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THE IMPACT OF E-LEARNING IN CHEMISTRY EDUCATION

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Abstract: *The developing the laboratory exercise in the chemistry course requires considerations of many things. Firstly, the laboratory approach can be different in type, whether it is real laboratory exercise, virtual laboratory experiment or remote access laboratory. Each of them has advantages and disadvantages. Using computer chemical simulations, students can perform even complicated and hazardous experiments and obtain deeper understanding of the chemical theory. On the other hand, the lack of teacher interactive communication and discussion is huge disadvantage. However, the remote laboratory approach gives the opportunity to work on real experiments, contact with the researcher or distant teacher. Also, the feeling of real experiment with operational problems, errors, non-ideal results, way of overcoming the problems are really beneficial to students. The pilot test of remote access to Gas Chromatography-Mass Spectrometry (GCMS) case study as a teaching and learning tools during Environmental Chemistry university course at Faculty of Science and Mathematics Nis has been performed and described.*

Keywords: *E-Learning, Distance learning, Remote laboratory, Pilot test*

1. INTRODUCTION

Nowadays, the approach to teaching and lecturer's skills are changing dramatically. The twenty-first century classroom is based on evergrowing introduction of new learning technologies. The e-learning concept that is widely accepted facilitate and support the learning and teaching proccess through the use of information and communication technologies.

Eventhough remote control has been used in different fields for some time, remote control for teaching chemistry experiments is relatively new.

Remote laboratories are increasingly appearing in a variety of disciplines and are quickly becoming a major part of a science educator's teaching arsenal. With the increasing availability and robustness of new instrumental techniques and software tools, the use of remote laboratories and remote access is being explored by many educators in the chemistry.

In this paper, the pilot test of remote access to Gas Chromatography-Mass Spectrometry (GCMS) case study as a teaching and learning tools during Environmental Chemistry university course realized at Faculty of Science and Mathematics at University of Niš will be described.

2. CHEMISTRY EDUCATION AND EXPERIMENTATION

Chemistry education through strong laboratory approach is at the heart of many university level chemistry courses. The importance of experiments in chemistry education can be seen in stimulation of interest in learning, experiencing the exploration, improving and testing the existing structure of knowledge.

Experimentation is considered as a fundamental part of the education and training of most chemists and so chemistry study programs require great ratio of practical components.

However, performing experimentation in chemistry teaching is ambicious and demanding task. Most laboratory experiments require the effective and safe coordination of personnel, equipment, chemicals, samples by skilled staff [1]. The costs for chemistry laboratory courses are much higher comparing to other natural science laboratory courses. Experimental approach in chemistry education is time consuming, expensive and often can be hazardous. Equipment is also limited by the number of pieces and also by the novelty of instrumentation. Also, students do not have much laboratory practical experiences and skills and thus have to repeat some parts of experiment which rise up the cost of the experiment. The experiments usually set the neccesity for one to one tutor to student assistance in doing the experiment.

3. REMOTE INSTRUMENTATION

The remote laboratory concept is often used and this is not the new concept. Remote instrumentation is used when instrument is inaccessible because of difficult location or hazardous reasons. For example, all nuclear fission reactors are operated remotely because of the safety issues, exploration spacecraft and deep sea craft are also remotely controlled.

However, the education is also the domain in which the remote concept is useful to be applied. The remote access is an excellent method for sharing expensive equipment for teaching purposes for more hazardous experiments.

Implementation of remote instrumentation method leads to cost-effective e-learning where students at a remote site need only computers and the Internet to perform the experiment.

In considering the approach of remote instrumentation in chemistry education, it is important to emphasize the difference between a virtual laboratory environment and remote teaching laboratory. A virtual laboratory environment represents the computer simulation of experiment or instrumentation. The advantages of virtual laboratories lay in the facts that they can prepare student for a real experimental situation and support experimental explanation and learning of theoretical knowledge and concepts. However, the simulation of an experiment does not exactly reflect the "real" world. Unlike virtual or simulated analytical instruments, remote control of equipment and experiments allows students to physically carry out real experiments over the Web. Thus, they obtain the real results for their real samples, perform the real analysis and make the real discussion and conclusion.

