

Chapter 21

What do Students Gain from Laboratory Experiences?

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ABSTRACT

The University of Western Australia invested significant funding to develop and test new technologies for student learning using the internet, including a substantial investment in remote access laboratories. Over 15 years of operation, some significant limiting factors have become apparent. The technology has not been widely adopted, either in our own faculty or elsewhere. Nearly all engineering laboratory classes still follow traditional patterns, as do lecture and tutorial classes. Therefore it is worth asking why the adoption of such an apparently attractive technology has been so much slower than expected. To answer this question we started a project to understand more about the practical learning outcomes from traditional laboratory classes. When we applied tools from psychologists to measure practical intelligence in an electronics laboratory class, we not only found we could measure a significant gain in hands-on practical intelligence, but also predict students' ability to diagnose equipment faults. For the first time, therefore, we can demonstrate that there are real advantages inherent in hands-on laboratory classes, and we can measure this advantage. It is possible that measurements of practical intelligence may reveal new and more powerful ways for students to acquire practical knowledge and skills from remote laboratories as well.

SOME FUNDAMENTAL QUESTIONS CONCERNING REMOTE LABORATORIES

Remote access laboratories have been widely reported by researchers and education innovators since the internet started to provide reliable data communications and easy access for large numbers

of users. However, most reports in the contemporary literature describe technical implementations without extended and detailed evaluation of student learning advantages. So far, it would appear, no detailed cost benefit studies have been reported. It would seem that the technology has stalled. Early implementations, such as Telelabs at the University of Western Australia (UWA), are

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in regular operation for large classes of students (Trevelyan, 2003, 2004). Yet the technology does not seem to have been widely adopted, nor have there been reports of serious attempts to negotiate industry standards that would be a necessary precursor for large-scale adoption.

Why has such a promising technology not been adopted so readily? Are the benefits as great as proponents (such as the first author) have claimed in the past?

This paper reports on a fundamental investigation of certain learning phenomena in conventional hands-on laboratories that arose from the question “What do students really learn in laboratory classes or remote lab experiences?” To explore this issue we started a project to understand more about the practical learning from traditional laboratory classes. What we found surprised us. We came across a substantial body of research on the notion of ‘practical intelligence’ (PI) that relates to the ability of a person to solve practical issues in a given domain. Psychologists evolved PI measurement instruments as part of an extended discipline-wide debate on predicting on-the-job performance of people using results from psychometric tests. We found that we could apply these techniques to measure significant gains in PI resulting from participation in hands-on laboratory tasks. PI is unrelated to students’ results from conventional assessment (examinations, tests, lab reports, tutorial exercises). More interestingly, we found evidence that suggests the possibility that PI can predict students’ ability to perform fault diagnosis tasks.

For the first time, therefore, we can demonstrate that there is a real advantage inherent in hands-on laboratory classes when compared with other learning settings such as tutorials and lectures and we can measure this advantage.

What we can learn from this work is that students’ learning in laboratory classes is not necessarily what we have come to expect. There is still much to discover and this chapter will describe some research tools to enable others to follow similar investigations.

There are significant implications for developers of remote laboratories and technology education researchers from this work.

Using the ideas developed in this research, we can create convenient on-line survey instruments that can readily measure the ‘practical’ or ‘hands-on’ benefits from laboratory experiences with large numbers of student participants. While this study reports results from hands-on laboratories, similar instruments could be developed for remote labs.

Second, this work draws attention to dimensions of learning that different from the conventional explicit propositional knowledge in the form of fundamental science concepts, often cited as the principle intended learning outcomes from laboratory classes (both hands-on and remote).

Third, this work draws attention to the need to thoroughly investigate students’ actual learning (and prior knowledge). We were surprised, time after time, that we overestimated the prior knowledge and capabilities of our students. Given this finding, it is not surprising that the learning students construct in their minds as a result of their laboratory experience can be quite different to what we might have expected when designing the laboratory class exercises (Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000).

REMOTE LABS - ENRICHING THE STUDENT LEARNING EXPERIENCE?

Like many other universities, the UWA invested significant funding to develop and test new technologies for student learning using the Internet. Over AU\$2.5 million was invested from 1993 till 2003, mostly from competitive grants. Just as aircraft pilots are trained using a combination of theory, simulators and training aircraft, the aim was to develop new styles of student learning using simulation, theory, and laboratory equipment. The internet promised a better way to make better use of expensive laboratory and staff resources.

Parallel research on telepresence led to the first industrial robot which could be operated using

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