COLLABORATIVE DISTANCE LEARNING WITHIN LABORATORIES BY USING VIRTUAL ENVIRONMENT

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Abstract: The advances in technology and changes in the organisational infrastructure put an increased emphasis on teamwork within the workforce. Staff of the organisations need to be able to think creatively, solve problems and make decisions as a team. So the development of such skills through collaborative learning is one of the primary goals of technology education.

In this paper, after a brief presentation of some research results in collaborative learning and virtual laboratories, two concrete examples of collaborative virtual environments for remote laboratories are discussed: the first developed within a German project, coordinated by the FernUniversität Hagen, Germany, and the second developed within an on-going European project coordinated by the University of Craiova,in the Minerva scheme.

Keywords: Distance Learning, Virtual Laboratory, Minerva scheme, ViRec project, Teleoperation, Collaborative Learning.

1. COLLABORATIVE LEARNING

In collaborative learning environment students work together in small groups toward a common goal. Some researchers in collaborative learning (Gokhale, 1995; Johnson et al., 1986) affirm that the active exchange of ideas within small groups not only increases interest among participants but also promotes critical thinking. The shared learning gives students an opportunity to engage in discussions, take responsibility for their own learning, and thus become thinkers (Totten et al., 1991). Within collaborative learning the success of one student can help other students to be successful.

In what follows we give some remarks about collaborative learning that could be grouped in five categories:

- Daily Practice: collaborative learning can be identified and should be encouraged when there is need for some people to learn together; collaborative scenarios are not necessarily intended to any pedagogical or organisational theory or ideology.
- Organisational: it is common practice to achieve goals by bringing together experts, multidisciplinary teams, etc. The challenge in these settings is to motivate each member to bring in his expertise in order to get the group to learn and work together. In the longer term, collaborative learning enhances the employee's ability to acquire collaborative and decision making skills within the organisation helping individuals to perform and work together with others in the work place.
- Learning-Theory: there are established reasons to believe that models of collaborative learning are very effective as means of learning.
- Empirical: research shows that collaborative learning offers cognitive advantages to learners and also has positive influence in enhancing the development of personality traits.
- Ethical: Collaborative learning empowers the individuals and enables people to live a more satisfying life in the future. This answer, referring both to children and adults, has emerged from radical views such as critical and other radical criticism of prevailing educational structures.

In spite of these advantages, there is still little evidence on its effectiveness at the university level and, particularly, in technical disciplines.

When implementing collaborative learning, the first step is to clearly specify the foreseen academic task. Afterwards, the collaborative learning structure has to be explained to the students. The students are also advised to carefully listen the comments of each member of the group and be willing to reconsider their own judgements and opinions. Hence, it was emphasised that every group member must be ready to contribute his or her ideas. After that the group can converge at a common solution.

Internet-based communication services facilitate new forms of distance learning and the development of Web-based virtual collaborative environments that bring together geographically distributed users. Web-based collaboration uses asynchronous (e.g. e-mail, file exchange, discussion forums) and synchronous (e.g. chats, white boarding, videoconferencing) means of communication between instructors and students.

2. VIRTUAL LABORATORIES

In engineering education, lectures are usually complemented by laboratory experimentation. Students can observe dynamic phenomena that usually are difficult to explain by written material. Furthermore, interactive experimentation on real world devices improves the motivation of the students and develops an engineering approach to solve realistic problems.

But, in distance education, laboratory experimentation represents a complex task, as compared to the conventional form of education, where students can be present in the university labs. A solution to avoid this drawback is given by virtual experimentation that is the experiments are simulated and visualised by means of virtual reality. Simulation represents a proper way to complement engineering education, but, in general, it can not replace experiments on real devices.

Another methodology to avoid the drawbacks of local conventional experimentation consists in teleoperation of laboratory experiments. Tele-laboratories are expressions of a more general distance learning education which is attracting at present wide attention in the academic world and governmental communities.

A thorough analysis of the concepts virtual labs and remote labs was carried out recently by Exel and collaborators (Exel et al., 2001) in a paper entitled "Simulation Workshop and Remote Laboratory: two web-based training approaches for control", where it is concluded that virtual labs are good for assimilating theory, but they cannot replace real processes, since a model is only an approximation which cannot reproduce all the aspects of a process. Providing remotely accessible experiments another advantage is obtained, when a unique or expensive equipment can be shared between several universities situated within one country or in different countries. In this way, a larger number of laboratory resources are available and students can choose from a variety of lab experiments.

