PROBLEM CENTRED LEARNING-TO-RESEARCH

John Pollard

Abstract – Engineering, information and computer technology education may integrate team skills, knowledge acquisition and understanding by using Problem-Centred Learning. Motivation for exploration and research starts with building self-confidence and self-reliance. Learning the skills to perform research is aided by the pedagogy in the classroom: student initiated ideas for group work, literature surveys, modelling, measurements and writing reports are the process stages of research. Teaching how to do a research project may use ‘research templates’ - visual maps of complex systems in which individuals can develop communicating modules. A template for three–tier software architectures illustrated a wireless and Web-based monitoring system that was developed over years of freely available and enthusiastic labour with a shoestring budget. Assessment of learning to research was by a design exercise examination and by a project report. Over the last three years, sixteen different taught-student co-authors have contributed to twelve papers for refereed conferences and journals.

Index Terms - engineering research, teaching-to-research, student collaboration, teaching framework.

INTRODUCTION

The framework of the education of engineering students studying information and computer technology in the Department of Electronic and Electrical Engineering at UCL has been designed

• to teach students using the solution of ‘problems’ as the motivation for learning from lecture material. This is ‘Problem-Centred Learning’,

• to teach students how to perform research tasks. They ‘learn-to-research’, and

• to assist academic research. Student energy and enthusiasm has been incorporated in each of the research process stages from initiation of new avenues of investigation to publishing of results.

For several years, the taught students on MSc courses and Third and Fourth year electronic undergraduates have been encouraged to work in teams as an introduction to self-sufficient exploration. The MSc students have been groomed by using Problem-Centred Learning in lectures. The approach is to postulate a particular problem to be solved by groups of perhaps six students. In parallel with group work, lectures supply knowledge about the generic area of the problem.

Student imagination has been captured. Topics that have been successfully researched by taught students include data communication system simulation, distributed processing, a remote-teaching tool-set, Web-based instrumentation and wireless mobile medical monitoring.

PREPARATION FOR RESEARCH

There is inevitably a development process on how to function effectively in a research team. Students need to be taught how to do research and the expectations of a collaborative effort.

Motivation and self-reliance

It is important to build on enthusiasm at the start of a new course of study. The objectives are to foster motivation and feelings of self-reliance, to build team spirit, to illustrate where information is to be found and to develop skills to retrieve it.

As an example: The MSc in Information Technology (MScIT) at UCL is a ‘conversion’ course for (mainly) mature students with a first honours degree in a technical field. They come from a wide range in ethnic and educational backgrounds. They would like to learn more about software, data communication and computers in order to enhance their earning potential.

The first exercise for new students is to learn to produce their own Web page. Their motivation to improve their employment prospects is cemented by advertising their Curriculum Vitae to potential employers.

Students are encouraged to explore sources of information from written material, from computer-assisted searches and from examples. No formal lectures are given about the programming of Web pages. However, extensive tutorial assistance is provided to develop programming ability and software package awareness.

There is active encouragement for collaboration. This is a new experience for most students. They begin to learn to teach each other.

1 John Pollard, Department of Electronic and Electrical Engineering, University College London, London, WC1E 7JE, UK jp@ee.ucl.ac.uk

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Integrating Problem-Centred Learning and lectures

Traditional lecture courses have the advantages that material has been selected by a person who has enough breadth of understanding to guide the series of lectures as a linear, sequential exploration. The intention is for students to move from ignorance to factual knowledge acquisition and from knowledge to conceptual understanding in a stage-by-stage process.

The aim of lectures is to help understanding rather than the mere gathering of knowledge. It is then possible to apply the knowledge to solve new problems – i.e. research [1].

An aid to understanding is Problem-Centred Learning, where students solve a given problem with their own methodology and with information garnered by themselves [2].

As an example: Students produce a User Requirement Specification (URS) on ‘…’ in parallel with lectures on how to produce a URS in general. Self-controlled student groups research, organise meetings, discuss and develop the suggested URS. The final document includes references to the appropriate British Standards.

The lecturer assesses this written work. A summary of student ideas is presented in class. The layout of desks in the lecture room is organised for convenience of division into ad hoc small group discussion. The group discussion and a final collective summary are designed to provide a self reflective and interactive environment where students progress by teaching each other [3], [4].

Skills development

Students require the appropriate skills if they are to make a positive contribution to research. They require interpersonal skills that are only developed by participation in teams. They need to search for and access new information. In addition, they are required to understand and contribute technical ideas in both written and oral forms. They need to be articulate.

At UCL, the location and resources of the library facilities are explained formally during the first week of induction. The information sources on the World-Wide Web are explored. Engineering students are asked to participate in small-group activities such as seminars, group projects and oral presentations throughout their courses. Regular laboratory reports and technical essays develop their writing skills. These are critically assessed for structure, content, references, grammar and spelling.

