Remote Controlled Teaching Experiments, in Science and Engineering Subjects, Accessible over the World-Wide-Web: the PEARL project

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Abstract: This paper introduces a major European collaborative project, PEARL, that is developing a system to enable "real world" teaching experiments to be undertaken by students working collaboratively over the Internet. The paper outlines issues in university level education that led to the project's definition, summarizes its pedagogic foundations, and highlights the emphasis on making the science and engineering curricular accessible for students with disabilities.

Introduction to the PEARL project

The PEARL (Practical Experimentation by Accessible Remote Learning) is researching and developing a system to enable students to conduct real-world experiments as an extension of computer based learning (CBL) and distance learning systems. The objectives being to give high quality learning experiences in science and engineering education by bringing the teaching lab to the students; offering flexibility in terms of time, location and special needs. This will extend Internet course delivery to accommodate collaborative working in practical experimentation. The project is developing a modular system for flexibly creating diverse remotely controlled experiments, integrating this with a collaborative working environment and accessible user interfaces. The project will research the pedagogic impact of this approach, validating its developments in different educational contexts and subject areas. These include: foundation level physical sciences (as part of an open & distance learning introductory course); cell biology (as part of a final year undergraduate course); manufacturing engineering (post-graduate training) and digital electronics (as part of undergraduate courses in design and testing).

Educational Issues

Experimental work is a vital part of science and engineering teaching at all levels. There is an increasing trend to use multimedia science education packages and "virtual science" in both school and university level education. These approaches have great value and if done well, however they generally focus on the teaching of science facts and principles and not the teaching of the *process* of scientific enquiry or engineering practice. A key objective in PEARL is to create a (CBL) facility for learning science and engineering as a process.

Access to experimental work in distance education has traditionally been achieved by including simple home experiment kits or intensive residential schools as part of the course. The project is seeking to facilitate a wider participation in experimental work in distance learning courses and to make this available throughout the course. For campus based universities, the expansion of student numbers has put increasing strain on facilities and has made it difficult to provide adequate access to teaching laboratories. By making these facilities remotely accessible they, can be offered to students at different times and with less space demands on the teaching laboratory.

Increasingly there are demands on universities to teach their students the use of complex technical equipment. This pressure comes both from the need to introduce the students to state of the art practices in their subject and to fulfil the expectations of future employers or industrial purchasers of university education. By providing remote access to experimental work involving expensive and sometimes safety critical equipment, the widespread use of such equipment by undergraduates and industrial clients becomes feasible. Further it becomes possible to share the use of key teaching facilities with other universities with inherent economies of scale.

The distinction between distance learning and traditional university learning is blurring with the rapid increase in Internet course delivery. However there is widespread concern about the quality of the educational experience offered in some current Internet based courses. The PEARL system supports high quality science and engineering courses by enabling practical work to be integrated with other Web/multimedia based teaching material.

Pedagogic Foundations

Much educational research has shown that a key factor in the pedagogic advantage of practical work is that it is normally undertaken by pairs or groups of students. This facilitates the development of the students' ideas in conversation with their peers (Scanlon, et. al. 1993). The practical work provides the focus for peer-to-peer interchange normally supported by the tutor. Important motivational gains for collaborative working have also been frequently demonstrated (e.g. Issroff 1993). Hence it is vital that the PEARL system facilitates such collaborative working at a distance.

Contemporary accounts of student learning accept that it is an active process and depends on interaction. Laurillard (see Laurillard 1993) offers a model of student / tutor / courseware interaction. She considers the learning process as a kind of conversation, and asserts that this process 'must be constituted as a dialogue between teacher and student (or student and student), operating at the level of description of actions in the world'. She classifies the types of interaction between instructor and student as being discursive, adaptive, interactive or reflective. In the PEARL system the teacher can implement a wide range of leaning modes. It facilitates the exchange and discussion of knowledge; reflection (by student and tutor); interaction at the level of the real world experiments; construction of and subsequent adaptation the experiments, by either the student or the tutor. There is thus a multiplicity of "conversations" envisaged in a PEARL practical session through which the learning objectives are achieved.

Science learning should also be an introduction to a community of practice (Lave and Wegner 1991), and this means that science learners need to be involved in the type of activities that real scientists perform. Therefore, all students need to experience practical work and all students need to experience collaborative working mediated by information and communications technologies, as these are the contemporary experiences of working scientists.

Access for Students with Disabilities

The PEARL project also seeks to make experimental work in science and engineering accessible to students with a wide range of disabilities. Indeed the project was originally conceived in to achieve this. Disabled students are grossly underrepresented in the science and engineering subjects at higher education. The reasons for this are complex, however access to experimental work is often cited as a key barrier. Much work has been done over the past 20 years to make computers accessible to people with all kinds of disabilities and a high degree of success has been achieved. Hence the tactic for the PEARL project is to firstly to make practical work computer controlled and then to ensure that the software and interface design follow well-established design for accessibility principles and that they are compatible with the available access technologies.

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