

# An Introduction to Enquiry/Problem- based Learning

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*Facilitate – the Irish Network for  
Enquiry/Problem-based Learning*

## Integrating a PBL Pilot Module into an Electronic Engineering Programme

### CONTRIBUTORS

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### NAME OF INSTITUTION

Department of Electronic Engineering  
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### Context – description of your education/institutional setting

The Department of Electronic Engineering at Maynooth University, Ireland was established in 1999 and graduated its first cohort of engineers in 2004. In recent years, a number of faculty involved in the undergraduate electronic engineering programme have become interested in the use of problem-based learning in general and specifically in how to most effectively integrate PBL into the programme. We looked in detail at Aalborg University in Denmark where PBL has been used extensively in engineering and science education for over forty years. An engineering professor<sup>1</sup> from Aalborg was invited to Maynooth in November 2011 and facilitated two PBL

workshops, one aimed at the entire Maynooth University faculty and one customised specifically to an engineering education context. The following June, three faculty members from the department visited Aalborg University to observe first-hand the so-called Aalborg model which is often referred to in the literature as Project-Oriented Problem Based Learning (POPBL). Between September 2012 and January 2013 these same three faculty members completed a part-time online diploma in PBL with Aalborg University [Aalborg 2015] while at the same time developing a pilot PBL module to be integrated into year 1 of the above 4-year engineering programme. This pilot PBL module was implemented during semester 2 of the 2012/13 academic year and has since been adopted and further refined as a substantial component of the engineering programme. In the following academic year a follow-on PBL module was developed and introduced into year 2 of the engineering programme. This case study gives a brief overview of the mistakes made and lessons learned in developing these PBL modules and integrating them into the programme.

<sup>1</sup> Professor Lars Peter Jensen

### Description of how, where and with whom you have used E/PBL

This case study is based primarily on the design, implementation and evaluation of a group Problem-Based Learning (PBL) pilot module with a cohort of first year students on the BE in Electronic Engineering Programme in the Department of Electronic Engineering, Maynooth University, Ireland. In an ideal world, PBL ‘modules’ are best integrated at the curriculum design stage such that they closely align with appropriate ‘taught’ module content in such a way as to provide a structured mechanism for each project group to discuss, reflect on and apply the content of these taught modules in specifying, orienting, analyzing and ultimately solving the problem upon which their group project is based. In the case of our PBL pilot, as is more often the case in practice, we were looking to retrospectively ‘insert’ our PBL pilot module into a conventional lecture-based programme having a number of service-taught modules delivered by other departments e.g. maths, physics etc. Such constraints meant that a complete curriculum redesign was not an option. The literature reflects this reality and Moesby (2004) offers detailed guidelines relating to making an iterative change from a conventional engineering programme towards a fully integrated PBL one. Such adjustments frequently reflect DeGraff and Kolmos’ (2003) common characteristics of PBL models. These characteristics relate to

- *Programme or Curriculum Structure*
- *The Peer-Learning Process*
- *Alignment of Assessment and Learning Outcomes*

These guidelines and characteristics, along with the staff training which we received from Aalborg University [Aalborg 2015], proved invaluable in the design and implementation of the pilot PBL module in the context of the existing programme.

As outlined above, the pilot PBL module was implemented during semester 2 of the 2012/13 academic year. The module involved a total of 18 students working in 3 project groups. The initial group sizes were 5, 6 and 7 though 1 student withdrew from the programme during the semester. Although the pilot module was based on the Aalborg PBL educational model, it was adapted to take account of local contextual differences such as student demographics and prior experience of group project work as recommended in [Moesby 2004]. The pilot module was integrated into the second semester of the four-year conventional engineering programme such that the project theme was closely associated with previous and parallel taught module content while still allowing significant scope for student direction/ownership. The project module comprised one third of the total student workload i.e. 10 out of 30 ECTS credits which equates to a nominal total of 250 hours project work per

student over the semester. Further details of the 4-year engineering programme and how the pilot PBL module was integrated into it are presented in [Lawlor et al. 2014].

**Key benefits of using E/PBL for students, staff and the institution**

A range of evaluation instruments were employed including detailed student quantitative and qualitative surveys and independently facilitated student and staff focus groups. The pilot module proved very effective as a means of enhancing student engagement and promoting effective peer-learning. Of the 17 students who completed the module, 15 expressed a preference for PBL relative to conventional teaching methods. The beneficial outcomes of the pilot were largely consistent with the expected benefits associated with PBL. For a comprehensive review of such expected benefits see, for example, [Hoidn 2014]. Other unexpected benefits associated with the staff workload and student and staff satisfaction also emerged and are described below.

**STAFF WORKLOAD**

One of the primary objectives of the pilot was to investigate the feasibility of making a transition from our existing educational model to a fully integrated PBL model for the entire BE programme. This investigation involved a detailed

analysis of the resources required in carrying out the pilot. We compiled a detailed record of the staff time required on all aspects of the pilot, namely, weekly group facilitation, workshops, assessment of interim and final reports, presentations and interviews. Based on this record, to our surprise, the pilot proved significantly less (approx 50%) demanding of staff time than the workload associated with 10 ECTS credits worth of conventional module delivery.

