The Development of On-line Experiments

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Abstract. *Simulations and animations using embedded Java applets have greatly increased scientific use of the Internet.*

Nevertheless, the most dramatic impact of the web upon science is still to come. Although not conceived as a way to interact with remote equipment, the Internet is well suited to such an application. There are persuasive pedagogical arguments in favour of allowing students to access real equipment (rather than just simulations) through the web. Most crucially, the range of challenging and innovative experiments available to students at every level can be greatly increased.

This paper briefly considers some of the factors to be taken into account when on-line experiments are being developed

Keywords. Web-based experiments, science education, on-line access, chemistry, physics, LabView

1. Introduction

Science is a key area of education, but one that far too many secondary school students view as unattractive. This is a notable and disconcerting reversal in attitudes from primary school, where children tend to regard science as one of the most enjoyable of subjects. By the age of fourteen or fifteen, interest has waned, to be replaced by an abiding dislike of such topics as the periodic table and coefficients of thermal expansion.

This dislike is well entrenched, extending up to and beyond University level. The situation in the UK is typical; the number of students taking a chemistry degree has fallen by a third in the last decade (Fig 1.) There are no signs that this trend is about to reverse, and it has already lead to the closure of a number of University chemistry departments.

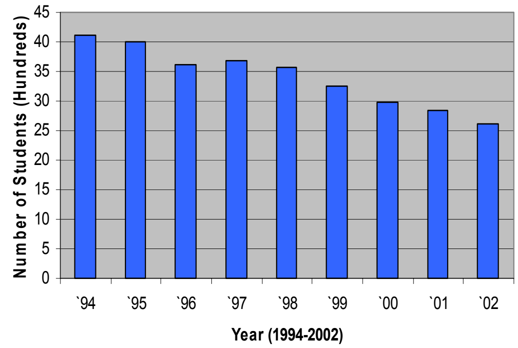

Figure 1. Students taking degree-level Chemistry in the UK (source: UCAS [1]).

The decline in the number of science students at University is a predictable consequence of falling numbers of students taking A-level chemistry at school, (the highest qualification for most school students in the UK). The A-level figures (Fig. 2) show a long-term downtrend, with the number of candidates falling by some 20% since 1990. The numbers of students taking science courses at secondary school level have also fallen (a 20.7% decrease in UK).

Fewer students are taking science degrees and entering science-based professions, a trend that would be a source of serious concern in any science-based economy. Studies have variously attributed the decline to:

Lack of attractiveness of science courses [2].

The view that science taught at school needs to be more interesting and relevant to modern-day life [3, 4].

A restrictive regime imposed on teachers which diminishes the freedom available to determine how courses should be taught. There is a view that such regimes have also made it more difficult for teachers to enthuse students by limiting the opportunity to introduce enrichment activities.

Limitations to the curriculum as a result of the need to meet time and resource constraints, and to satisfy examination requirements.

The inability to provide resources which are useful, helpful and meaningful to the students and that adequately address the content in the courses they are studying.

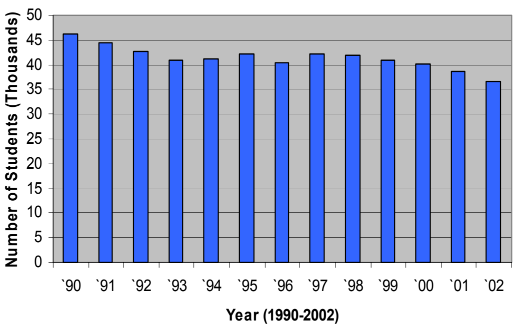

Figure 2. Students taking A-level Chemistry in UK (source: AQA [5]).

To improve the effectiveness of science resources, any material accessed on-line must be easy to understand for both students and teachers, relevant, reliable and up-to-date. Ideally access should also be free. The development of the Internet has provided new opportunities for teachers across all areas of the curriculum. Science teachers are perhaps in the most favourable position to make use of this technology and a variety of CD ROMs, web databases, simulations, web-based quizzes and scientific resource centres have been developed.

However, these resources often amount to little more than computer-based compilations of information, and are rarely genuinely interactive. They may resemble computerized interpretations of the old "programmed learning" books, which are not sufficiently flexible to be used beyond the specific context for which they were written. As a result, they can serve only limited goals.

On-line databases and simulations are potentially a useful addition to teaching resources, but once the time required to locate them and determine how they might be incorporated into the curriculum has been taken into account, teachers may find that they add little to the course.

