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Gavin Duffy

Technological University Dublin, gavin.duffy@tudublin.ie

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6. Improving the Quality of PBL Modules in an Engineering Programme

Gavin Duffy,

School of Electrical Engineering Systems

Contact: Gavin.Duffy@dit.ie

Abstract

Engineering programmes have a strong reputation in the delivery of technical knowledge and skills. Graduates need equally high levels of competence in personal and professional skills to not only improve themselves and meet the existing requirements of employers and professional bodies but to also help them manage the inevitable changes that society is facing in an increasingly populated world. The need to move from traditional to student-centred learning in the context of engineering education was the motivation for this project. This can be facilitated through the use of group-based, problem-driven learning as this offers high integration of technical and non-technical knowledge and skills and requires more engagement with the programme from today's student.

The School of Electrical Engineering Systems in the DIT now delivers a number of engineering modules in this format but experience has shown that it takes a significant amount of time for students to develop personal skills to a high degree. The aim of this project was to develop additional group learning modules and enhance existing ones to pay more attention to personal development. Each of the first three years of the Bachelor of Electrical Engineering programme now contains a group-based module in which learning is project or problem driven and the tutor pays significant attention to individual personal skills. The concept of progressive development of personal skills was also investigated and a framework to develop these in a structured way through the delivery of group-based modules was proposed. The development of further group learning modules and an examination of the effectiveness of this framework will form the basis for continuing this project into the future.

Key Words: curriculum design, first year curriculum, problem-based learning

Outline of Fellowship Project

Introduction

This project involved the co-operation of a core group of five staff with a number of other lecturers involved to a lesser degree and the teaching fellow acting as researcher, reporter and organiser. The main activity of the staff was to act as a learning group confronted with the problems of 'how to facilitate group work, how to assess individuals in a group and how to give feedback'. This debate was informed by the research activity of the teaching fellow, input from an experienced problem-based learning (PBL) tutor in the College of Engineering and Built Environment and each person's experience of tutoring in the class room. Although we had been delivering group-based modules in which learning was driven by the problems or projects for a number of years we had been paying little attention to the *process* the students were following in their group work and individual activities. This project resulted in the addition of a group-based module to year two of the Bachelor of Electrical Engineering programme which filled the gap between the existing modules in years one and three.

All three modules were then delivered with a greater emphasis on 'the process', i.e. the tutor paid more attention to individual behaviour in the group: offering ideas, discussing, critical thinking, taking responsibility for self-directed learning, completing tasks, reporting back and many other actions that result in each member contributing as positively as possible to the group project. These skills are personal in nature and are demonstrated to varying degrees by each individual. The tutor's aim was and is to monitor and give feedback

so these skills can be enhanced and developed, the group works well and the students learn the required technical knowledge. This is consistent with the view of PBL as outlined by Boud (1985), Barrows (1988) and Woods (1994).

A parallel activity to the improvement of tutoring practice was to examine the electrical engineering curriculum in the context of developing personal skills and competences. Many of the current outcomes defined by the accrediting professional body, Engineers Ireland, relate to the development of personal and professional skills (Engineers Ireland, 2007). This is an activity that can and should happen throughout the entire programme and not just in one or two isolated modules or the final year project. In the context of medical education it has been argued that the sustained delivery of learning through PBL provides an opportunity to progressively develop self-directed learning skills (Mifflin, Campbell, & Price, 2000).

This is achieved by steadily diluting over time the high level of direction from the tutor offered at the start of the programme. Students should immediately start taking greater responsibility in their learning and continue to grow in this way throughout the programme. The tutor fades from the group over time as both the individuals and the group become more autonomous. The model proposed by Perry (1999) covers a similar theme but from an intellectual point of view – students should progress from seeking the one right answer from the teacher (dualism) to realising there are multiple solutions, one of which they choose to commit to (relativism).

How can we do this in engineering? A framework to facilitate the progressive development of personal skills was developed during this teaching fellowship project. The emphasis in the first two years should be on the learning process. Frequent, formative assessment by and feedback from the tutor should focus on individual contribution to the group process during this period. Students must be *required* to contribute to the group discussion, question others, offer ideas, complete tasks, report back and demonstrate the wide range of attributes that need to be developed for them to be successful professionals. These skills should be explicitly stated, observed and assessed (Woods et al., 1996). Students should emerge from these two years as relatively competent group workers with a reasonably high level of self-direction. The use of reflection, although outside the normal language of engineers, should be given consideration as a powerful tool to help the learner to realise where development is needed and what actions can be taken to make the change. (Consider Kolb's learning cycle (Kolb, 1984) and Schön's reflective practitioner (Schön, 1991) for useful concepts in developing engineers.)

As they display group collaboration and self-direction to greater and greater levels the emphasis on these skills can be relaxed. Attention can be paid to other process skills such as critical thinking, creativity, management and ethics. Greater weightings can be given to the *product* of the group. The number of contact hours with the tutor can be reduced. Time invested in year one can be saved in year four. Projects should become progressively more complex. Exposure to industry and/or community projects should be considered in year three as a reasonably professional approach can be expected of the students at this stage.