**STUDENT REACTION**

As part of the end-of-pilot survey we questioned the students on how they felt the PBL approach worked for them in relation to their development of certain key skills often associated with PBL. As shown in Table 1, the overall student reaction was generally positive although 8 of the 17 students were unsure as to the effectiveness of PBL for exam preparation. In the focus group session, the students indicated several positive aspects of the pilot which they felt had worked well, namely, the workshops, the reflective journals, the online discussion, the practical application of theory, the group work, the self-directed learning, the ‘real-life’/experiential learning and the ‘variety of roles’ which they had the opportunity to experience.

**Table 1**  
**Student overall response in relation to certain skills**

Instruction – place an ‘X’ in the appropriate box for each of the statements listed below	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
PBL is an effective method of learning for me.	5	10	2		
PBL prepares me for my exams.	1	6	8	2	
PBL prepares me for my future professional life.	8	8	1		
PBL improves my teamwork skills.	9	6		2	
PBL improves my written communication skills.	4	9	4		
PBL improves my presentation skills.	7	10			
PBL has motivated me to learn.	5	8	3	1	

**STAFF REACTION**

An unanticipated outcome from the staff perspective was that despite some short-comings of the PBL pilot implementation, all three staff involved in the pilot found the experience far more interesting and enjoyable than the conventional module delivery. For example, all three felt that reading one substantial group project report having significant elements of self-directed and peer-learning was far more gratifying than reading several sets of individual lab reports

where students have simply followed pre-defined procedures without necessarily having to reflect deeply on the development of those procedures or having to devise and refine their own analytical procedures in orienting and addressing their group problem.

### Contributor's reflections - inspirations and aspirations

One of the key points of Professor Jensen's workshop in November 2011 was that based on his 40 years of experience of the Aalborg educational model<sup>2</sup> (initially as a student and later as a member of the faculty) the single most effective learning intervention is the peer-learning which takes place within the project groups. This key point certainly inspired us to find out more about the approach and challenged us to reflect on how best to organise our curriculum with a view to harnessing the power of peer-learning. In addressing this challenge, one of our primary aspirations was to learn from the wealth of PBL literature in order to avoid repeating mistakes of the past.

An unfortunate feature of much PBL research literature is that it assumes a dichotomy between direct instruction and problem-based learning and attempts to measure the relative effectiveness of these as two alternative approaches. Best practice in PBL, however, calls for a systematically aligned mix of direct instruction and related group project work [Hoidn 2014]. Systematic alignment of the assessment methodologies with the programme learning objectives is another characteristic of best practice in fully integrated PBL models. DeGraff and Kolmos (2003) cite the absence of such alignment as 'one of the classic mistakes made when changing to PBL' (659). If important process competences are to be effectively achieved, then this importance needs to be reflected in the assessment methodology. Fundamental to this alignment of assessment methodology with programme learning outcomes is the percentage allocation of marks to the programme components. At Aalborg University project work accounts for 50% of the students' time and this percentage is also allocated to the project assessment [Moesby 2004]. Our current level of PBL integration is still some way off this 50\50 ideal but our experience to date has been very encouraging and we are therefore continuing to explore curriculum migration possibilities to bring us closer to this ideal.

<sup>2</sup> Professor Jensen started in Aalborg as an engineering student in 1974.

Despite the small number of students involved in the PBL pilot, the findings were very encouraging and suggest, subject to further validation, that the PBL model is an effective way to engender a range of important skills such as communication skills, teamwork, enquiry-based learning, peer-learning, project management, collaborative and individual innovation and creativity all within the context of mastering the electronic engineering discipline-specific learning outcomes. These preliminary findings inspired us to proceed to introducing a follow-on PBL module into year 2 of the programme.

For the purpose of the year 1 PBL pilot, in line with the Aalborg model, we conducted group interviews as a significant element of the assessment. However, we have since moved to the use of individual interviews and find this approach to be more appropriate for the assessment of target learning outcomes at an individual level.

Finally, for anyone interested in PBL for engineering education, some introductory training in group facilitation is strongly recommended [Aalborg 2015] before or during a PBL pilot study.

### Resources we found useful (limited to 5)

Aalborg University MPBL, 2015. Master in Problem Based Learning in Engineering and Science, <http://www.mpbl.aau.dk/>. Accessed 24/ June/2015

De Graaff, E. and Kolmos, A., 2003. Characteristics of Problem-Based Learning, *International Journal of Engineering Education*, Vol. 19, No. 5, pp. 657-662.

Hoidn, S. and Kärkkäinen, K., 2014. Promoting Skills for Innovation in Higher Education: A Literature Review on the Effectiveness of Problem-based Learning and of Teaching Behaviours. OECD Education Working Papers, No. 100, OECD Publishing. <http://dx.doi.org/10.1787/5k3tsj671226-en>

Lawlor, B., McLoone, S.C. and Meehan, A., 2014. The Implementation and Evaluation of a Problem Based Learning Pilot Module in a First Year Electronic Engineering Programme. 5th International Symposium for Engineering Education, University of Manchester, September, UK.

Moesby, E., 2004. Reflections on making a change towards Project Oriented and Problem-Based Learning (POPBL). *World Transactions on Engineering and Technology Education*, Vol.3, No.2.

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