Professional Learning from Remote Sites

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Abstract - **The rapid growth of internet-based technologies has brought fundamental changes to the use of laboratories. It enables remote access to laboratory equipment and instruments. In the future, not only computers will be connected to the internet, but more and more devices like individual washing machines, entire plants or autonomous lawnmowers, will be accessible remotely through the internet. These devices can be controlled, programmed, configured, observed, and maintained from distance. Nowadays, the use of online experiments for training, teaching, and learning purposes has become pervasive in many disciplines. In engineering fields, this technology needs to be integrated in the curricula to prepare students for their professional lives. They need knowledge in remote control and distributed product development. This paper presents the work of the Network of Excellence in Professional Learning (ProLEARN)[1] by the working group "online and remote experimentation". It provides an overview of the development of a catalogue of online experiments, information on a common technical framework, and lessons learned from educational evaluations. Three other members of the working group will complete this introduction [1]-[3].**

Index Terms - Virtual and remote experiments, knowledge base catalogue, educational value of online experiments.

INTRODUCTION

Professional learning requires learning content that is relevant to the working context as well as active learning forms that build factual and also applicable knowledge. Since engineering is a practical discipline where doing is the key, hands-on laboratory experiments are essential elements in science, engineering, and technical education. Real or virtual objects in experiments are common in many disciplines. Experiments allow the application and testing of theoretical knowledge in a practical setting.

The introduction of the internet has boosted the implementation of remote and virtual laboratories. Especially in science, engineering and technical education online experiments have become a crucial part during the last years. Online experiments are remotely controlled experiments consisting of real experiment equipment or software simulations that are built for learning purposes. In a remote laboratory, students and devices are at different locations. Students work with a computer that is connected online to a real experiment device.

The experiments enable students and professional learners to get hands-on experience without the need to leave their workspace and go to a traditional local laboratory. Compared to local experiments, remote and virtual experiments have the potential for flexible learning in time and space, access to a large number of experiments and cost savings through experiment sharing [5]. This increase of efficiency makes the laboratory equipment available to a larger pool of students. Consequently, they have the potential for a much wider and more efficient use of resources.

CATALOGUE OF ONLINE EXPERIMENTS

Nowadays, there are many examples of online experiments that are of great importance especially for engineering education [6]. But it is difficult for learners to access and to use them as they are not integrated into a common framework. They differ widely in their user interfaces, user management and time reservation schema. This is also the case for supportive functions like taking notes, data recording and data processing. Furthermore, there is no comprehensive overview available of these experiments. So it is difficult for educational institutions, teachers and students to find online experiments suitable for education and training in their field. Experiment developers could get a quicker start in building new laboratories if they had better access to technical know-how of other experiment developers. Educational researchers could better build upon the work of others and focus their research if they had an overview of all educational evaluations performed with online experiments.

In order to make better use of existing projects, one working group of the "Network of Excellence in Professional Learning (ProLEARN)" [10], funded by the European Union, is dealing with the consolidation of European research in this field. A web-based catalogue of online experiment descriptions has been created to provide an overview of existing online experiments and laboratories. This electronic online repository of experiment descriptions allows educators, experiment developers and educational researchers to locate online experiments of interest. If required, they can contact the experiment owner for further

[1] The "Network of Excellence in Professional Learning (ProLEARN)" strives to integrate European activities in e-Learning into a powerful and meaningful community in order to establish Europe as a world leader in this field.

information and negotiate access rights to the experiment, obtain technical information for building their own lab or obtain scientific articles on educational evaluations [6].

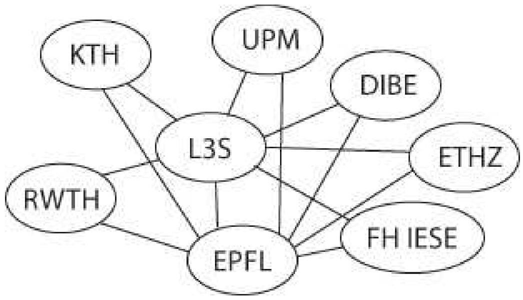

FIGURE 1
NETWORK OF PROLEARN PARTNERS[2] CONSTRIBUTING TO CATALOGUE OF ONLINE EXPERIMENTS

As a first step, metadata attributes for online experiments had to be defined. Categories include experiment components, number of set-ups, interaction modes, availability, reservation policy, and guest access [7].

