

## Laboratories Based on Internet: comparative analysis of current experiences and development of a virtual laboratory

João Batista Bottentuit Junior<sup>\*,1</sup>, Clara Coutinho<sup>2</sup>

<sup>1</sup> Faculty of Sciences of the University of Porto - Portugal

<sup>2</sup> Institute of Education of the University of Minho - Portugal

This paper introduces the concept, advantages and the development methodology of the virtual laboratories. It will be presented examples of usage of the virtual laboratories in an educational context as well as the conclusions of the comparative analysis of these projects. At the end it will be presented the virtual Organic Chemistry laboratory developed in Pontifícia Universidade Católica do Rio Grande do Sul, which was the object of study of the research project developed by one of the researchers of this article.

(Portuguese abstract) Esta comunicação apresenta o conceito, as vantagens e a metodologia de desenvolvimento dos laboratórios virtuais. Serão apresentados também alguns casos de utilização dos laboratórios virtuais em contexto educacional assim como as conclusões obtidas na análise comparativa desses projectos. Por último será apresentado o laboratório virtual de Química Orgânica desenvolvido na Pontifícia Universidade Católica do Rio Grande do Sul que constituiu o objecto de estudo no projecto de pesquisa em desenvolvimento que trabalha um dos investigadores deste artigo.

**Keywords:** Virtual Laboratories; Information and Communication Technologies in Education

### 1. Introduction

Nowadays no one questions the importance of the Information and Communication Technologies (ICT). The computer became an extremely important tool in our world and schools have already concluded that it is through it that students (future professionals) communicate with the world.

With the discovery of the Internet, several communication tools were developed as well as other resources, so besides being possible to communicate with the world directly and in real time in seconds, it is also possible to get an inexhaustible amount of information.

ICT can be used in very different contexts within the educational system and also with very different purposes and research methods. Due to this diversity, the most common situation is to use them in classrooms as a support to teaching activities, for example the electronic presentations as a support to the teacher's lesson when introducing contents or the access to resources available on the Internet in the classroom. These cases represent traditional teaching with access to technologies.

Recently, the evolution of the Internet and the WWW, the development of software capable of creating and editing pages for the web, as well as the expansion of communication services as email, forums, chats or videoconferences allow new ways of communication between the different sections of the school community and their relationship with the society. The opportunities to virtually extend the classroom appeared, among others, giving to web-based education an infinity of educational potentialities [1].

One of the challenges is to use the Internet as a virtual laboratory, where students can put into practice their theoretical knowledge using Internet-based laboratories. The concept of virtual laboratory is very general, because it covers diversified technologies and human resources essential to actions involving remote control in time, scale or distance. The need to use this kind of virtual environments can appear due to research demands, as it happens when it is necessary to use very specific tools, for example big electronic microscopes to see a unique experiment because of its scale, such as a nuclear fusion or be-

---

\* Corresponding author: e-mail: jbbj@terra.com.br, Phone: +351969981713

cause students and tutors are geographically separate and this is the case in an educational context with interest for us. [1]

This article is divided in four parts: the introduction presents the subject of our work, the second part introduces the virtual laboratories, its advantages and disadvantages and the ways they are developed. The third part presents some examples and experiences of the use of virtual laboratories in some universities and the main goals. The fourth and last part introduces the project of a virtual organic chemistry laboratory, which is been developed by one of the authors of this paper as a masters thesis in multimedia education in the Faculty of Sciences of the University of Porto.

## 2. Development of a Virtual Laboratory

The development of the virtual laboratories begins with planning the desired research or experience and then some multimedia software, which will be used to create the laboratory components and interactions and relations between the different experiences, are chosen. Nowadays, the most used tools are those from macromedia, namely FLASH, which is capable of create animations, FreeHand for draws, DreamWeaver to develop sites, Director and FireWorks to create animations. Besides these tools, it is also important to understand some programming language, such as Java.

Based on the topics quoted [2], the following steps should be followed during the development:

- Elaborate the experience so it can exist an efficient study process;
- Define learning goals;
- Document each diagram and picture;
- Define questions in order to evaluate what was learned;
- Define which design tools will be used, bearing in mind that macromedia tools are very efficient in these cases;
- Define which graphical frame and interfaces will be used to allow students a good approach to reality;
- Development of virtual experiences;
- Define hyperlinks and programming routines;
- Make available all files on the server;
- Test the virtual experiences in order to avoid possible mistakes or faults;

After developing the components, draws, animations and project, it is necessary an instrument on which the laboratory will be available, in this case the Internet. The files of the laboratory also need to be on a server. The access is made through a client-server module.

In some articles and websites is possible to find false virtual laboratories that can be define as multimedia applications or digital atlas. These websites cannot be define as virtual laboratories, because they don't allow an interaction between the student and the experience, showing just some animations or even static images of the production of a physical experience.

### 2.1 Some Cases or Experiences of the Use of the Virtual Laboratories in an Educational Context

Some universities and research groups are already investing in the area of the virtual laboratories. Next we will present some projects under development.

