PBL in Engineering Education

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International Perspectives on Curriculum Change

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INTRODUCTION

During 2014–2015, a series of webinars entitled PBL History and Diversity was broadcast from the UNESCO Centre for PBL in engineering science and sustainability at Aalborg University. Following is the description of the series: "In the 1960s and 1970s, a handful of higher education institutions implemented a new and innovate learning approach – Problem Based Learning (PBL). PBL aims to develop a more student centred, close to practice and meaningful learning. For 40 years, PBL did not only survive but it has also grown and evolved due to research, development and implementation in several higher education institutions across the world, resulting in different models and practices. Nevertheless, the different PBL models relate with each other through basic principles around which the learning process is organised. Problem based, team based, self-directed and contextual learning are examples of these principles. This first series of webinars starts with PBL history by presenting its origins and philosophy, followed by seven examples of models PBL developed and practiced around the world" (taken from www.ucpbl.net).

The goals of the webinars were to understand PBL philosophies, models, and practices and further, to relate the models through learning principles and dimensions. This book arises from the webinar series. All of the PBL programs described in the chapters of this book were highlighted in the webinar series.

The intended audience for the book includes higher education institutions as well as researchers and practitioners who aim to implement, or change, their teaching and learning practices to PBL (i.e. problem based, project organized learning). All of the programs highlighted represent engineering education, however the case examples are described taking PBL principles as the point of departure which can make this book an inspiration for other disciplines and areas of educational research.

CONTENT

The book is composed of eight chapters. The first chapter by Anette Kolmos, Chair of the Aalborg Centre for Problem Based Learning in Engineering Science and Sustainability under the auspices of UNESCO, addresses three main strategies of curriculum changes allowing the identification of three types of institutions depending on the type of strategy used. Furthermore, the different strategies underlie different types of drivers/triggers and problems addressed by the change process.

The following chapters present six PBL models from Singapore, Malaysia, Tunisia, Portugal, Spain and the U.S.A.

These models exemplify curriculum change in engineering education and are described based on: (i) objectives and knowledge; (ii) types of problems, projects and lectures; (iii) progression, size and duration; (iv) students' learning; (v) academic staff and facilitation; (vi) space and organization; (vii) assessment and evaluation (Kolmos, de Graaff, & Du, 2009). There is also a focus on a perspective of the time of the change process. Therefore, additional aspects such as drivers, implementation, challenges and perspectives, to the above guidelines are included, providing a holistic understanding of change process. These cases not only exemplify some aspects of the type of change addressed in the first chapter, they are also stories of thriving success which can be an inspiration for those who aim to implement PBL and change their engineering education practices.

The motivation for the book is to bring new theoretical insights to PBL theory and principles, and descriptions of PBL curriculum that thrived through time and from different contexts.

DISCUSSION

Leading off the book, Anette Kolmos defines PBL and provides a historic perspective. She invokes Barnett's (Barnett, 2009; Barnett & Coate, 2004) categorization of knowing, acting, and being to highlight three modes of universities, which are academic, market-driven and community based. Then, further discusses the placement of PBL within the 3 modes. Kolmos and her colleagues (Jamison et al., 2014; Kolmos, Hadgraft, & Holgaard, 2016) created a characterization of curriculum change strategies as being add-on, integration, or rebuilding. She describes the three in detail. As a result of these discussions, Kolmos provides the reader multiple perspectives through which to view the PBL programs that are described in the following chapters, really setting the stage for the characterization of learning and PBL within learning.

Mohd-Yusof describes independent courses that utilize PBL at the Universiti Tecknologi Malaysia (UTM), in "Sustaining Change for PBL at the Course Level" (Chapter 2). The UTM approach is characterized as course-based, cooperative PBL that is instituted using a scholarly approach and highly influenced by the principles from cooperative learning and the medical school PBL cycle.

Lima, Dinis-Carvalho, Sousa, Alves, Moreira, Fernandes, and Mesquita, in "Ten Years of Project Based Learning in Industrial Engineering and Management" (Chapter 3) at the University of Minho (Portugal) describe how PBL is implemented in semesters 1 and 7 in a 10-semester Master's degree program. Characteristics of the Minho program include interdisciplinary project with a dual focus on the development of both technical and transversal competences in the engineering graduates.

