Enhancing laboratory activity

with computer-based tutorials

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Students should be encouraged to take full advantage of expensive laboratory resources by being adequately prepared. Computer-based laboratory tutorials have proved very successful in generating competence and confidence in the laboratory as well as reinforcing lecture material. This paper presents an outline of the tutorial process with its on-line referencing of the recommended textbook, the favourable reaction of students, and discussion of logistical and authoring problems.

Introduction

In a degree course in electronic engineering, great importance is attached to laboratory work, in which students have the opportunity to develop their creative skills in a practical environment. For example, in the first year of the course they are expected to design and test some basic circuits using data available on the characteristics of the semiconductor devices to be used. Many of the students cannot be prepared sufficiently for this activity by attendance at lectures, in which basic principles are expounded to large classes. First-year students have widely differing knowledge, experience and ability in circuit design. Therefore, without individual tuition many of them are insufficiently prepared for their laboratory work. Weaker students often neglect to study the laboratory documentation thoroughly in advance and they make poor progress in the laboratory.

We are developing computer-based tutorials specifically designed to prepare students for laboratory work by enabling them to grasp the relevant theory and carry out preliminary calculations in a self-paced interactive environment made interesting by the use of graphics and animation. In this way, students are enticed to prepare in advance for the laboratory. While they would like simply to be given the answers, they are required to earn them in a structure where lecture material is reinforced and they are exposed to methodical procedures. With highly-motivated and able students the printed word can suffice but Computer-Based Learning (CBL) is ideal for interactive study enhanced by use of colour and animation; in many spheres it is still a novel medium.

The computer-based laboratory tutorial

Written using *Authorware Professional*, our computer-based laboratory tutorials guide electronics students through the preliminary work they are expected to carry out before coming into the teaching laboratory. They are taken through successive procedures and detail of the experiments; their prerequisite knowledge and understanding of material are tested as the tutorial progresses. They extract from data (a skill on its own) typical device parameter values and apply them in preliminary design and calculation of circuit performance. Access to relevant circuit diagrams is provided, as is the ability to return to earlier material. Throughout the tutorials, on-line reference is provided to the recommended text which has been adapted to disk as required. Also, at specific points in the tutorial, the reference text can be accessed directly at the relevant section. The essential theory inevitably requires the use of text and equations but such material is interspersed with questions and answers which provide interactive work for the student. Graphical material is used wherever possible and is animated by, for example, moving components and connections around in circuit diagrams. Colour is used to distinguish different variables such as voltages at different points in a circuit.

Students are guided through the application of theory in the specific context of the practical laboratory experiment. This requires at least a basic knowledge of the subject, as no attempt is made to develop the subject from fundamentals as would be done in a lecture course. However, the reference text is at hand.

Potentially the computer-based tutorial is very compact, with the PC/terminal capable of handling extra items such as the experiment script itself, reference texts and data material, calculator, notepad, etc. in additional windows.

It may be suggested that this preparation is rather passive. On the contrary, students are involved in significant activity while they interact within the tutorial. And, although they work in the tutorial with typical values extracted from data sheets, in the actual laboratory they have to recalculate using real measured values of parameters. This repetition serves further to reinforce the material.

On-line referencing

A disk version of the recommended textbook (Ritchie, 1993) was available. Unfortunately this was intended for typesetting purposes rather than end-user consumption. It contained many commands for controlling fonts, sizes and spacing which had to be deleted. Figures had to be scanned from the printed text and cleaned up before inserting. Also, equations had to be reconstructed. These processes were very time-consuming.

Access to the relevant chapter of the reference text (423K) from the tutorial uses the

Authorware JumpFileReturn function which, by passing the page number of the reference, allows access to the specified reference point. Using packaged files, access is rapid (seven seconds using a 25 MHz 486 PC). The facility to browse either side of the reference point is provided. Quitting the reference returns (in five seconds) to the exit point from the tutorial. It is interesting to note that JumpFileReturn functions may be nested, thus enabling referencing within references.

Consumer reaction

The first of these tutorials was written for the First-Year Hardware Laboratory in the Electronics Department at the University of York, supporting an experiment on field-effect transistors (FETs). Running this tutorial met with unqualified enthusiasm from students and staff. The value is immense, introducing a new structured phase into the active learning process which engenders confidence and competence. In comparison with previous cohorts, staff were impressed by the extremely searching questions posed by the most able students and by the improved level of understanding shown by their weaker colleagues.

All students, strong and weak, enjoyed the tutorial and found it very useful. It complemented the lecture course on FETs as well as reinforcing it, and was valuable for revision. Being able to work at their own speed was appreciated. There were many requests that the computer-based laboratory support be extended to cover lecture material as well.

Some students felt that answers to questions in the tutorial were provided too readily, but an authoring decision had been taken specifically to direct the tutorial towards the laboratory experiment and not to a study of the general field. In doing so, students are guided through a logical approach to the work which in itself, as with case studies and design examples, forms an informative and stimulating experience.

Yet more interaction, animation and graphics have been requested. As with printed material, content and presentation are under continuous review and future versions will enhance the offering.

Problems

Unfortunately, a CBL framework has its drawbacks, especially the overhead of expensive authoring time. Even with experience, it is unlikely that one hour of quality screen tutorial can be produced in less than forty hours. A laboratory experiment (like a lecture course) tends to be very parochial, having been developed by an individual member of staff over several years. Invariably, investment has been made in specialized equipment and circuit boards. So it is unlikely that there exists CBL material which is immediately applicable to an experiment – one has to start from scratch. However, fewer staff are required to demonstrate in the laboratory; this saving can be diverted to generating new material.

A significant problem is access to the PC laboratory; an hour session for each of 100 students makes significant inroads into bookable and open-access time. Scheduled classes for software training should not be reduced to accommodate this activity. The problem multiplies if other groups have similar activity at the same time. In time, however, as more and more students possess their own powerful PCs, access to tutorial software via network or by disk distribution will enable them to participate while in their own personal environment, independent of the central facility.

At present, the tutorial system is not compact. Students work from a printed laboratory script and still need pencil and paper, not only for rough working but to make notes for later reference in the laboratory and for retention. Hand-held calculators are much in evidence. Browsing is rather more difficult than with printed text as the computer-based tutorial is a focused sequential activity.

A few rather more sophisticated word-processing and drawing facilities would be welcomed in *Authorware Professional,* in particular an ability to draw arcs and sinewaves plus pixel-erase and pixel-edit (fatbits); subscripting with auto size reduction; and Greek symbols such as Omega and Pi as options rather than in a different font.

Conclusion

Computer-based tutorials have proved very successful in enticing students to prepare themselves for laboratory work. Written to guide students through preliminary calculations for an experiment, the tutorial reinforces understanding of the material and provides on-line access to the recommended text. It is a self-paced exercise in which a student takes not more than one hour to become well-prepared for a six-hour laboratory session, thus making far more productive use of that session. This activity is seen as an enhancement of paper-based study, not as an extra imposition. In some establishments it is felt necessary to pass a test before entering the laboratory; with the enthusiasm generated by the computer-based tutorial this will not be necessary.

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Reference

Ritchie, G.J. (1993), *Transistor Circuit Design – Discrete and Integrated* (third edition), London, Chapman & Hall.