The remote instrumentation from a distant location gives the real-time experiment concretizing the understanding of procedures. Thus, by approaching with the computers, even mobile phones, and Internet-capable devices the connection to the remote laboratories can be made to trigger the instrument.

The student can alter experimental parameters, run a real experiment, analyze data collected, and prepare reports both within the supervised teaching laboratory and outside regular hours.

In general, the virtual laboratory offers students special benefits such as conducting online experiments almost 24 hours a day, without typical limitation in space and time. Even more, this laboratory offers them doing experiments selectively, within the fields they are interested in. This flexibility gives new opportunities to students to improve the interaction between teaching and learning.

Remote access has also afforded unexpected advantages for the instructor. Upgrades to instrumental software and hardware require frequent changes to instrumental analysis course packs or laboratory manuals. Access to the instruments via the Internet has made these upgrades much easier. Staff can access the instruments and the key screens needed to utilize the instrumental software can be captured and pasted into the course pack document on their office computer. Additionally, student files can be accessed and checked for consistency with reports submitted for marking from the office computer. Multiple user access to the Web site permits an instructor to observe students using instruments in the laboratory via remote access and to interfere when help is requested using a chat tool.

Special effectiveness can be achieved on more complicated and expensive instrumentation controlled with PC specialized and licensed software and drivers, which can not be easily installed on the client side. Remote access offers experience of real doing measurement, close to virtual reality. The instrumental techniques that can be usually undergone this procedure are: nuclear magnetic resonance, mass spectrometry, High Performance Liquid Chromatography (HPLC) or GCMS, ion chromatography, ICP-MS. On-line interpretation of chromatograms, spectral data, mass spectrometry identification through database fingerprints and fragmentation patterns or FT-Infrared spectroscopy are just a couple of examples where the chemistry student or vocational learner can vastly benefit.

In instrumental analysis applications, access to a variety of databases (e.g., spectral and mass spectrometry databases) would be provided to aid in compound identification. Other approaches to facilitating training on the Web site would be a site for frequently asked questions coupled with a troubleshooting flowchart or decision tree to help students solve some difficulties involving access to instrumentation and the process of instruction. This would be particularly important to guide students accessing the site for the first time when the need for guidance is most critical.

The example of remote analytical instrumental approach is shown in Image 1. Several analytical instruments are connected by local area network (LAN). An Internet security server was set up to permit access to this LAN over a firewall. One advantage of this arrangement is that the bulk of the software required resides with the institution rather than on the remote workstation. Students or guests accessing any of the instruments would only require an Internet browser at their locations [2].

Remote laboratories are a step beyond the computer generated laboratory simulations. They are alternative to work in a real laboratory. Remote teaching laboratories are being employed in four ways [3]:

1. for demonstration and observations of experiment;
2. for caring out measurements (especially real-time measurements);
3. for manipulation of instruments in experiments;
4. for collaboration at a distance.

Observation. Facilitating observations remotely is by far the simplest and most robust version of a remote experiment. Usually the observer interaction is minimal and is often limited to controlling for example the camera (control of astronomical camera or electron microscope).

Measurement. A few examples include measuring the reaction kinetics in chemistry, thermal conductivity experiments in food engineering, chemical analysis using gas chromatography or carrying out single crystal X-ray diffraction measurements.

