Guest Editorial

METHODOLOGY FOR THE STUDY OF PBL IN ENGINEERING EDUCATION

The call for papers for this theme issue opened with the statement that during the past decades Problem Based and Project Based Learning (PBL) established a reputation as a successful pedagogical method in higher engineering education. The effectiveness on students' learning in different aspects, such as motivation, deep learning, self-directed learning, professional skills, critical thinking, creativity, life long learning and process skills such as project management, communication and collaboration have been sustained by research. However, more evidence is needed to document the impact of PBL on the knowledge and skills students are attaining, as well as other potential effects. What evidence do we have, for instance, confirming that PBL truly results in deep learning, more complex knowledge and the ability to collaborate across discipline and cultural barriers?

We concluded that in particular, there is a need for discussing the research methodology applied in studies of PBL, focussing on aspects like:

- A theoretical understanding of teaching and learning, in particular, in relation to innovative educational approaches.
- Methods of data generation and analysis in relation to the research context.
- The complexity in knowledge creation when crossing the border of discipline and culture.
- Self reflection on the identities of being educational practitioner and educational researcher.
- Effectiveness of learning methods in relation to specific groups (i.e. gender, cultural).

In response to the call for papers we received 37 abstracts, indicating that research on PBL is pursued in many different places. The received abstracts witness a widespread geographical distribution of PBL all around the world—in particular in Asia, Southern part of Europe and South America, However, because so much has been published on PBL already we set the standard quite high. Many of the authors described own experiments with PBL in own class rooms and we were looking for much more rigorous studies of PBL which may only take place after some years of systemic PBL practice. We invited 17 authors to expand on their abstract—all studies with a lot of potential. All these papers have been reviewed by at least 3 reviewers from the group of authors, the editors and from the EER society in general. In the end we selected the seven papers to be published in this theme issue.

The first four papers focus on different aspects of the theoretical understanding of PBL concepts.

The first paper, "*Predictors of Student's Engagement and Persistence in an Innovative PBL Curriculum: Applications for Engineering Education*" by Denis Bédard, Christelle Lison, Daniel Dalle and Noël Boutin from the Université de Sherbrooke, Canada presents the results of a study focusing on the engagement and persistence of undergraduate students in two PBL engineering curricula (Electrical Engineering and Computer Engineering) at the Université de Sherbrooke in Canada. The authors discuss the results in terms of applications for engineering education. The study was conducted with the help of 192 undergraduate engineering students who volunteered to complete a questionnaire and 15 students who participated in interviews. Results from the questionnaire show that the best predictor regarding students' engagement and persistence is the provided "support," which reduces stress. The interview results reveal that the most effective support for students proves to be the stable learning environment (PBL tutoring sessions) as well as the scaffolding measures for managing time and organizing learning practices.

The second paper "*Engineering students' self-regulation, study strategies, and motivational beliefs in traditional and Problem-based curricula*" by Benoit Galand, Benoît Raucent and Mariane Frenay from the Université Catholique de Louvain, Belgium present a study comparing perceptions of the learning environment, motivational beliefs (self-efficacy and goal orientations), self-regulation strategies, study strategies, and satisfaction among engineering students before and after the shift from a lecture-based to a problem- and project-based (PBL) curriculum. Two cohorts of students who attended a traditional curriculum and the new PBL curriculum participated in a survey with a questionnaire. Results of multivariate analyses show that PBL students perceived stronger academic support and a weaker organizational structure, use more frequent use of adaptive self-regulation and deep processing strategies, less frequent use of surface processing strategies, lower satisfaction, higher attendance and heavier study load. There were no differences for motivational beliefs and collaboration between students.

The third paper "*Measuring the Value Added from Service Learning in Project-Based Engineering Education*", by Angela R. Bielefeldt, Kurtis G. Paterson, and Christopher W. Swan aims to study project based service learning (PBSL) in engineering education. PBSL covers a spectrum of community-based projects both locally and internationally. Literature indicates that the knowledge and skills gained by the students are at least on par with gains from traditional project-based learning (PBL). PBSL activities have undergone increasing levels of assessment, driven by the outcomes assessment requirements for engineering program, but also because of apparent positive impacts to student participants. Results show that impact on student attitudes and identity, the influence of PBL versus PBSL appear more profound, although the statistical significance of these results is questionable. This reported study highlights possible methods to determine the added value of service-based learning especially when coupled with project-based engineering education. Examples of evidence in the analysis of PBSL versus PBL in engineering are provided to further examine the state of this field.