Metadata for online experiments

The online experiments metadata schema is the format for describing online experiments, similar to the schema for a specific library catalogue used to describe books. As an online experiment is a special kind of learning object, we preferred to specify our schema as an extension to an established metadata schema for learning objects rather than developing a new one from scratch. Thus, only the additional attributes haved to be specified and development efforts were kept at a low level. The extension is based on the EducaNext metadata schema. EducaNext is a global portal supporting the creation and sharing of knowledge for higher education. It is open to any member of the academic or research community for the exchange of educational content and sharing knowledge.

The online experiments catalogue is available at the EducaNext portal [4]. Currently, there are 52 entries in the catalogue of online experiments with a wide range of different classes like computer science, medicine, biology, physics, geology or mechanical, electrical or chemical engineering. Some experiments are set up on an interdisciplinary basis and cover more than one discipline [6]. The main areas of remote experiments are situated in mechanical engineering on the technological side and computer science on the scientific side. The most common learning method is self-directed learning alone or in groups. To store the online experiment descriptions according to the metadata schema, a content management system was set up. It is possible to enter descriptions and search for descriptions over the Internet through a web-based user interface [6]. Access to store and retrieve descriptions is free of charge.

TECHNICAL FRAMEWORK

A joint technical framework for online experiments allows experiment developers to concentrate on a specific part of the experiment and to provide a component of high quality. The online experiments make a large coherent network together. Each experiment in this network can easily be used by learners once they have mastered the first experiment and understood the common basic principles.

As a first step towards the technical framework, the working group has identified the essential services common to most online experiments. The specification document includes modules such as: manipulation and operation, tutoring and supervision, collaboration and teamwork support, authoring and deployment as well as management [7]. Implementation is accomplished with an integrated toolset that fits the framework. Partners can integrate own software components to build an open source European toolset based on the EPFL eMersion[3] toolset. eMersion is a multidisciplinary initiative to deploy innovative pedagogical scenarios and flexible learning resources for supporting web-based experimentation in engineering education. This project has been developed at the School of Engineering, Swiss Federal Institute of Technology in Lausanne (EPFL)[4] and is currently refined and spread in the framework of the ProLEARN European Network of Excellence. Partners use the toolset to re-implement existing experiments and build new ones. This provides insight on features and components needed for different application domains for the further development of the toolset [7].

EDUCATIONAL VALUE OF ONLINE EXPERIMENTS

As described, working with real devices or realistic device models is an important part of engineering and technical education. Laboratory sessions have to be included in the education curricula in order to enable students to apply their theoretical knowledge to a practical situation and to adopt new skills within a realistic environment [8].

Traditional laboratories are supervised by a tutor who gives students feedback on their progress and provides technical assistance. He or she also motivates students, assesses the learning progress, and sets time limits [9]. In remotely controlled experiments, where students get their learning experience over the Internet, instructional support has to be provided, too [8]. From an educational point of view, the use of remote laboratories requires an innovative educational approach. In general, small groups of students work on predefined assignments. This allows them to share their expertise and ideas to solve the often complex measurement, construction or programming tasks. Learners need to cooperate with other remote learners and a tutor to solve demanding experimental and constructive tasks. The tutor supports the student over a distance via synchronous and asynchronous communication tools such as text chat,

[2] KTH = Kungl. Tekniska Högskolan, Sweden, UPM = Universidad Polic-técnica de Madrid, Spain, DIBE = Università degli Studi di Genova, Italy, ETHZ = Eidgenössische Technische Hochschule Zürich, Switzerland, FH IESE = Fraunhofer Institute for Experimental Software Engineering, Kai-serslautern, Germany, EPFL = École Polytechnique Fédérale de Lausanne, Switzerland, RWTH = Rheinisch-Westfälische Technische Hochschule Aachen, Germany, L3S = L3S Research Center, Germany.

[3] http://lawww.epfl.ch/page13172.html (12.06.2007)

[4] http://www.epfl.ch (12.06.2007)

video conferencing and application sharing [8]. They make instant support and problem solving possible.