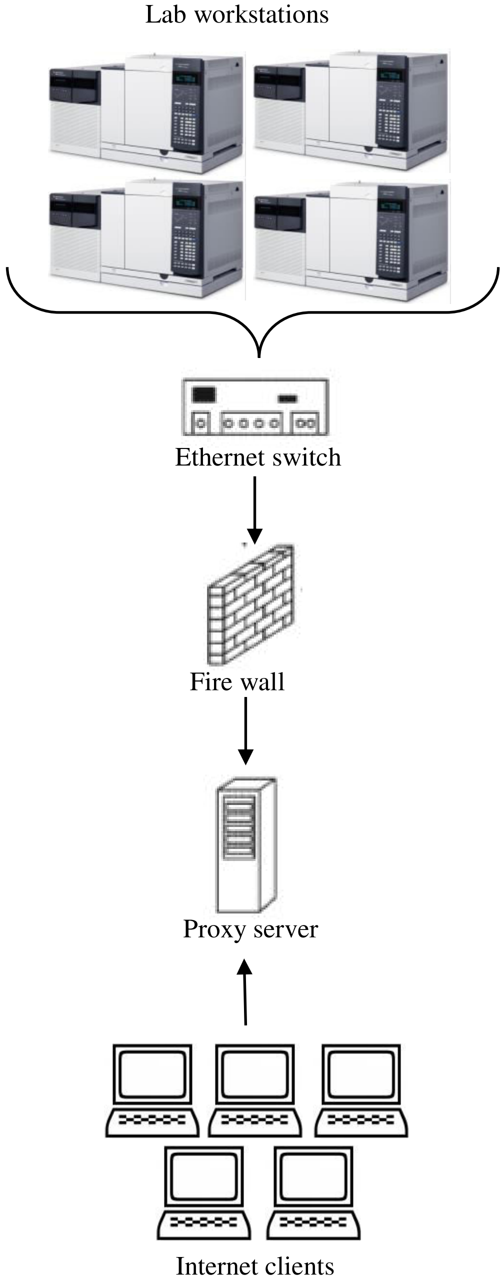

Image 1: Remote Analytical Instrumental Approach

Manipulation. In addition to observing and measuring, some remote experiments will require actual physical control of objects. This could be the control of an electric motor or more interactive robotic operations, such as manipulating a mechanical arm.

Collaboration. Certainly one advantage of Internet access is that it can facilitate sharing not only of experiments and instruments, but also of data. This employs observation and measurement, along with collaboratively pooling individual student findings to gain better statistical results. Others are also taking advantage of the remote control environment to incorporate a collaborative component to their teaching practical's.

The virtual laboratory system architecture consists mainly of several subsystems, as shown in Image 2. The virtual simulation must be based on appropriate (developed or purchased) software and database. As a rule, each experiment application shares the same database which contains two functions insert-into-database (saving user information and experiment data) and select-from-database.

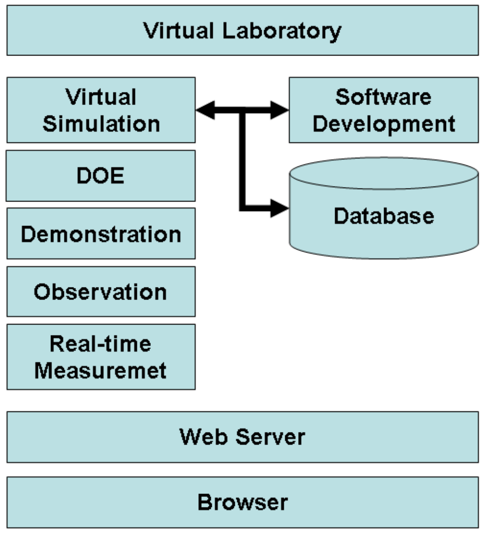

Image 2: System architecture for education

This section mainly focuses on theory demonstration and observation experiments, and runs without veritable experiment instruments. These activities must be preceded by design of experiments (DOE) as a powerful tool that can be used in a variety of experimental situations. The real-time measurement section mainly focuses on instrument-sharing experiments and remote control experiments (pre-experiment, experiment and post-experiment.). Here the pre-experiment can be replaced by DOE including a pre-test regarding the experiment content and appropriate procedure, while the post-experiment can be represented by data acquisition and data processing as well as by experiment reporting.

Virtual laboratory should be based on so called browser-server-database-application architecture, which usually consists of several modules, such as client, web and application servers and finally instruments. The web server should provide Internet services. At the same time, it should generate and host the virtual experiment platform, which should serve as a spot for interactive experiment execution of operating virtual instruments, but for data collection and for displaying the processed results. Data acquisition and data processing are the task of application server.