Research stages

Student energy and enthusiasm can be incorporated in each stage of research, from initial idea, through literature survey, modelling, and measurements to reporting results:

- **Student initiated research**: Selecting an area of interest is often influenced by student interaction - a feedback process between teacher and taught.
- **Literature survey**: Students can readily perform literature searches on the World-Wide Web for an essay. It is a motivation for their formal knowledge acquisition in their continuing education. This survey is efficient because of the staff-student ratio and it can be fun for the students.
- **Modelling**: As an example for a course on Software Systems: A software system for facsimile image compression was designed and built. The required background material included the manipulation of symbols. This was introduced in the formal education process and the specification was developed collectively. The model was partitioned to appropriate modules as exercises for student teams.
- **Funding**: All universities in the UK are funded by the state. Government funding bodies have been convinced that provision of computers, software aids and hardware for research improves the education of engineers. This is the justification of tying education funding of engineering departments to national performance in a four-yearly Research Assessment Exercise.
- **Measurements**: Experimental apparatus is used to measure the operation of the engineering research topic under different parameters. The measurements can be done as the laboratory part of engineering teaching if the Web is used to configure, control and measure the research apparatus remotely [5]. The use of remote data acquisition means that students may be introduced to real experiments. Their freely contributed labour can be used to investigate many different input parameters. Their access may be controlled. Results can be obtained quickly.
- **Reports**: Papers were written for publication as an interactive process between (several) students and supervisor. In some cases, individual reports were incorporated together in a final summation.

The writing of papers pays off in the teaching process since it provides motivation. Students see that by dint of hard work they have the opportunity to get their names in print.

**RESEARCH TEMPLATES**

All students are required to undertake a project. Research skills had been developed and now ‘research templates’ were used to illustrate systems in which students could participate in original research.

These templates were visual illustrations of complex software systems that were developed in, perhaps, a four-year period. The individual student project was then a small piece of a larger system.
An example research template was a Graphical User Interface of a general-purpose Data Communication Simulator (DCS) that had the appearance of an block diagram composed of pictorial icons that represented hardware components. These were familiar to students of telecommunications. Each icon of the interface was in fact a software button that activated menus and sub-menus. These menus allowed each component to be configured with software parameters.

The simulator is used as a basic research tool [5] and to illustrate features of particular telecommunication systems in lectures.

The research template had the effect on the students that they were participating in a worthwhile venture as part of a larger structure. A student was assigned an icon-button that, say, represented an electronic filter. Software was then produced that simulated the actions of many different types of filter.

Other students at different times and on different courses of study chose different icons to represent in software.

This complete data communication simulator was built over several years that enlisted perhaps 20 students’ efforts as projects. Students produced over 50,000 lines of C code.

The DCS project was adapted so that it could be activated over the Web. It was expanded to allow multiple simulations on remote machines in a distributed architecture. This system could be partitioned to software components [6] that were tractable for individuals to comprehend and build.

Another type of research template was the architectural diagram that illustrated a large, complex software system. Once more the purpose of the template was to assure students that they were working as part of a team that stretched over several years of students. The individual could see the contribution to the whole. In addition, the student could see how one contribution linked with others.

An example architectural diagram of a software and hardware system to allow wireless and Web-based monitoring is shown in Figure 1.

The system has been used to make it suitable for monitoring elderly and infirm people in their own home [7].

A different kind of research template was the Use-Case template that is shown in Figure 2. This template was used to explain the more detailed interactions that are required for individuals or small groups of students to produce Web-based software designs.
Students are excited by technological fashion. This has the effect of student motivation being driven by short time-scale ideas. There is then continuous movement in areas of research that can be incorporated into teaching curricula.

From the lecturers’ point-of-view these market-driven examples need considerable intellectual effort to remain in a position to direct current research/teaching overlap. An advantage of the extra effort is that the students’ employment prospects are considerably improved if they can converse knowledgeably about current developments.

SUMMARY

The modern engineer faces a lifetime of learning. It is suggested that, as preparation, engineering education should integrate team skills, knowledge acquisition and understanding by using Problem-Centred Learning.

Learning how to research does not come automatically. An education framework that incorporates research templates as visual aids enables students to conceive of a complex system under study by a team. The conscious knowledge of the inter-relationship of the modules allows an individual to investigate one part in depth. Different coteries of students can interact over the years on a common project.

Working on newsworthy, recent developments that they can talk about in a social environment enhances student motivation. In addition, incorporation of the freely available and enthusiastic labour of students may advance research even with only a shoestring budget.

Over the last three years, sixty projects have resulted in sixteen different taught-student co-authors contributing to twelve papers for refereed conferences and journals.

REFERENCES