FIGURE 2
HARDWARE AND CONSTRUCTION OF THE LASER EXPERIMENT

Within the work of the working group "online and remote experimentation" we determined factors influencing educational value. This includes the areas of collaborative learning, the impression of interacting with reality (authenticity) and the ease of use (usability). These divisions are conducted by the L3S Research Center[5], Hannover, the KTH[6], Stockholm [3] and the EPFL[7], Lausanne [1].

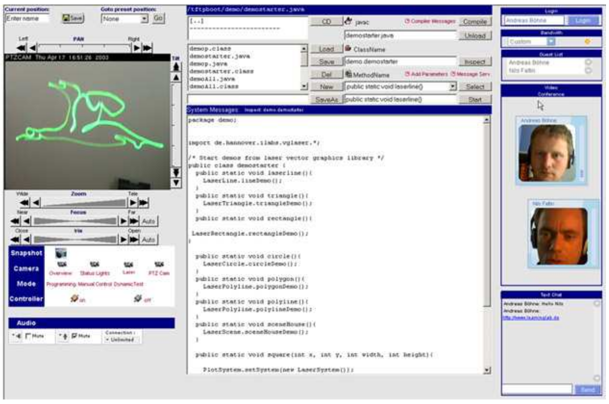

FIGURE 3
WEB-BASED EXPERIMENT ENVIRONMENT FOR LASER DISPLAY EXPERIMENT CONSISTING OF AREAS TELEPRESENCE (LEFT), PROGRAMMING (MIDDLE) AND COMMUNICATION (RIGHT)

At the L3S Research Center we investigate the influence of face-to-face communication versus computer-mediated communication within student groups and between students and tutor on learning effectiveness, motivation, and consulting effort. The educational value is determined through laboratory tests where students use online experiments under controlled conditions or through field tests. To determine the effect of distributed group work in the specific context of remotely controlled experiments, we carried out a comparative evaluation. It compared the learning process of distributed groups with groups cooperating locally. Evaluation methods included student observation, performance tests, measurement of knowledge gain, and student satisfaction. In both cases, students were supported by a tele-tutor. Both groups had the same task assignments and were assisted by the same tele-tutor to determine constant factors in the study.

Although computer-mediated communication is more difficult than face-to-face communication because of missing social clues, the remote assistance has proven to work very well with application sharing and audio transmission being the most important communication media. Distributed student groups compared to collocated students had only little lower task success. This effect is smaller than the effects of initial knowledge and language proficiency. The outcome can be seen as an indication that distributed remotely controlled laboratories are an educationally sound alternative to collocated laboratories. Students can benefit from the increasing flexibility in time and location without major losses in the quality of the educational experience [8].

CONCLUSIONS

Online experiments have become an elementary part of engineering education. Numerous online experiments have been developed during the last year and are widespread in different disciplines.

A knowledge base catalogue of online experiments descriptions has been created to provide an overview of existing online experiments as well as laboratories and to facilitate their search for students and educators. Since good content is the key to success for such a knowledge base, the catalogue needs a sufficient number of online experiment descriptions, so that people are motivated to search for experiments. Only if enough people search in the catalogue, experiment owners are motivated to enter new descriptions for their own experiments. For this reason the group continuously enters experiment descriptions to reach this critical mass. As a European project, the focus is clearly on European experiments, but also some world class international experiments can be found in the database as well. An advantage is that all core partners and associated partners can contribute easily by writing new descriptions. Currently, the catalogue includes more then 50 descriptions of online experiments and is being extended continuously. This can be the foundation for a self-amplifying cycle: as more learners are attracted to use the catalogue, more experiment hosts are motivated to publish their offers.

However, a comprehensive catalogue of online experiments and a common framework is not enough to improve the learning situation. To establish a high educational value to professional learning organizations and their students, it is also necessary to determine the educational value of online experiments. By using them in a reasonable educational setting, students should be prepared for the ability to learn in a self-directed mode. This is an important factor for success in life-long learning. It is important to support the students' self-directed learning so that they achieve maximum responsibility and control over their learning progress.

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5 http://www.l3s.de (12.06.2007)
6 http://www.kth.se (12.06.2007)
7 http://www.epfl.ch (12.06.2007)

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