Chapter 4
Remote Experiments in Freshman Engineering Education by Integrated e-Learning

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ABSTRACT

Information communication technologies (ICT) have made it possible to introduce Integrated e-Learning (INTe-L) as a new strategy for teaching physics in engineering education. It is based on the methods that the sciences use for the cognition of the real world. INTe-L utilizes the e-laboratory which consists of remote experiments, e-simulations, and e-textbooks. Its main features include observations of real world phenomena, possibly materialized in data and their evaluation, the search for relevant information, its classification and storing. Only then come the explanation and the mathematical formalism of generalized laws and their consequences. Essential to this method is the active part the student must take in the learning process: in lessons, seminars, and laboratory exercises, but also his/her substantially increased activity in form of projects, search for information, presentations, et cetera.

In this chapter, we present the outlines of the remote laboratory integrated in the INTe-L system, using the Internet School Experimental System (ISES) as hardware and an ISES WEB Control kit as software. We suggest an architecture for implementing remote laboratories, with data transfer across the Internet, based on standard and reusable ISES modules as hardware and Java supported ISES software. The Learning Management System (LMS) MOODLE turns out to be a highly effective means of organization of physics courses. The first experience on teaching units Free fall (http://remotelab4.truni.sk), Simple Pendulum (http://remotelab5.truni.sk), and Natural and driven oscillations (www.ises.info – see Remote laboratory) is presented.

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INTRODUCTION

The physics teaching methods at secondary schools and universities are at a critical stage in their development. The traditional way of delivering physics in an overwhelming majority of physics courses has characteristics we are familiar with. Most of the class time involves the teacher lecturing to students; assignments are typically homework problems with short quantitative answers. Seminars and especially laboratory work are more or less “recipe” style, usually only loosely bound to the time schedule of the lectures, and examinations are largely based on written exams containing theory and a bit of problem solving (Wieman & Perkins, 2005). Over the past couple of decades, physics education researchers have studied the effectiveness of these practices including extensive conceptual understanding, transfer of information and ideas from teacher to student in a traditional physics lecture, and beliefs about physics and problem solving in physics (McDermott & Redish, 1999; Adams, Perkins, Podolefsky, Dubson, Finkelstein & Wieman, 2006; for reviews with useful citations, see references in Wieman & Perkins, 2005). The definitive conclusion is that no matter the quality of the teacher, typical students in a traditionally taught course are learning mechanically, memorizing facts and recipes for problem solving, and are not gaining a true understanding. Equally alarming is that in spite of the best efforts of teachers, typical students are also learning that physics is boring and irrelevant to understanding the world around them, including their future professions.

The impetus for the development of most new emerging teaching technologies is the desire to remove the barriers to students’ independent and exploratory work in all sorts of laboratories for the purpose of elucidating the real world (Wieman & Perkins, 2005; Thomsen, Jeschke, Pfeiffer & R. Seiler, 2005; Feisel & Rosa, 2005). The main development, with few dissenting voices against this trend, was to bring about a change in physics laboratories in the direction of substituting research laboratories for the “recipe labs” (Domin, 1999). It is useful to refer to the 1977 document of the American Association of Physics Teachers which formulated five goals the physics laboratory should achieve (American Association of Physics Teachers, 1990):

- **The Art of Experimentation:** The introductory laboratory should engage each student in significant experiences with experimental processes, including some experience designing investigation.
- **Experimental and Analytical Skills:** The laboratory should help the student develop a broad array of basic skills and tools of experimental physics and data analysis. Computers, when used as flexible tools in the hands of students for the collection, analysis, and graphical display of data, can accelerate the rate at which students can acquire data, abstract, and generalize from real experience with natural phenomena. The digital computer is an important tool for an inquiry-based course in physics because it has become the most universal tool of inquiry in scientific research. However, computer simulations should not be used as substitutes for direct experience with physics apparatus.
- **Conceptual Learning:** The laboratory should help students master basic physics concepts. The use of computers with laboratory interfaces allows real-time recording and graphing of physical quantities. The qualitative use of real-time graphing in computer-based laboratories has increased interest in using the laboratory to enhance conceptual understanding. The combination of two factors — laboratory course design based on an understanding of the preconceptions that students bring to the study of physics from their past experience, and the continuing development of