Above mentioned architecture may be based for example on LabVIEW programming and built-in TCP/IP protocol, which should carry out the communication between the application server and the client application written in LabVIEW.

In this architecture the client (students) first builds a connection with the application server, sends control commands together with the adjustement of some processing data (processing the experiment data by itself) and receives messages that the platform is ready for interactive experiment demonstration and observation, as well as for real-time measurement and displaying the results in various forms.

4. GCMS INSTRUMENT REMOTE ACCES – A CASE STUDY

The Faculty of Sciences and Mathematics at the University of Niš offers Environmental Chemistry course in Master Study programme of Environmental Chemistry (4 hours of lecture and 3 hours of laboratory practice per week). This course currently introduces students to complex chemical processes in the environment and their mutual interrelationships and dependance. Specially highleted topic is biogeochemical processes in unpolluted and polluted environmental systems, chemical spieces in the reservoars, exchange pools, fluxes through their migration and detection of different chemical species. The lectures cover some part of theory of GCMS as a useful tool for identification and quantification of chemical species in environmental compartments. The scope of systematic understanding and skills of experimental research methods in the environmental chemistry is limited by the availability to practice on modern, sophisticated analytical instrumentation, such as GCMS.

However, bearing in mind the surcumstances regarding equipment availability to teaching, not only researching, their timely limited usage, a GCMS instrument at the Faculty is not fully available Thus, laboratory exercises usually show a lack of practical approach of working on the instrument. The need of active-learning methodology in instrumentation techniques and „hands-on“ laboratory exercises are more than necessary. This conditions give space to necessity of implementation of remote access to the instrument, and the case study of this implementation is given here.

The Gas Chromatography theory section of the course is given prior the GCMS case study at 4 hours of lectures. Learning objectives comprise the following:

- On completion of the Gas Chromatography section of the Environmental Chemistry course, students will be able to: (i) define chromatography and related terms, (ii) develop conditions for analysis: stationary/mobile phase and detection and (iii) optimize the separation process.
- On completion of the Mass Spectrometry section of the course, students will be able to: (i) evaluate and assign mass-to-charge (*m*/*z*) ratios for xenobiotics using the obtained fragmentation pattern, (ii) define a GCMS protocol for identification and quantitation of the investigated analyte.

The TeamViewer is used as a free desktop sharing program. TeamViewer provides remote control, desktop sharing, online meetings, web conferencing and file transfer between computers. To connect to another computer, TeamViewer has to be running on both machines.

Direct connection between the guest and host computers is initiated through TeamViewer at the request of the guest by ‘‘calling’’ of the host computer. When TeamViewer is started on a computer, it generates a partner ID and password (user-defined passwords are also supported). To establish a connection between a local client and a remote client, TeamViewer generated ID and password of either client are required. The local client requires the remote client's ID and password to gain control over the remote client, whereas the remote client requires the local client's ID and password to gain control over the local client.

Once connected, the remote client can see the instrument software interface on the desktop of the host computer and can request full instrument control just as if it was connected directly to the instrument. Thus, the TeamViewer has provided a unique opportunity for students to be exposed to and operate modern analytical instrumentation and engage in experiments that would not have been possible previously.

Using similar approach, remote access to other instrumental techniques that can be undergone this procedure, such as HPLC or ICP-MS, being tested at the Faculty of Sciences and Mathematics in another pilot project.

5. CONCLUSION

The remote instrumentation and laboratories for experiments in chemistry teaching have been developing for almost twenty years.

The remote laboratory approach in chemistry education gives opportunity to distance educator a tool to integrate the laboratory component within chemistry course. The student satisfaction is great due to the fact that they get the real results, using real substances and make the real conclusion, just as they would in the laboratory with the equipment. This gives the opportunity to students to upgrade their laboratory, instrumental skills learning at the distance.

The pilot test of remote access to GCMS case study as teaching and learning tools during Environmental Chemistry university course has been performed and described. A case study with remote access to a GCMS instrument using Team-Viewer at University of Niš was developed and tested.

Remote access to scientific instrumentation can be used to modify case studies to enhance student learning and teaching practice in environmental analysis.

LITERATURE

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