perspective în Ştiințele Educației*, Casa Cartii de Stiinta Publishing House, Science Education Collection, vol. **47**, 2008, Cluj Napoca, pp. 353-356.

[5] L. M. Gorghiu, G. Gorghiu, T. Alexandrescu, L. Borcea, Virtual Experiments for Supporting Chemistry Lessons and Demonstrations, *Bulletin UASMV*, **65(2)**, Cluj Napoca, 2008, pp. 662.
[6] L. M. Gorghiu, G. Gorghiu, T. Alexandrescu and L. Borcea, Exploring Chemistry Using Virtual Instrumentation - Chalenges and Successes, *Research, Reflections and Innovations in Integrating ICT in Education (2009) - Proceedings of the Fifth International Conference on Multimedia & ICT's in Education*, Lisbon, Portugal, FORMATEX, Badajoz, Spain, vol. 1, 2009, pp. 371-375.