The role of IT in teaching experimental science: from the multimedia perspective

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Why a Workshop on Dry Labs?

Many motivations might bring one to examine the role of computers in the laboratory class: concern over the expense of *real* labs; concern over the encroachment of computers into these labs; a feel of excitement that computers might be able to add something to lab work that is currently missing. For whatever reason, it is maybe appropriate to begin by thinking about our motivations for doing *real* lab work in the first place.

Why Practical Work?

When talking amongst physicists and raising the suggestion that a lab experiment might be better simulated, the response is often "But they *must see* the real thing; must *do* the real physics (or chemistry or biology)." For some reason we, as scientists, have a strong belief that there is intrinsic value in lab work. We see the lab as fulfilling several roles: as an essential part of students' experimental training; giving them activities of an experiential nature; "proving" or "illustrating" concepts; setting a role model as to "what science is all about".

We persist with lab work in the face of some research that suggests not all is well. Students often dislike it; are confused about its purpose; come away with dubious learning outcomes and even take away a misleading message regarding "what practical science is all about".

Professor Fred Goldberg, an American physicist and science educator, makes significant use of both practical experiments and computers in his physics courses. His use of the computer is novel in that he uses it as an instrument to enable students to make visible their thinking — to draw on the screen their reasoning about the equipment they are working with. Whilst he clearly advocates the beneficial role of practical work, he makes an interesting observation (Goldberg and Bendall 1995) of students *observing* the results of a simple experiment, yet, due to their prior *expectations*, recording the outcome as just the opposite! This should remind us that there are many more subtleties to student learning outcomes than students simply completing a successful experiment.

Is it appropriate that we take the time to ask ourselves two questions in order to help place the role of computing in context:

What do students benefit *uniquely* from lab work?

What *message* do students take away with them from labs?

This workshop should give an opportunity to focus on these questions.

Should We Simulate?

We are all aware of the traditional reasons often trotted out for using computer simulations: cost, danger, time, complexity, *etc*. But now we have two new players in the game which might give us new reasons to turn to simulations. They are *virtual reality* and *on-line experiments.*

(a) Virtual reality

Although virtual reality is still very much in the realm of research tools, it is already being taken seriously as a simulation environment for teaching science (see, for example, *Project ScienceSpace*, at http://www.vetl.uh.edu/ScienceSpace/ScienceSpace.html). Once the virtual reality headset it put on, a world of new experiences are possible: test tubes can explode safely, balls can bounce around with their vectors attached and frogs can be dissected odourlessly!

(b) On-line experiments.

There are a vast number of Web sites that connect in some way to a piece of physical equipment (point your Web browser to http://www.awe.com/mark/fave-inter.html for a starting list). From the banal of viewing coffee pots brewing to the joy of watching a busy street in Los Angeles! Some of these sites offer useful experiences for science students: controlling a robot or driving a telescope, for example.

Simple science experiments are possible, although not many have been set up to date. Maybe there is a place for such "on-line experiments" in which students reap all the benefits we attribute to Web-based activities: do it anywhere (don't even have to enter the lab!), do it in their own time, do it on any computer.

This could become particularly powerful when coupled with virtual reality—students could "see" and "feel" the experiment from the security of their armchair. But is this for good or evil? Would students ever *really* know whether the experiment was real or simulated, wet or dry? Maybe an analogy to the Turing Test is appropriate here, along the lines that if you can find no way to distinguish your experience from the real thing… then will anyone care??

This poses another, rather obvious, question for us to ponder:

What benefits can simulations offer to a practical science experience?

Modes of Use of Multimedia

The remainder of this presentation looks at various examples of using multimedia in the lab environment within the University of Melbourne.

(a) Pre-Lab and Post-Lab Support

Computing can be used *before* students enter the lab, and *after* they leave, in a manner to help them prepare, or digest, the lab material.

A project in the School of Botany at the University of Melbourne (Pauline Ladiges) presents students with much general information about their subject, but also shows them some aspects of the up-coming lab in the hope that they will see and understand it better when they get to the real lab. Figure 1 shows an image from this package in which a section from a leaf is shown as seen through a microscope.

