On-the-Job Informal Learning via an Activity Based Approach

A. Pester, M.E.Auer
Carinthia University of Applied Sciences, Villach, Austria

Abstract—Active learning or working by means of online laboratories is especially valuable for distance working or education. Users in the workplace can access remote laboratories without having to travel. This flexibility is important for teleworking, education and lifelong learning.

Using online laboratories has the potential of significantly reducing obstacles related to cost, inefficient use of time and facilities, inadequate technical support and limited access to laboratories. This kind of development leads to the seamless integration of work and learning (embedded learning). Some of the most important fields of application are in telecommunication, electronics and mechatronics.

Our experience in designing and running a remote engineering curriculum by using distributed online laboratories shows that some aspects of the ideal laboratory learning situation are more emphasized, while others receive less attention.

On the other hand, especially in online engineering education, which can be carried out as job informal learning, experiments with real hardware, and not only virtual simulations are essential. This increases the importance of online engineering, which develops solutions for this kind of needs in education.

Index Terms—on the job learning, active learning, online engineering

I. INTRODUCTION

Today’s workers often require extensive training throughout their professional careers. The amount of money invested in the professional development of workers is substantially growing and can reach between 250,000 and 300,000 € by the time they reach 55 – 60 years of age.

Informal job training is a growing tendency increasing because of the shorter life cycle of formal knowledge obtained in traditional school settings, higher education institutions and adult education programs. The sum of knowledge and skills obtained empirically or through lifelong learning is becoming increasingly important. Informal learning in the workplace and learning on demand are becoming more common as learning strategies that reward these types of learning strategies, which have become hallmarks of modern society.

Learning in the knowledge based society requires an active approach to learning and active, independent, self-directed learning strategies. Experiments and simulations carried out in online labs provide opportunities for students to experience learning in a more hands on manner. Active learning, or working by means of online laboratories, is especially valuable for distance working or education.

As broadband internet access increases learners (both students and engineers) can access remote laboratories from both formal learning facilities or from the comfort of their homes. The ability to efficiently use online distributed laboratories from remote facilities allows persons to expand practical, active learning without having to meet conditions that might otherwise limit access. Both learners and practicing professionals need laboratories that are more flexible and accessible to acquire the further knowledge and skills they require as they evolve to meet the demands of a knowledge based society, and online labs provide a practical, accessible, and cost effective way to provide diverse learning, practical and simulation experiences.

We have experience in the use of online-labs for informal job learning in the area of electronics and mechatronics, based on different projects, we proceeded together with industrial partners in these industries.

II. ACTIVE LEARNING ON ONLINE LABS

A. Online Labs

It is useful to distinguish among three basic types of engineering laboratories: development, research, and educational. While they have many characteristics in common, there are some fundamental differences. These differences must be understood if there is to be agreement on the educational objectives that the instructional laboratory is expected to meet.

Practicing engineers go to the development laboratory for two reasons. First, they often need experimental data to guide them in designing and developing a product. The development laboratory is used to answer specific questions about nature that must be answered before a design and development process can continue. The second reason is to determine whether a particular design performs as intended. Measurements of performance are compared to specifications, and these comparisons either demonstrate compliance or indicate where, if not how, changes need to be made.

While a development laboratory is intended to answer specific questions of immediate importance, research laboratories are used to seek broader knowledge that can be generalized and systematized, often without any specific use in mind. The output of a research laboratory is
generally seen as an addition to the overall knowledge that we have of the world, be it natural or human made.

However, when students, especially undergraduates and part time students go to the laboratory, it is not generally to extract some data necessary for a design, to evaluate a new device, or to discover a new addition to our knowledge of the world. Each of these functions involves determining something that no one else knows or, at least, not generally available. Students go to an instructional laboratory to learn something that practicing engineers already should know. That “something” needs to be better defined through carefully designed learning objectives if the considerable effort devoted to laboratories is to produce a concomitant benefit.

In a laboratory environment, we have an experimenter who is performing an experiment. Both the experimenter and the experiment can be local or remote. Therefore, we can classify laboratories as shown in Table 1, where we distinguish between local, remote and virtual labs.

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Local Simulation</th>
<th>Virtual Lab</th>
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<tbody>
<tr>
<td>Hands-on-Lab</td>
<td>Remote Lab</td>
<td>Virtual Lab</td>
</tr>
<tr>
<td>Local Lab</td>
<td>Remote Lab</td>
<td>Virtual Lab</td>
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The laboratories in the far right column we call Online Laboratories [13]. That means that the most important mode of use of these laboratories is the online mode via Internet or Intranet.

Online labs are software simulations or hardware-based experiments in real time on specialized distributed servers. Obviously, there is still need for further investigations to fully characterize and create a taxonomy of online labs and the learning that occurs in such labs.

Both conventional laboratories and online laboratories can consist of one or more experiments. There are different types of online experiments:

Experiment visualization: This service allows students to realize an online a lab activity determined by, for example, the course teacher. Students obtain the display on their computer from the teacher’s desktop to control the measurement instruments involved in the experiment.