We have, over a number of years, investigated web-based experiments that permit the user to interact with real equipment remotely. Such experiments have the potential to enhance the teaching of science at a range of levels, from the primary school to degree level.

While the Internet was not devised as a medium by which one could access remote equipment, (and in its early days was so slow that genuinely interactive experiments were not possible), high-speed access to the web is now common, not only within industry and Universities but also in schools. This has made possible the development of truly interactive experiments which allow students to use real equipment through the web. This paper considers briefly how such experiments may be placed on the web and outlines their advantages.

2. On-line experiments – the requirements

To be of the widest possible value, a web-based experiment should be:

fast - so that multiple users can be served without significant delay;

suitable for a wide audience - in other words, flexible and multi-faceted;

have some compelling rationale - so it is closely related to the syllabus that students are studying for example, or can be effective in raising interest in science in a broader audience;

able to provide readily-interpretable and reliable results;

constructed so that users can manipulate data in an intuitive fashion – to help the user understand how the data illustrate the concepts involved;

provided with suitable back-up web-based resources both for student learning and for teachers.

In addition, experiments must be in some way distinctive. There is no point in offering a web-based experiment if it merely reproduces one that is currently run in the student's own institution.

We have developed a web-based project which allows users free access to equipment based in Oxford via web pages (http://noise.chem.ox.ac.uk). Users anywhere in the world can access this equipment and run experiments that are close to real-time.

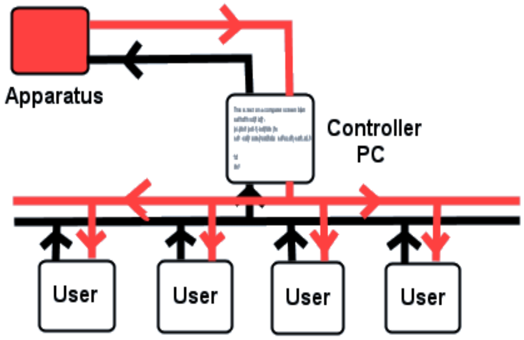

Figure 3. Schematic of an on-line experiment.

The experiments have several aims: they provide a resource that may be of value to students at schools and colleges, they support teaching in our own institution; they may be of interest to casual users of the web who find the relevant web pages through a search engine; most of all, they may help to enhance interest in science at the school level.

Apparatus in the remote laboratory is under the control of a PC running **Labview 7**. This is fast, versatile and relatively easy to use industry standard software. Users access the equipment through a web browser. Web pages that allow interaction with the equipment through Java applets are automatically downloaded by the browser as required. **A Java** server on the controller PC handles incoming requests for experiments generated by these applets and relays information between user and apparatus.

Examples of the output created for users are given in Fig. 4 and 5.