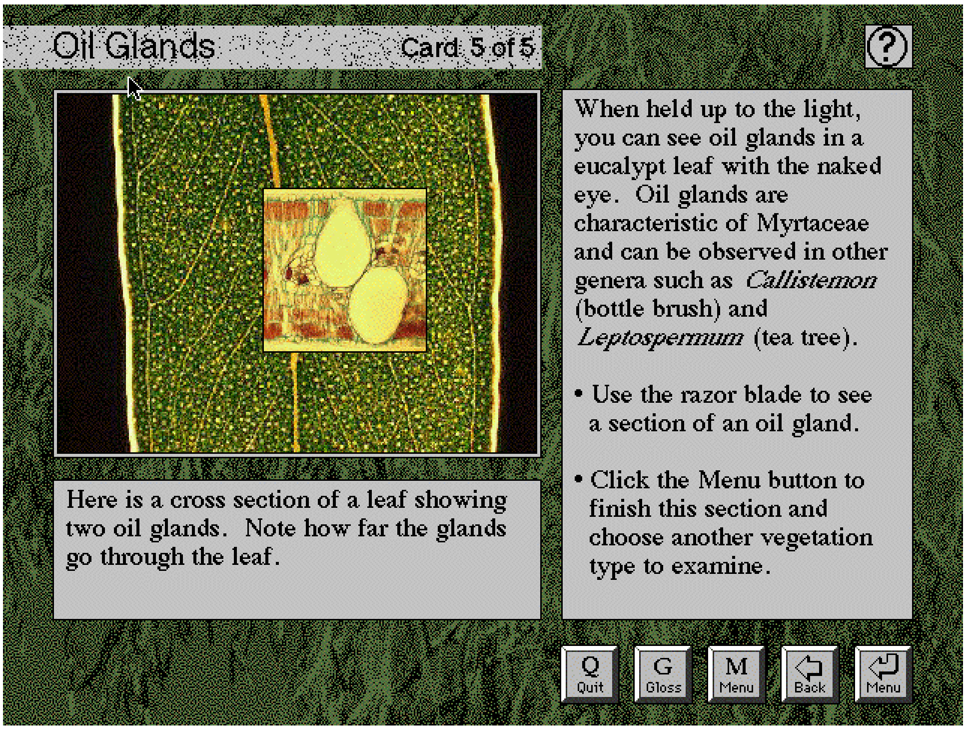

Figure 1. An image in which a section from a leaf is shown as seen through a microscope.

The School of Chemistry has replaced some of its wet lab time with computer software designed to teach students both practical and analysis techniques which they will use in subsequent labs.

Within Physics, second year students use a commercial circuit simulation package (*B^2Spice*, Beige Bag Software) to play with circuits *before* entering the lab, as well as afterwards.

Each of the above examples seeks to prepare students better for their lab work so that they may carry it out more effectively and benefit more from it.

(b) Support During Labs

Clearly the computer has a strong role to play as a device to aid in *analysis* within the lab. But its potential is much greater than that.

Once computers are present on the lab benches, they can be used to provide testing and on-line manual support. In Pharmacology, data-logging by computer was introduced as an alternative to using obsolete chart recorders. Once in place, the computers could also be used to present information about the lab work, including *QuickTime* video clips of various techniques which are hard to explain in words. Figure 2 shows a screen from one of the packages developed (Darren Williams) with the *QuickTime* movie in the top left-hand corner of the screen.

Figure 2. One of the packages with the *QuickTime* movie in the top left-hand corner of the screen.

In Physics, the commercial virtual instrumentation package *LabView* (National Instruments) is used by students to construct "programs" which control the equipment they use for monitoring circuits in an electronics lab. They make their lab experience more efficient while learning up-to-date techniques in instrumentation and control.

A slightly different approach to using the computer during a lab is to use a simulation to help in the explanation of the experiment being performed. The School of Physics uses the optics simulation *RayTrace* (Ian Moore, Queensland University of Technology) alongside optical benches, encouraging students to make links between the *real* physics and the representation by the simulation.

(c) In Place of Labs (!)

Dare we *replace* labs with computer activities?

Three recent CAUT projects come close to this but each offers experiences not possible in an undergraduate laboratory.