Experiment control: This service allows students to perform experiments by remotely controlling one or more actual measurement instruments. Students can choose a specific experiment within a set of predefined experiments and can run them only if the required instruments are currently available.

Experiment creation: This service allows students to remotely create an experimentation environment. Experiment creation allows virtual instruments to interact with real hardware.

Another systematization of online labs is based on the level of control of an online-lab: remote instrumentation, remote parameter control or remote control logic [9]. This systematization is oriented to the level of control of the inputs, outputs and the logic that the user of such lab has. In addition to these systematizations, common software engineering considerations such as universality (accessibility, multilanguage support, openness of the system), technology (security, portability, kind of control) and management (IT-support, user management etc.) should be included. In the case of online labs for teaching, didactic usefulness is also added. These characterizations are more user than technology oriented and have their origin in today’s broadest field of applications of online labs and in technology enhanced teaching as they provide orientation that should be taken into account when developing new online labs.

Some authors suggest increasing the level of group communication and collaboration in remote lab spaces, as well as the sense of reality of such learning situations. Their vision is to evolve from telepresence to social presence, “… the feeling of being socially present with another person at a remote location.” [11, p. 45] and to increase the authenticity and reality of such experimentations. On the other hand, the pedagogical success of remote experimentation depends on embedding these experiments in a clear pedagogical concept for a course. It is important not only to deliver the technology, but also the educational framework, including how to learn with the equipment along with clear learning objectives that precisely define the desired learning outcomes. The difference for teachers is that they have to more deeply analyze the objectives of their lab work and how to reach them using remote technologies. Students, on the other hand, must learn to work with a higher degree of autonomy and overcome the lack of interactive communication and collaboration which they are used to in traditional hands-on-labs. More resources need to be invested in pedagogical research to create hybrid learning spaces and effectively combine online labs and hands-on-labs to improve conceptual understanding, experiential learning and reflection.

Another point is the combination of virtual and real experiments in a single lab environment. The goal is to provide a side by side comparison between (numerical) simulation and the real (physical) experimental results, and provide, on the other hand, a service that combines multi-user virtual experiments with a single-user hardware experiment. These are so-called Hybrid Laboratory.

B. Online Engineering Education

The learning environment in laboratories is highly complex, but well structured. The learning methods usually used in these situations depend on the specific situation, but self-directed learning prevails, although many experiments combine self-directed and collaborative learning.

On the other hand, the communication skills and the skills used in collaborative learning are better trained in an online lab situation. Splitting the communication channels in such a complex situation stresses a learning process to handle this lack of communication into one or more directions, emphasizing communication with the team-partners over other channels. When designing online experiments, the developer has to model these situations, because the ability to participate in collaborative learning and teamwork in a teleworking situation must be trained in addition to the training involved in the experiment itself.

The emphasis on work in laboratories has varied over the years. While much attention has been paid to curriculum and teaching methods, relatively little has been
written about laboratory instruction. For example, in surveys of the articles published in the Journal of Engineering Education from 1993 to 1997, it was found that only 6.5 percent of the papers used the word “laboratory” as a keyword. From 1998 to 2002, the fraction was even lower at 5.2 percent [14].

One reason for the limited research on instructional laboratories may be a lack of consensus on the basic objectives of the laboratory experience. While there seems to be general agreement that laboratories are necessary, little has been said about what they are expected to accomplish. In most papers about laboratories, no course objectives or outcomes are listed, even though it is not unusual for the author to state in the conclusion that the objectives of the course were met. An accepted set of fundamental objectives for laboratories, as set out in this paper, would help engineering educators focus their efforts and evaluate the effectiveness of laboratory experiences.

In an EU funded SOCRATES project IEEE Members from Austria, Germany, Ireland, Romania, and Slovenia developed a Joint European Master Program in Remote Engineering (MARE project). This master study program promotes:

Basics, applications and experience in remote engineering

Design and application of virtual and remote working environments

Advanced teleworking solutions such as online labs
Remote Technologies for complex engineering tasks
Use of hardware, software tools and simulators in networks
New ways for SME to apply high-tech equipment

The master study program provides the opportunity:

To use equipment and distributed software tools on the Internet or company intranet
To organize, implement, serve and maintain remote solutions
To participate actively in the labor process for people with special needs

The master program includes a total of 10 modules completed during the 4 semester program. The first 3 semesters have 3 modules each and the final semester is reserved for the master thesis project and includes only one module. The students learn in a dual mode (each module is available in both traditional and an e-learning modes). All modules are part of the Open Courseware Initiative of MIT and stored on a special CMS. The study program is planned so that final stage is carried out in parallel in four European universities. Upon course completion, students are awarded a degree “Master of Science in Engineering – Specialization Remote Engineering”. Importantly, students can spend one semester (3 modules) in any one of the partner institutions participating in this project and receive the corresponding credits at his home university. Until now the program is accredited in four countries and is already implemented in one country (Austria) as a master study program and also as a vocational master study program. The first generation of students has already completed this program. Leading specialists from the other partner universities teach some of modules in the Austrian university (in total, 30% of the program).