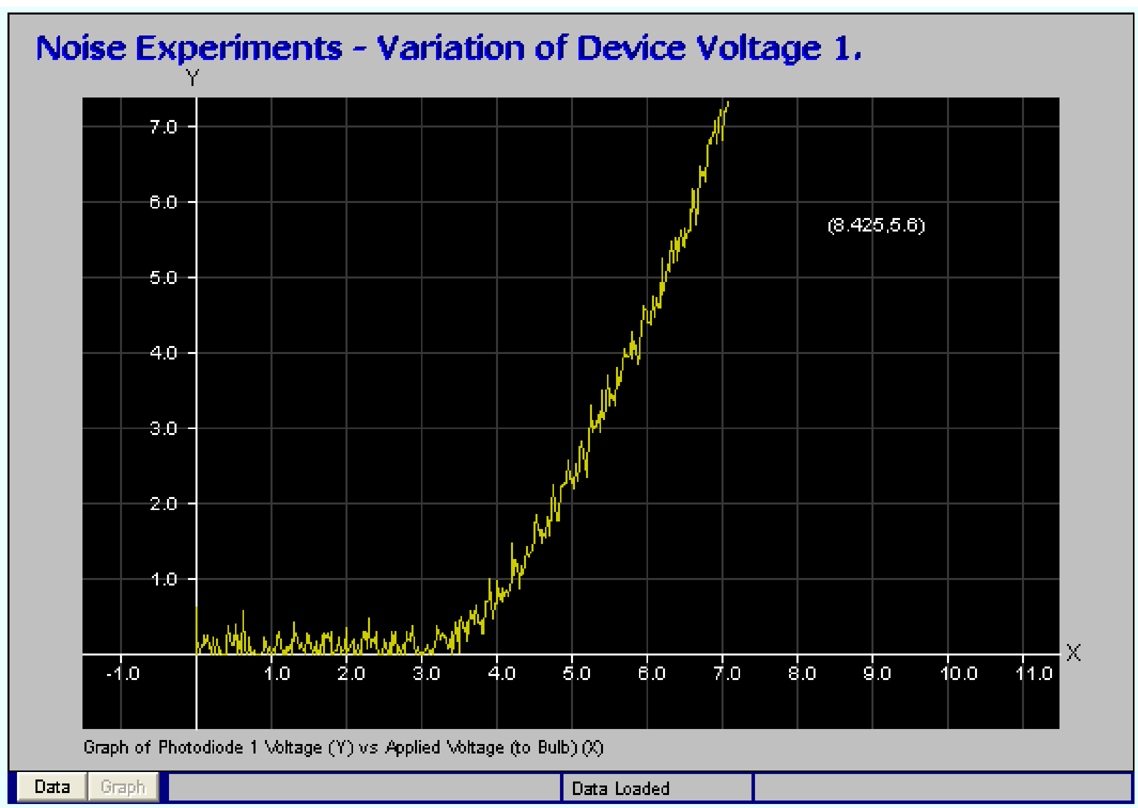

Figure 4. Output from an experiment on light-emitting diodes.

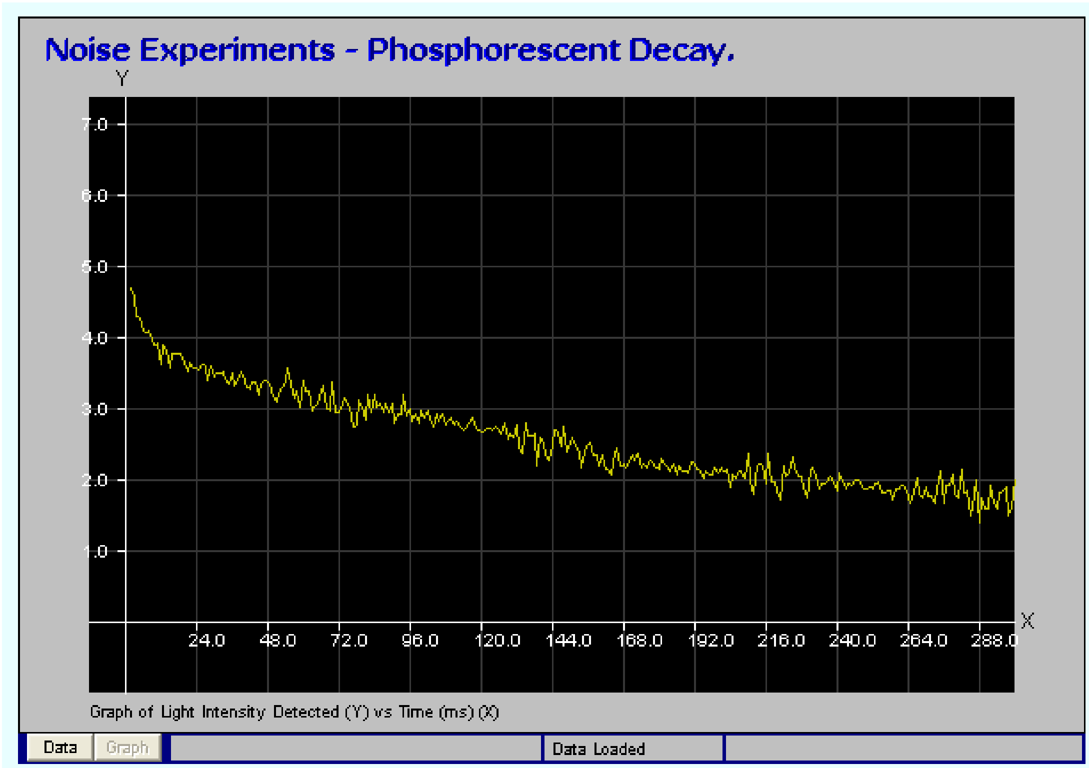

Figure 5. Output from an experiment on phosphorescent decay of mercury fluorescein acetate.

The project is being extended to include more experiments and a collaborative project that will bring together some of the largest chemistry departments in the UK has been established.

The aim is, in the medium term, to establish a network of experiments spread across a number of sites, widely accessible to students at both school and University level.

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