#### University of São Paulo – USP - Brazil

The University of São Paulo has a project named school of the future and one of its modules is the virtual laboratory. In this project, students and tutors do chemical and physical experiments in paper and send them through the Internet to the school of the future, where a team of tutors and programmers trans-

form the project into reality. Although this example is called virtual laboratory, it is far from the real concept of virtual laboratory, because the existing examples do not represent real experiments. The experiments are made by flash animations without any intervention of the student. These examples can be defined as an educational multimedia application rather than virtual laboratories. Virtual laboratories exist when students interfere, creating a thought, and when they are not just simulated presentations where students don't act, just watch. The experiments in this project are in the physics and chemistry area and they are for different grades and different ages. Despite the need to improve some aspects, this project is excellent because it introduces the ICT in schools.

#### **University of Minho – UMINHO - Portugal**

The University of Minho has the Vlabs project that makes available the virtual laboratories for students through animations, videos and remote control of the experiences, providing additional computer contents to laboratory classes. The project is led to develop contents and experiences useful in laboratories classes of subjects in the area of Sciences and Technologies. These contents are available on the Internet to allow students a previous study as well as distance learning (e-learning). The team involved in this development is multidisciplinary, with teachers of the area of Sciences and Education. The experiences were developed for areas such as biology, physics, chemistry, health, education and psychology and to be used in university. The methodology of these laboratories is interaction, manipulation and observation of the experiences.

#### **Pontifícia Universidade Católica do Rio de Janeiro (Pontifical University) – PUC-RJ – Brazil**

The project “Virtual Laboratory” of PUC-RJ aims to work for a scientific cooperation with direct application in Physics laboratories. The Virtual Laboratory has several software that work together and help in the treatment of information, control and in the creation of a telepresence environment between researchers, making it easier for research groups placed in different regions to share information. The purpose is to create an environment where people, tools and information can easily interact. The virtual laboratory allows the remote access to an experience, the manipulation of data and makes easier the communication between researchers through computers. The use of the physics laboratories of this research institute is only for universities.

#### **São Paulo State University – UNESP - Brazil**

The Virtual Learning Chemistry Laboratory of the faculty of sciences of the Baurú Campus of São Paulo State University involves various chemical experiences, from explanations about the security procedures to general and organic chemistry experiences. The experiences are descriptive and for observation, which means that the user doesn't need to make any kind of effort to conclude them. Besides the chemical experiences, some important information will be part of the laboratory, for example manual to develop a technical scientific report, laboratory glassware and equipments used in real laboratories, security procedures, scientific articles, updates made with the course of time, various animations, links and the team responsible for the development of the laboratory. This laboratory has as main targets the university students, although some experiences can be use in schools.

### 2.2 Comparative analysis of the virtual laboratories

Four virtual laboratories were evaluated, among them 3 (three) from Brazilian institutions and 1 (one) from a Portuguese university and most of them have subjects of chemistry and physics.

After analysing the characteristics and capacities of each case, the following characteristics can be identified:

- All of them allow free access to the experiences;

- Only 1 (one) has a guide or exploration guide;
- Only 1 (one) allows the production of a virtual experience with a complete interaction of the users. A complete interaction happens when the user has to perform a series of duties to complete the experience and doesn't simply watch the simulations;
- Only 2 (two) can be used in an educational context, but they need improvements for that;
- None has evaluative activities or suggestions for its use;

The above-mentioned projects are good initiatives to introduce virtual experiences, but a multidisciplinary team in technical areas developed most of them and only one of the laboratories has educational components. This fault leads to tools without pedagogical resources and methodologies. Another important issue is the lack of instruction manuals, which caused tutors to be less interested in using these experiences.

### 3. Evaluation and Development of a Virtual Organic Chemistry Laboratory

The project, which is been developed by one of the authors of this paper within the scope of the Masters in Multimedia Education of the Faculty of Sciences of the University of Porto, focus on the evaluation and development of a virtual organic chemistry laboratory developed by Professor Doctor André Arigony of Pontifícia Universidade Católica do Rio Grande do Sul (PUCRS). The graphical interface of the system can be observed in fig 1.

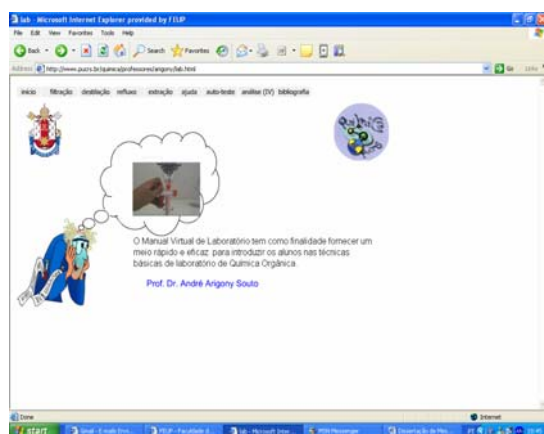


Fig. 1 Entry window of the virtual laboratory.