A Zoology project (Rob Day & Michael Nott) is using the Web to enable students to explore population dynamics with real and simulated data. For practical reasons, this kind of experiment can only be done by students using a simulation. Choosing the Web as an environment gives students access to a powerful communications medium which they utilise to query each other as well as their tutors.

A Physics project (Jon Pearce & David Jamieson) provides students with a simulation with a difference: most of the data are research data from one of the School's research groups. This gives students added motivation as they play with data which are *real* and not contrived or simulated. The experimental environment is that of an expensive research machine (nuclear microprobe) which is certainly inaccessible to undergraduate students. Figure 3 is a screen from this "simulator" showing a diagrammatic representation of the microprobe together with the data that students can explore.

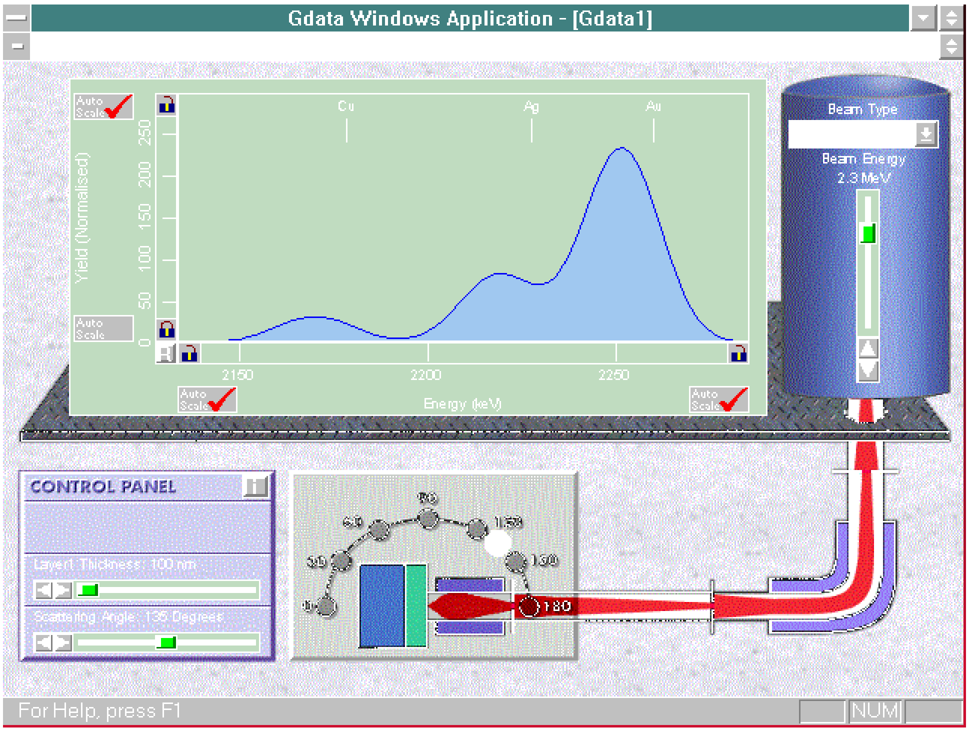

Figure 3. A "simulator" showing a diagrammatic representation of the microprobe together with the data that students can explore.

A further Physics CAUT project (Michelle Livett & Jon Pearce) just under way takes students *out* of the lab by making *QuickTime* videos of everyday physics available for analysis, via the Web. The concept here is that much *real* physics takes place outside and cannot be studied in a lab. A reasonable substitute is to give students video clips, together with powerful analysis software, and let them explore in their own time.

What Technology *Now* Offers?

Current technology offers us many temptations that were not readily available on a few years ago. We have user-friendly front-ends that make using sophisticated software less complex. Computing power is such that we can produce advanced visualisations, animations and carry out very complex analysis. The World Wide Web gives us the potential of on-line experiments, vast databases, communications and collaboration, and "do it anywhere, on anything, at anytime" computing.

With all this being laid before us, it would appear that now is an appropriate time to re-examine some of our sacred cows and to examine critically what these new technologies can offer.

Reference

Goldberg, F and Bendall, S (1995) Making the invisible visible: A teaching/learning environment that builds on a new view of the physics learner. *American Journal of Physics*, **63**, 11.