In the "Iron Range Engineering (IRE) Model" (Chapter 4), Johnson and Ulseth describe a PBL model in the USA that is in the market-driven mode that was created using a rebuild change process. Vertically integrated project teams, oral exams,

and deep development of reflective practices uniquely characterize the IRE model. The semester-length projects sit at the heart of the curriculum. The IRE model is delivered in semesters 5–8 of an 8-semester Bachelor's degree.

"PBL in Engineering Education: Republic Polytechnic's (Singapore) Experience" (Chapter 5) is presented by Wang, Yap, and Goh. In place since 2002, the Republic Polytechnic (RP) program, consisting of 6 semesters and leading to a diploma degree, is characterized by a series of short, "bite-sized" problems lasting from one to several weeks each. Students in their teams start a typical day at RP with a problem-statement, and then proceed to collaborative research and end with the delivery of a solution and reflection of the day's learning. Through this mode of learning, students develop confidence, teamwork skills, and self-directed learning abilities.

At Mondragon University in Spain, Project Based Learning is delivered in every semester in all Bachelor's and Master's programs. Arana-Arexolaleiba and Zubizarreta describe the model in "PBL Experience in Engineering School of Mondragon University" (Chapter 6). The goal of the PBL implementation is to develop graduates with technical and transversal skill capabilities ready for industry. An initial goal of the implementation was to result in the increase in student motivation to learn.

Finally, Bettaieb, in the "Esprit (Tunisia) PBL Case Study" (Chapter 7), describes how the change to PBL was motivated by the disconnect between the capabilities expected of engineering graduates and the capabilities that were demonstrated by graduates of the traditional model. In the PBL model, students complete projects in 7 out of the 10 semester Master's program. Students on teams of 5–6, complete full semester, complex, ill-defined projects. Students are motivated to deeper learning through the application of real scenarios and the opportunities for control over their own learning.

The book, taken as a whole, shows much diversity in the application of PBL as the social construct that it is. From one-day problems to projects which are a part of the curriculum to programs that are defined by full-semester projects in all semesters. The programs have starting dates that range from 2002 to 2012, with most programs already beyond 10 years of implementation.

Common themes emerge from the narratives. Each program is characterized by continuous improvement. Indeed, change appears to be the only constant for most programs through their developments. The development of employability skills was central to the motivations for change and the results of each program. The language varied from professional skills, to transversal skills, to soft skills, but the sharp focus remained the same for each program. In the programs that reported on research done on their graduates, they showed substantial growth in professional skill development and metacognitive/self-directed learning abilities. Further, most programs showed a proclivity towards developing engineers for industry employment often describing strong partnerships during the education phase.

Upon conclusion of the cases, we have included a closing chapter that compares and contrasts the models using the structures from Kolmos' chapter and the structures

the authors used to construct their cases, "Perspectives on Engineering Curriculum Change – Final Remarks" (Chapter 8).

In closing this introduction, we hope that the reader is inspired to dig into the PBL stories from the diverse (both globally and through implementation) engineering programs. Our intent is to provide you inspiration as you contemplate implementation of PBL or changes to your own PBL models.

REFERENCES

Barnett, R. (2009). Knowing and becoming in the higher education curriculum. *Studies in Higher Education*, *34*(4), 429–440. doi:10.1080/03075070902771978

Barnett, R., & Coate, K. (2004). *Engaging the curriculum in higher education* (1st ed.). Maidenhead & New York, NY: Open University Press.

Du, X., de Graaff, E., & Kolmos, A. (2009). *Research on PBL practice in engineering education*. Rotterdam: Sense Publishers

Jamison, A., Kolmos, A., & Holgaard, J. E. (2014). Hybrid learning: An integrative approach to engineering education. *Journal of Engineering Education*, *103*(2), 253–273. doi:10.1002/jee.20041

Kolmos, A., Hadgraft, R. G., & Holgaard, J. E. (2016). Response strategies for curriculum change in engineering. *International Journal of Technology and Design Education*, *26*(3), 391–411.