This virtual laboratory allows the direct interaction of the student and doesn't let him conclude the experience without having the proper knowledge. Some of the motives to use the virtual laboratories are:

- They are great resources to be used inside and outside classrooms;
- They reduce the expenses of the use of a real laboratory;
- They allow e-learning;
- It's a constructive tool that respects the learning rhythm of students;

Some reasons to choose chemistry are:

- It's a science area that allows experiences;
- It's a subject that has many abstract concepts;
- It's a subject that has a great number of fails;
- There are always new educational materials for these subjects.

The virtual laboratory that is been studied has four experiences in organic chemistry, which are filtration, distillation, backflow and extraction. The system has also a virtual tutor to guide all experiences. After

choosing the virtual experience, he will indicate the steps that should be followed. Another resource available to the student is the editing video in a real laboratory, an option that facilitates the understanding of how the equipment works. The laboratory has other resources such as tests, help and subject revision.

This research has two different stages: questions to collect information and development of a prototype. In the 1<sup>st</sup> stage two inquiries will be applied, one is directed at chemistry and physico-chemical teachers that have to answer about ICT and evaluation of the pedagogical and functional character of the Virtual Organic Chemistry Laboratory. The second inquiry directed at computer and ICT teachers aims to evaluate the use of the Virtual Laboratory in a technical, pedagogical level and graphical interface of the tool. This stage is very important to reveal the general characteristics of the system as well as its potentialities and possibilities of improvement. The persons that will answer to these inquiries are mainly students of the masters in Multimedia Education and Chemistry of the Faculty of Sciences of the University of Porto. The number of persons helping in this research is 60 (sixty), 30 (thirty) are chemistry or physico-chemical teachers and (30) thirty are ICT or computer teachers. The objective was to find a sample of persons with a technical and pedagogical level able to answer questions about the pedagogical and computer potentialities of the virtual laboratory.

In the second stage all answers will be collected and analysed. With the given answers and suggestions we can elaborate a plan of developments and implementation for the new laboratory with better resources and functionalities. The conclusions will allow the development of a prototype that aims:

- To place the laboratory content in one school grade;
- To improve possible mistakes in its use;
- To develop more evaluative activities such as games and quizzes;
- To develop exploration guides of the experiences;
- To implement the given suggestions;

When this prototype is finished, it will be added to a virtual learning environment that is used in the e-learning courses. [3] A virtual environment is a space full of meaning, where human beings and technical objects interact, leading to the building of knowledge, which means learning.

The goals for using the virtual laboratories through a virtual learning environment are the creation of a control mechanism of log ins and log outs, using chats as a cooperative teaching tool, forums and all benefits that these systems can offer for teaching and learning.

The environment that will be used is moodle. [4] MOODLE is a learning management system easy to customize and with powerful functionalities, supplied by Open Source, for free and developed under a pedagogical perspective.

After this new virtual laboratory has been finished, we want to collect the opinion of those who answer the inquiry, in order to know what improvements this new system can provide.

#### **4. Conclusion**

In this paper we started to define a virtual laboratory (simulated experiences using multimedia), then we introduced the advantages and disadvantages of these experiences based on Internet as well as the proposals to its implementation and development in an educational context.

The virtual laboratories take advantage of the Internet services but its usage is very restricted to universities and companies and it is very uncommon to report, in literature, its use in schools. Non the less, it's becoming an updated issue regarding time and space for learning, because laboratories based on Internet strength the idea that teaching and learning don't need to happen only in classrooms. It can happen any time, anywhere people wish to learn.

We hope that the results of the research about the use of a virtual laboratory in a classroom can be presented very soon to all scientific community of the educational system, so it can be implemented in other contexts, namely in activities such as e-learning.

#### **5. References**

- 
- [1] Anido, L.; Llamas, M. & Fernandez, M. "Internet-based Learning by Doing", [Online] available in <http://www.sosak.ieee.ca/soc/es/May2001/17/Begin.html> e Acesso em 16/03/2006. (2001)
  - [2] Restivo, M. T. "Laboratórios Virtuais: duas Aplicações no Ensino de Engenharia", VII Simpósio Internacional de Informática Educativa- SIEE05. Leiria, Portugal. (2005)
  - [3] Santos, E. O. "Ambientes Virtuais de Aprendizagem: por autorias livres, plurais e gratuitas", Revista FAEEBA - Educação e Contemporaneidade, Salvador, v. 11, n. 18, p. 425-435, jul./dez. (2002)
  - [4] Belchior, M. ; Freitas J. C., "E-Learning (Moodle), As TIC nos Projectos de Intervenção Local: Uma Actividade Colaborativa", Actas da Conferência Internacional de Tecnologias de Informação e Comunicação, Challenges 2005. Braga: Centro de Competência Nónio Século XXI da Universidade do Minho. (2005)