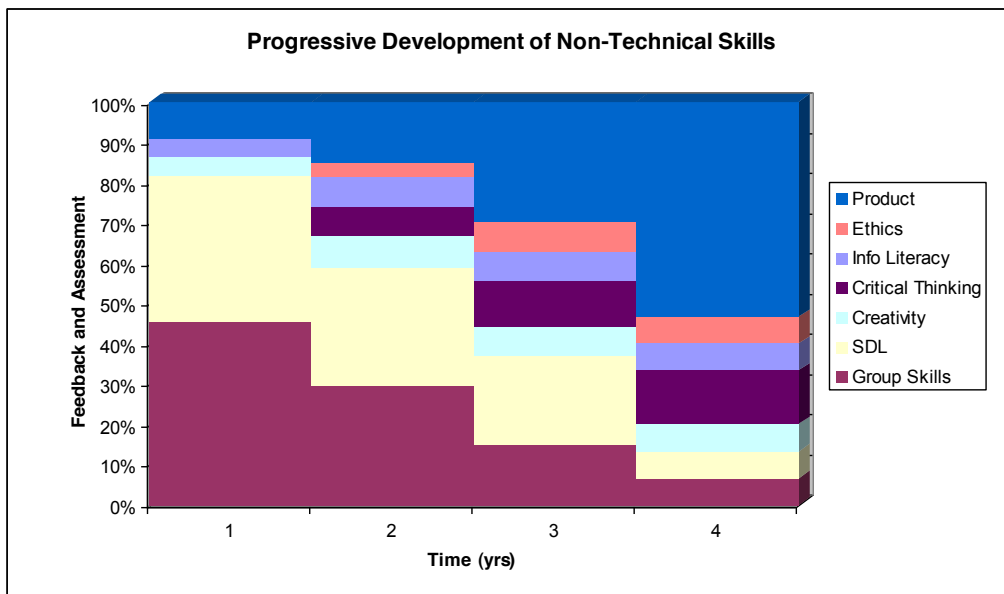


Figure 6.1: Change in focus on the process and the product during a four year programme. A selection of process skills are used to illustrate the point (SDL = self-directed learning).

Project Evaluation

The addition of an extra group-based module to the existing two modules on the Bachelor of Electrical Engineering combined with a greater emphasis on the learning process have enhanced the amount and quality of student-centred learning on this programme. The Bachelor of Engineering Technology offered by the School in the same discipline was also enhanced in a similar way. A large number of students therefore experienced a greater focus on the personal skills needed to work in a group on an open-ended project. Higher levels of engagement with the programme were observed by the staff which was consistent with delivering these modules in the previous years.

The formation of a cohesive group of staff to learn about tutoring and grow as PBL practitioners was a very important outcome from this project. This laid a foundation of PBL experience in the School that can only have a positive impact on the School's activities into the future. For example, a consequence of the formation of this group is a plan to refurbish a laboratory into a flexible learning space so that group work can be more easily accommodated. Further consolidation of group-based learning into the School's programmes are likely to continue with one goal being the provision of a group-based module in each semester so that sustained attention can be given to personal development.

The first workshops on PBL delivered by staff from the School happened during this project. Two workshops on student induction into group learning were delivered as well as two workshops for tutors.

The need to reconsider the traditional approach to engineering education to more closely align our learning, teaching and assessment methods with our programme outcomes (Biggs & Tang, 2007) is discussed in a paper presented at an Institute of Electrical and Electronics Engineers (IEEE) conference on Transforming Engineering Education that was held in Dublin in April 2010. The framework outlined above was discussed in more detail in this paper. The preparation of graduates not only for a more globalised world but also for a world that is facing environmental uncertainty, and in which a move to sustainability is inevitable, is also

facilitated by the group-based approach. The development of students' personal skills, the complex nature of open-ended problems, the ability to think creatively and critically, the move towards relativism and the development of a reflective practice are all positive inputs to preparing an engineer for this uncertain world. This was the argument in a second paper submitted to the Third International Symposium on Engineering Education, 'Educating Engineers for a Changing World', held in University College Cork in July 2010. This paper discussed the suitability of group-based learning in helping graduates be prepared for the future and the paper further elaborated on the framework for progressive development.

Project Recommendations to the College/Institution

Increasing the quantity and frequency of group-based project-driven modules is in line with the DIT strategic plan to move towards student-centred learning, enhance the first year experience and increase the use of formative assessment. Group-based modules can be delivered badly and tutors can have very different perceptions of the method. It is important that we display a high quality and professional approach in our delivery of these modules. Programme committees should expand debate beyond what we teach to include how we teach and how we develop our students in a coherent way from first to final year. The provision of flexible learning spaces is a strong enabler for this approach.

Proposed Future Work

This project will continue to evolve in the years ahead. An increase in the use of group-based learning in the Bachelor of Engineering and Bachelor of Engineering Technology will be debated in the programme committees with a view to embedding one per semester into these programmes. The refurbishment of laboratory space will be a project for 2010/2011. The proposed framework for the progressive development of personal skills will be further developed and this will also be evaluated in the coming years.

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