The fourth paper "*Exploring Project Based and Problem Based Learning in Environmental Building Education by integrating critical thinking*" by Wei Pan and Joseph Allison, School of Engineering, University of Plymouth, aims for understanding of the process of students' critical thinking using an integrated critical thinking process model. This study was carried out on a multi-disciplinary group building design project for the second-year undergraduate students in the Environmental Building programme. The results show indicate that surface learning dominated the PBL process at the early stages of the project and it was suggested to provide proper mechanisms to enable deeper learning. This required the philosophy of critical thinking to be embedded in the design and implementation of the curricula, before and during the project. The process model of critical thinking developed provides such a mechanism, to help students create, develop, justify, implement and evaluate building design solutions. The mapped process of the design project provides a worked example of integrating critical thinking into PBL in Environmental Building education, which should contribute to future debate on PBL in the wider higher education community.

Next there are two papers dealing with aspects of assessment in PBL.

The fifth paper "*Assessment in Problem-based Learning incorporated into traditional Engineering Education: Difficulties and evaluation*", by Dr. Andreja Drobnič Vidic, University of Ljubljana, Slovenia, highlights the issue of assessment in problem-based learning (PBL) when it is incorporated into a traditional curriculum. Using process and outcome-oriented assessment methods, the authors introduced an assessment scheme that addresses all outcomes and contains individual and group assessment.
In PBL settings, it is difficult to assess the skills of linking concepts and principles to procedures, which has implications for successful problem solving in teamwork. Since engineers need to have a good basis of structured scientific knowledge, they need transferable teamwork skills. The study aims to analyse difficulties of group assessments, with "problem project" integrated in the assessment scheme. The assessment scheme was used in an experiment, where PBL and traditional instruction were compared in an introductory statistics course. In the experiment, significant difference in students' achievements across "problem project" was observed.

The sixth paper "*An assessment of Project Based Learning Environment based on Students: A Short Course Case Study on Circuit Design for VLSI.*" by Ersun Iscioglu and Izzet Kale, University of Ankara, Turkey and the University of Westminster, U.K. respectively consists of a qualitative study aiming to evaluate Project Based Learning (PBL) based on student perceptions. The data were analyzed with descriptive methods. As a result of the study it was determined that students find that this approach has provided benefits for them by giving them responsibility, increasing their motivation, enhancing deep learning, learning by doing (experiencing), applying theoretical knowledge in practice, improving their problem solving skills, seeing real-world problems, being informed about their own learning styles, improving the feeling of self-confidence, performing time and project management effectively.

The last paper "*Responses to Problem Based and Project Organised Learning from Industry*" by Anette Kolmos and Jette Egelund Holgaard, Aalborg University, Denmark aims to analyze the response from industrial partners to problem and project based learning (PBL). The empirical perspective is represented by a case study from Denmark, studying how employers respond to PBL models in Engineering and Science Education based on data from studies carried out by industrial organisations. The results are that in general Danish employers highly value PBL in engineering, which speaks for PBL as a good example of combining student centred learning in an educational context with innovation practice in an industry context. However, employers also stress a need for increased integration of business models into future engineering education, which poses new challenges to the development of PBL models.

Research on PBL, or in fact research in higher education in general has long been dominated by strategies of applied research. The theoretical backing was often week, with mostly idealistic pedagogic models and empirical data mostly pertained to cases studies evaluating specific courses in a specific place. With the seven selected paper we feel we have evidence that educational research on PBL is maturing to a level where

we can build on knowledge gained in previous studies and with a collective effort advance our understanding of the mechanism behind the advantages of the educational model—but indeed also elements which might need to be improved in order to enhance students' learning outcomes.

The articles in this issue witness the need of interdisciplinary research methodology in the study of PBL by use of already existing research methods and instruments and development of more domain specific methodologies. We suggest that there should be a next theme issue in a few years reflecting the challenge to develop new interdisciplinary research methodologies for the study of PBL.

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