Teleoperated laboratories have applications in research or industry as well, like:

- high school comprehensive usage of the laboratories,
- directly comparison of the procedures,
- demonstrations at conferences,
- distance maintenance, telediagnosis,
- embedded Web-services.

Some requirements for teleoperated (distance driven) laboratory experiments are the following:

- teleaction,
- telepresence,
- recording and transmission of measured data,
- security of the structure of the experiment,
- protection of the access,
- management of the access.

When dealing with such kind of applications, it is important to transport the feeling of a real experiment to the remote user, a goal provided by a video and audio broadcast.

As only a group of students at a time receives access to an individual experiment, schedules and exclusive access procedures to the experiment are necessary. Users should be able to book experimentation time in advance. They carry out the whole booking procedure by themselves in order to choose the time most appropriate to their needs. The main requirement on the server side is the safety of the experiment and of the server. The experimental plant on the other hand has to be protected against any action that can damage or destroy it. For this reason, all commands given to the plant controller must be analysed and those dangerous controller settings have to be avoided. If the controller algorithms can be defined by the user without any restriction, system instabilities caused by the controller are difficult to be detected in advance. To evaluate students work, it is useful to log all communications between user and experimental environment.

To provide remote experimentation to a group of students, typical synchronous communication techniques, like video-conferencing, are not suitable because of bandwidth limitations. A video-conference with more than two communication partners is a typical point-to-multipoint application. If a true collaboration of all partners is desired, the partner with the smallest bandwidth limits the communication. Our application of a remote lab requires real interaction between the students and the tutor, so a bandwidth-saving way of interaction is required as an alternative to the video based communication. Pure text-based communication (Chat) does not meet our requirements because a multi-user remote lab application needs the possibility of real interaction. The tutor has to be enabled to introduce and to explain the details of the experiment by some kind of visual representation of the experiment. In this collaborative virtual environment only one student at a time has active access to the experiment.

3. EXAMPLES

In what follows we give some examples of such developments. The main design idea of the remote experimentation systems used within such projects is to use the Web as communication structure and the Web browser as user interface. A Web Server is the interface between the client (student) and the experiment. A video and audio broadcast can provide the remote user with the feeling of being physically present at the location of the real experiment.

Three German universities (University of Bochum, University of Dortmund, FernUniversität Hagen) are currently developing a virtual laboratory as a network of remotely accessible laboratories, in order to set up a prototype experimental environment. The students will have access via Internet to various experiments in control engineering, which are physically situated in the control laboratories at these three universities. With remote experimentation unique or expensive equipment can be shared between different universities. Since a wider range of laboratory resources can be made accessible, the students have the choice between more experiments. They can use the virtual laboratory at any time and at any place and save travel time and cost.

The software modules of the collaborative environment for the virtual laboratory (Fig. 1) are generic and can be used in several remote experiments at German universities. The collaborative environment is divided into two main modules - a rendering and graphics part on the client side and a communication middleware on the server side. On the client side VRML is used to display the virtual 3D environment.

Fig.1

An interesting development that can be pointed out belongs to an output of University of Sieni (Casini M, et al, 2003), where a remote laboratory of automatic control was set up. The main goal of the envisaged structure is to allow students to interact with a set of physical processes through the Internet. In this way, it is created a channel to drive the experiments from a lab remotely located, including changing of control parameters, analysing the results remotely etc. This automatic control telelab, called ACT, allows the student to design a particular controller by means of the MATLAB/ Simulink environment, and to test it on the actual plant through a user-friendly interface. ACT has a flexible architecture, allowing an easy integration of new processes for control experiments. The main features implemented by ACT are: activeness, full availability, instrumental easiness, easy interface, remote Simulink-based Controller design, easy addition of new processes, laboratory presence, reference change, on-line reference and controller parameter changes etc.

Every experiment can be controlled according to two modes of operation, namely predefined and user defined, depending on the kind of the control laws chosen by the student. The main feature of the ACT is that a remote user can synthesize the controller without learning any special language excepting MATLAB/ Simulink environment (taught to students from Automation specialisation). Moreover, the ACT is accessible in a very easy way from every computer connected to the Internet through any browser, without the necessity to downloading any special software or plug-in.

