PROBLEMS IN THE SEMICONDUCTOR INDUSTRY

Teaching Design and Implementation of VLSI Systems using Problem-Based Learning

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1. Introduction

This paper describes the use of problem-based Learning (PBL) in the delivery of a level 3 unit: *Design and Implementation of VLSI Systems*. A "hybrid" approach has been taken with lectures being interleaved with floating facilitator, PBL sessions. A series of four problems were presented during the course of the unit, each problem focusing on a different aspect of the unit. This unit was run for the first time during Semester 1, in the academic year 2005-06.

The development of professional and personal skills in engineering students is becoming increasingly important. A recent survey of employers, conducted by the IEE (Institution of Electrical Engineers) [1], highlighted a mismatch in the skills required by electronic engineers, and the skills that graduates possessed. This finding is in line with similar studies and engineering educational reviews in both America and Australia, reported by Mills and Treagust [2]. These studies emphasise a lack of teamwork and communication skills. Problem-based learning provides a method of integrating these professional skills into the curriculum [3] that is well aligned with modern theories of learning such as constructivism [4].

This development takes place in a background of increased interest in enquiry based learning (EBL) of which PBL and project based learning are examples.

The University of Manchester has been working in collaboration with University College London and the University of Bristol [1] on the implementation of PBL into the third year of electronic engineering degree programmes. This work has been supported by the IEE and the Higher Education Funding Council for England (HEFCE). In Manchester, PBL has been introduced into the electronic engineering degree at several levels. In the third year, units incorporating PBL are offered in VLSI Design, Optoelectronics and Robotics and in the second year PBL is used in tutorials and a major embedded systems project [5].

The University of Manchester has recently won one of the HEFCE awards for the establishment of a Centre of Excellence in Teaching and Learning (CETL) in EBL, (CEEBL [6]), which is supporting the development of EBL across the University.

This development draws on the support and expertise of the above initiatives.

2. The Approach

In this unit, four PBL problems are run in parallel with a complementary stream of lectures. Generally each week consisted of a facilitated PBL session and a lecture. The lectures contained relevant background material on related topics to the problems, but as far as possible the lectures and problems did not overlap. Five groups of 7-8 students were supported by an expert and non-expert facilitator.

The first problem, "Beam Me Up Scotty!" involved the selection of an Application Specific Integrated Circuit (ASIC) for a new Star Trek toy. The students had: to reactivate their prior learning on ASICs; research the fixed costs, variable costs, lead-times, performances and abilities of different ASIC technologies; then make a judgement on the most appropriate ASIC technology for the task. For this first problem, a topic was chosen with which the students had some familiarity, since this would be the first PBL problem that they had encountered.

The second problem, "Deep Thought", explored the problems involved in the hypothetical design of a next generation "Cranium" processor. Students were asked to investigate issues of clock skew, power supply fluctuations and signal cross-talk for this fictitious processor. Through this investigation, the increasing dominance of interconnection problems arising from the progressive miniaturization of integrated circuits became apparent.

The third problem, "Travelling Salesman", highlighted the complexity of chip design tasks. The travelling salesman problem was used to illustrate NP-hard problems. This was then related to the tasks of placement and routing in chip design.

The last problem, "Square Kilometre Array [7]", looked at the demands the processing of signals from this ambitious radio telescope would put on future generations of signal and micro processors. It would require the continued exponential scaling of integrated circuits, described by Moore's Law to continue over the next ten years. This led students to investigate the technological barriers anticipated by the International Technology Roadmap for Semiconductors [8].

Knowledge from the problems and the lectures was tested in the end of unit exam. The last two problems were also assessed through individual reports based on the team research, each of the two reports represented 10% of the unit mark.

3. Evaluation

Integrative evaluation of this unit was conducted, based on the process described by Draper et al [9], where the focus is on understanding the experience of the students engaged in the learning activity. A series of evaluation questionnaires were used.

Initial questionnaires were administered on-line, through links distributed via e-mail. The response rates were very low; consequently later questionnaires were administered on paper, during the final lectures and tutorial of the unit. The response rate for these later questionnaires was governed principally by attendance, though a few questionnaires were not fully completed.

Confidence Logs were used to record the confidence of the students on the learning objectives of the unit [9]; these were applied pre and post the PBL unit. Due to low response rate the pre-PBL results are unreliable. The post-PBL results showed some degree of confidence for all the learning outcomes.

The Study Process Questionnaire developed by Biggs et al [10] measures the students' approaches to learning, whether deep or surface. On average the cohort came out as having a Deep Learning Attitude of 28.8 and a Surface Learning Attitude of 24.8 (scale 0 to 50). These results are very similar to an independent group of second years [5], so are probably typical of the profile of our students.

The Learning Resource Questionnaire developed by Brown et al [11] measures the frequency of use and usefulness of resources. This showed that students rated discussions with other students followed by the internet as the most frequently used resources, indicating team work and self-direct research taking place. However, they valued lectures and textbooks followed by the internet, suggesting perhaps that they are more comfortable with traditional forms of learning.

The Perceptions to PBL questionnaire revealed a very positive attitude to PBL. The strongest responses showing that they liked PBL, realised that it made them take more responsibility for their learning and that it improved their ability to find and use information to support their learning.

A focus group with the students reinforced many of the positive messages of the Perceptions questionnaire. They were pleased with the implementation of the PBL and the level of support that they received from staff. They also recognised many of the group working and communication skills they were developing through PBL and the benefits these would have in the future employment.

Reviewing the individual reports did reveal a disappointing level of scholarship in many cases. Only the best essays showed a high level of research and synthesis leading to the development of informed views about the topics. Others were much more cautious in expressing opinions beyond those that they had read, which in some cases was only recommended reading. There were a few incidents of plagiarism. The skills of citation and reference showed need of development. These observations reflect the fact that our students receive few opportunities to develop and practise these critical skills, which indicates a need to include more PBL activity into the curriculum. Despite this, it was felt that the understanding that the students showed as a whole was far better than they would have achieved if the same material was delivered through a traditional lecture course.

The impression from facilitating the sessions was that a lot of active learning was taking place. Students were forming teams, arranging meetings and organising research. Lively discussion ensued as students reported back their findings and compared notes. For most of the problems the students were able to demonstrate appropriate learning and a deep appreciation for the issues involved.

It was noted, however, that not all groups functioned as effectively. One group seemed to be carried by the perseverance of one of its members. This group was also less communicative, preferring to exchange reading materials than to discuss issues. The selection of the teams needs to be given greater consideration.

4. Further Development

The unit will be run again next year, with similar problems and lecture structure. More guidance will be given in problem two to assist students to see the bigger picture. Where the lecture material did overlap with the PBL material, clearer distinction will be made. More attention will be given to the selection of the groups.

5. Acknowledgements

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6. References

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