The study program modules include, beside the basics in mathematics, informatics and IT technology, topics including:

- Internet technologies
- Human-Computer Interface
- Distributed databases
- Graphical and network programming
- Wireless Communications
- Image processing
- Soft computing control
- Telerobotics
- Remote control systems and sensors

The multidisciplinary structure of the curriculum comes out because of the different competencies the students bring to the program regarding remote engineering and technology enhanced learning, as well as the collaboration between different countries experiencing different contexts.

The master study program in remote engineering at Carinthia University of Applied Sciences (Austria) is very research oriented, affording participating students the opportunity to participate in different research and development projects. Students gain more practical experience than in traditional course and gain well-grounded theoretical knowledge as they have to present the results of their work at different project meetings and scientific conferences.

III. EXPERIENCE WITH THE CURRICULA

The curriculum on remote or online engineering has been already carried out several times. About 80% of the students have been part time students. The teaching process is organized in the modalities of project-based learning and on the job learning.

The strong side of such an approach is that the students can use a lot of the things they learn directly in the workplace. On the other hand, the students bring a lot of interesting problems and questions from their daily practice directly to the classroom and discuss these face to face (f2f) with their professors.

Our experience in designing and running this remote engineering curriculum by using distributed online laboratories shows that some aspects of the ideal laboratory learning situation are emphasized more than others.

For the repetition of theoretical knowledge, the learner needs well-trained skills in self-directed learning and sometimes also in collaborative learning. The author and instructors need to be skilled in delivering theoretical material in a precise and concise way. The point to be emphasized regarding this situation is that many communication channels we have in a face to face situation fail, since the learner is only faced with texts, graphics and interactive tests. Often there is no direct
possibility to query the instructor in cases when the learner does not understand the material or the test questions. Exact descriptions, interactive group and individual tests and a strict moral imperative of honesty (no cheating) can solve these problems.

The learning possibilities are broader in an online situation because the student can repeat simulations or experiments and play around with different parameter values several times.

We combined this kind of informal learning with phases of intensive f2f and classroom learning in summer schools, which were supported from the EU Lifelong Learning program (TARET I and TARET II) (see www.online-lab.org/taret). The summer courses have duration of 2 weeks. In these summer schools, students from several European partner universities (as usual, 5-7 partners) work together with professors from all of these universities. The first summer school in 2007 was about Telerobotics and the second in 2008 was about wireless communication. A third summer course is planned for 2009. The goal of these courses is for students to get not only a deeper insight into what they are studying, but also discuss the subject from different approaches in an intensive manner. These courses have already had a great impact on the internationalization of the study program.

An additional advantage of this kind of learning organization is the possibility to learn and work in small international project groups. The instructional strategy is organized mostly project-based and practically oriented. The short f2f period makes it possible to combine this with the job learning.

These summer schools are also a possibility to smooth one weak side of on the job learning – the systematization of the learned subjects. The systematic part of learning is not as strong in this kind of learning. This means that such an approach can be rather good used in parts of the master study programs and in higher semesters of bachelor study programs, but it is not applicable to teach basics.

IV. CONCLUSION

Our experience in designing and running a remote engineering curriculum by using distributed online laboratories shows that some aspects of the ideal laboratory learning situation (as described above) are more emphasized while others are weaker.

Learners had to learn and reflect on different learning styles and skills not only related to self-directed learning and collaborative learning, but also to blended learning. This is also necessary for job informal learning. So before beginning this kind of learning, learners have to test their abilities to use these different methods. On the other hand, authors of learning material and instructors need to be skilled in delivering the material that support different individual learning styles and promote interaction between learners or learner groups. The activity based approach in engineering education provides, at least, a better understanding of the learned material.

Use of online experiments in online engineering learning environments enhances these activities. In engineering education, the experimental part (and not only simulation) of education in online learning environments should be increased. What students need is a plan for testing the experiment under various conditions. Because of having to repeat experiments, laboratory time under traditional labs is often limited. However, students can work in remote labs 24 hours a day and seven days a week, so the opportunity to gain access is greater than in the case of local labs. The prerequisites students need for this are only a Web browser and an access slot, which they can obtain from brokerage software. By working in a distributed lab environment, students can also use experiments developed at other universities, which users may not be able to not find in their home universities. However, one important problem arises in the online mode. Up to now, the influence of the user on the experiment set up is restricted. In a local situation, experimenters must design the experiment according to a given plan or develop their own. In online situations, the experiments and simulations are usually predefined and the variability is limited. This means, with respect to learning, that the experimenters’ meta-cognition in this type of situation is not as well trained as more special knowledge and skills.

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AUTHORS

Michael E. Auer is with the School of systems engineering, Carinthia University of Applied Sciences, Austria, 9524 Villach. He is Head of the Competence Center for Online Labs (e-mail: auer@cti.ac.at).

Andreas Pester is with the School of systems engineering, Carinthia University of Applied Sciences, Austria, 9524 Villach. He is Vice-Dean and Head of the master study program Online Engineering (e-mail: pester@fh-kaernten.at).

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