Another example refers to the project ”ViReC e-Initiative” – University Virtual Resource Centre based on a DLE (Distributed Learning Environment) – which represents an European dimension attempt for applying collaborative distance learning environments in higher education institutions. The project is financed by European Commission within Socrates-Minerva programme. The partnership incorporates several universities and research institutions from four countries: Romania, Germany, Ireland and Greece. The major background for this application is represented by an initial experience approached by one of the partners – Fachhochschule Regensburg – consisting in setting up the Bavarian Virtual University, where an important contribution belongs to the teaching staff from the University of Craiova.

Among several remarkable foreseen outputs, the creation of virtual laboratories crossed with some real equipment, represents a challenging achievement.

At present, partners are involved in individual developments concerned with some envisaged outputs planned as tutorials and exercises for remote labs in the fields of Network Security, Network Management, Computer Architecture and Data Base Systems (Fig. 2).

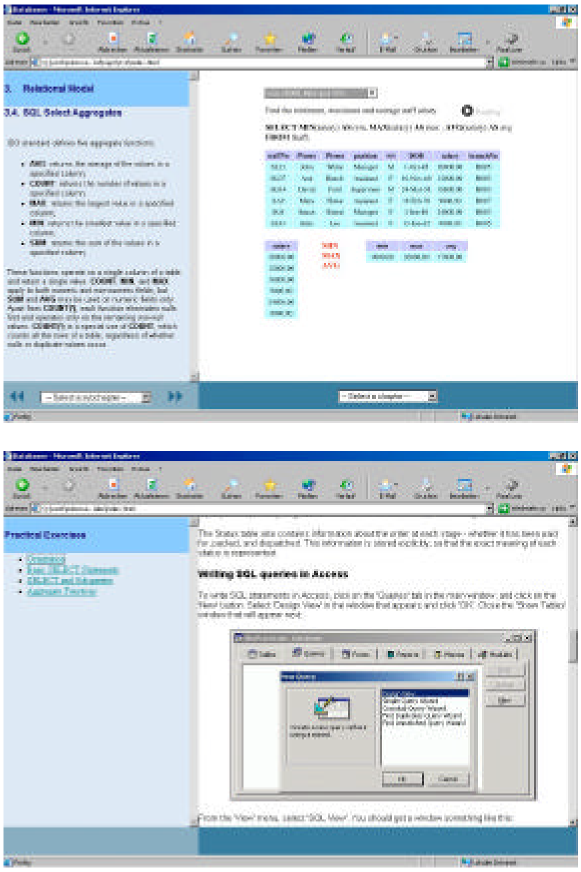

Fig. 2

The first tangible results are to be reported in autumn 2003 at a Workshop dedicated purposely to this goal.

With regard to collaborative feature of projects it could be mentioned a successful recent development called IVDS - that is the International Virtual Design Studio. This project was carried out by a Consortium composed of the Union Collage (USA), Queen's University (Canada) and MEDU University (Turkey). The objective of IVDS is to provide a collaborative design experience to students in different international locations (Notash L., 2003).

The IVDS was created in 1996 by the Union Collage in Schenectady, NY, and Middle East Technical University in Ankara, in response to the need to develop the skills among students that are necessitating to complement the emerging global environment of today's workplace. After that in 1997 Queen's University of Kingston, Ontario, joined the project team.

Eventually IVDS provides teams with international culture interaction and team building, long distance project collaboration and communication, creative thinking, and project management experience.

The work on IVDS project and its outcomes pertain to the area of geographically distributed student groups linked by Internet, to constitute multicultural design teams aiming to develop a creative thinking. It could be appreciated that IVDS is a remarking project since it includes both design and international components. The assessments show that the students find it a very positive experience where they work as international teams during which they learn many important issues related to design engineering. The IVDS allows students across the world to work together in engineering design projects, while challenged with cultural, educational differences.

4. CONCLUSIONS

Virtual laboratory experiments have many advantages, like a comprehensive usage by many universities, a bigger number of available experiments, a higher level valued experiments, that are independent of place and time, and are not requiring travel costs and time. Anyhow our experience with development of such laboratory shows that in order to be efficient they require more intensive advices, media competence of the tutors, live "presence" and feedback of the students about the laboratories. Collaboration and workgroup should be initiated by the tutor of the laboratory experiment and supported by collaborative exercises.

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