The challenge of practical work in an eUniversity *- real, virtual and remote experiments*

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Practical work forms a key part of University level education in many subjects. Current and emerging trends in higher education, such as the increasing use of the WWW in educational delivery, the move towards a "flexible university" approach and the growing need to deliver life-long learning, presents challenges as to how provide such practical work to the university students of tomorrow. This paper outlines these challenges then points to likely solutions and critiques these. **World-Wide-Web: the full version of this paper can be found at:**
http://kmi.open.ac.uk/projects/pearl/publications/index.htm

1. Introduction

Practical work is seen as a key component of many university level courses [1]. The educational objectives for providing such work include [2]:

- To provide illustration and demonstration principals taught in lecturers
- To motivate students and as a focus for student-student/student-tutor interaction
- The development of practical skills seen as important for professionals in the subject area
- The development of collaborative and team working skills
- To introduce students to the "community of practice" [3], of engineers or scientists
- To give a context for the teaching of data analysis

All science and engineering students need to experience practical work and they further need to experience collaborative working mediated by information and communications technologies, as these are the contemporary experiences of working scientists and engineers. In many science or engineering courses such practical work would typically occupy about 35% of the students' scheduled time.

The higher education sector is rapidly changing; the boundaries between distance learning and traditional teaching approaches are blurring in response to market pressures and given the increasing availability and use of Web based technologies and educational multimedia. There are increasing pressures on the provision of practical work in this context [1]. These come from a variety of factors including:

- Increasing student numbers, or insufficient numbers for the viability of some activities
- Professional institutions and prospective employers demanding students learn up to date techniques and to use modern equipment
- Issues of student timetables that are increasingly more tailored and flexible
- The increasing economic pressures on educational provision, always an under-resourced area

2. Responses to practical work provision in distance/eUniversity contexts

There is a growing emphasis on the WWW as a delivery medium in higher education. Some pundits predict that by 2002, 75% of US based university courses will be primarily delivered by the WWW. Europe is undoubtedly more circumspect here but there are major eUniversity initiatives in most European countries and within 5 years it is likely that the normal experience of a university student will be that of an education predominantly mediated through their personal computer. So how will practical work be provided in this context?

Access to practical work in distance education has traditionally been achieved by including simple home experiment kits or intensive residential courses. There is now an increasing trend to use multimedia science education packages or "virtual science". This approach has great value and if done well can be very powerful in elucidating complex scientific principles. However it generally focuses on the teaching of science facts and principles and not on the teaching of the process of scientific enquiry or engineering practice. There is a growing community of academics, information technologists and engineers who are exploring the provision of real-world teaching experiments that can be conducted at a distance, mediated over the WWW [e.g. 4, 5]. This potentially holds key advantages in terms of pedagogy, cost effectiveness, credibility and access to facilities.

3. Pedagogic critique

Contemporary accounts of student learning accept that it is an active process and depends on interaction. Laurillard [6] offers a model of student/tutor/courseware interaction, that facilitates an analysis of how educational technologies may be applied to support the different interactions that make up the learning process. This provides a framework for devising technological solutions for practical work provision. The basic classes of interaction (or conversation in Laurillard's terms) are: 1.) The passing of knowledge and discussion; 2.) Reflection (by student and tutor); 3.) Construction of the experiments, and subsequent adaptation of the experiments, by either the student or the tutor; and 4.) Interaction at the level of the real world experiments.

The traditional hands on experiment in a laboratory gives the opportunity for all these interactions to be realised. This is less readily the case for the virtual science approach. Students often interact with a virtual science package alone or in small groups but probably with only asynchronous contact with a teacher. The simulations are largely fixed and there is little opportunity for the student or the teacher to modify an experiment in response to a student question or emerging hypothesis. There is a further challenge for the virtual science approach: the issue of credibility. Through computer art and games most students today have an extensive experience of virtual worlds realised in a computer simulation. They are fully aware that the laws of physics in these worlds, for example, can be very different from those we experience in the "real-world". Thus they will, possibly only subconsciously, know that a simulation will behave as programmed and this may or may not be a faithful representation of the behaviour it is seeking to model from the "real-world". Thus a virtual experiment will not confirm or refute a hypothesis.

The remote control of real-world experiments offers a way of overcoming many of the limitations of the virtual science approach as well as giving the flexibility in delivery being sort. However it is not without its own limitations. A major criticism being that it may "*fall between the two stools*" (tools): 1.) Hands on, in the lab, teaching experiments; 2.) Virtual science approaches based on computer simulations.

It is quite reasonably claimed that remote experiments will not be able to fully reproduce the "gestalt" of being in a laboratory, e.g. the smell of the results of a chemical reaction. However, it should be possible to produce a sufficient sense of "presence" remotely to achieve most learning objectives. It is also claimed that students may not able to distinguish remote from virtual; "*it's all bits and bytes down a wire*". This would mean that the credibility criticism given above to virtual science would apply here too. But again, a sufficient sense of presence should overcome this. Perhaps the most challenging criticism is the economic one: that remote laboratories will not yield significant benefits over virtual science to justify the additional costs involved.

4. Conclusion

Current trends in higher education present a real challenge to the provision of practical work at that level. However the value of such work is almost universally recognised, especially in the science and engineering subjects. Thus as we move towards more on-line delivery of education we need to adopt approaches that still make available to students experimental work conducted in the "real-world". The remote control over the WWW of a teaching laboratory or an experimental facility offers potentially significant benefits here.

References

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