A Developmental and Adaptive Problem Based Learning (PBL) Model Across the Curriculum:

From Theory to Practice in Integrating and Assessing PBL Experiences across the James Madison University Engineering Curriculum

Olga Pierrakos [1], Robin Anderson [2], Elise Barrella [1]
[1] Department of Engineering, James Madison University
[2] Department of Graduate Psychology, James Madison University
Harrisonburg, Virginia, USA

***Abstract* — Problem-solving is generally regarded as the most important cognitive activity in everyday and professional practice. Problems in real-world practice have been described as messy, complex, and ill-structured, whereas many engineering classroom problems have been described as well-structured with single correct solutions. How do we prepare our students for real-world problem solving? In this collaborative and participant-centered workshop, faculty will be introduced to a novel and adaptive Problem-Based Learning (PBL) model developed and implemented in JMU's Engineering program over the past eight years and supported by NSF awards. Participants will be provided with PBL theory, PBL examples, a PBL classification framework, assessment tools, and a PBL template for use across courses and curricula.**

Keywords—problem based learning; problem solving; assessing learning; problem classification.

I. INTRODUCTION

In recent years, Problem Based Learning (PBL) has received much attention in engineering education. A student-centered pedagogy with a rich history in medical education, PBL has started to impact engineering education as well. Although it is common to see PBL integrated in a few courses within an engineering curriculum, it is less common to see PBL integrated throughout an engineering curriculum where students experience open-ended problems and projects in meeting learning outcomes. Further, although some assessment around PBL experiences exists, more evidence is needed exemplify the learning that occurs in a variety of PBL experiences.

Being one of the newest ABET-accredited engineering programs in the Unites States, James Madison University enrolled its inaugural class of engineering students August 2008 and graduated its inaugural class in May 2012. During the summer of 2008, the new program received a National Science Foundation award to integrate and assess a novel, developmental, and adaptive PBL model throughout the curriculum. This workshop is based on 8 years of work and lessons learned based on these efforts to design a new curriculum around PBL problem solving, thinking, and learning [1-8].

The sponsor for this workshop is the National Science Foundation.

II. WORKSHOP DESCRIPTION

For researchers and educators alike, there is an interest in better understanding the nature of PBL experiences because not all PBL experiences are created equal. Understanding how aforementioned problem characteristics vary is essential for demystifying the process of learning through PBL and through traditional pedagogical methods. Different PBL experiences lead to different learning outcomes. Educators should intentionally design authentic learning experiences that expose students to all types of problems – well-defined to ill-defined, simple to complex in terms of knowledge integration, individual to team-based – so that students learn to be adaptive problem solvers. *There is no fee for attendees.*

III. GOALS

The four overarching goals for this workshop are to:

(1) Provide background and discuss problem-based learning (PBL) theory and problem solving contexts in engineering education.
(2) Describe the development, classification, and assessment of the novel and adaptive James Madison University PBL model using evidence-based approaches.
(3) Provide attendees resources to develop, classify, and assess a variety of PBL activities in their own engineering courses and throughout curricula.
(4) Generate a collection of peer-developed ideas on the development, classification, and assessment of a variety of problems for undergraduate engineering courses.

IV. OUTCOMES

A key outcome of this session is dissemination of PBL materials. The session facilitators will provide the tools on developing, classifying, and assessing a variety of PBL experiences in the undergraduate classroom. The potential impacts of methods and tools could have transformative implications for undergraduate education.

V. AGENDA

During this participant-centered session, we will highlight some of our current research on the development, implementation, and assessment of the innovative JMU PBL model. Examples of PBL experiences in a variety of courses across the engineering curriculum will be provided. The agenda is:

(1) *Introduction* - Brief presentation on PBL theory, JMU PBL model and history, assessment and research findings. [20 min]
(2) *Question & Answer Period.* [10 min]
(3) *PBL Mapping* - Small-group reflection and large-group discussion of the variety of problems incorporated in undergraduate courses using a problem classification framework. PBL mapping will take place during this time to showcase to participants that PBL experiences can be characterized differently. [20 min]
(4) *PBL Template* - Presentation to share the PBL classification framework (in the form of a template) developed by the JMU PBL research team, comprised of engineering educators and assessment specialists. Both a blank template and several filled-out will be provided. [20 min]
(5) *PBL Template Activity* – Participants will use the PBL template to characterize existing PBL experiences and/or develop new PBL one. [30 min]
(6) *Reflection and Sharing* - Small-group reflection and large-group discussion on developing a variety of PBL experiences using the problem classification framework and template. [20 min]
(7) *PBL Assessment* – Presentation to share PBL assessment methods and resources will be shared. [20 min]
(8) *Wrap-up summary and Q&A.* [15 min]

VI. FACILITATOR QUALIFICATIONS

The facilitators have conducted over eight PBL-related workshops to faculty across engineering and other STEM disciplines. Dissemination has taken place in regional and national venues. Our team of facilitators brings expertise on PBL, learning theories, problem classification, assessment, and pedagogies. Having delivered similar workshops before, we will also be sharing/incorporating findings from the previous workshops so that we can provide examples of how this model applies to other programs.

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REFERENCES

[1] Pierrakos O., R. Kander, E. Pappas, R. Prins, Nov. 2008, "An Innovative Engineering Curriculum at James Madison University: Transcending Disciplinary Boundaries Through Innovative Problem Based Learning Practices," *ASME International Mechanical Engineering Congress & Exposition*, Boston, MA.

[2] Russell J., Pierrakos O., France M., Kander R., Anderson A., Watson H., June 2010, "Incorporating Problem Based Learning (PBL) in a Freshman Engineering Course: Methods for Classifying and Assessing PBL Projects," *ASEE Annual Conference & Exposition*, Louisville, KY.

[3] Pierrakos O., A. Zilberberg, R. Anderson, Fall 2010, "Understanding Undergraduate Research Experiences through the Lens of Problem-based Learning: Implications for Curriculum Translation," The *Interdisciplinary Journal of Problem-Based Learning*, Vol. 4 (2), pp. 35-62.

[4] Pierrakos O., Nagel Robert, Pappas Eric, Nagel Jacquelyn, Moran Thomas, Barrella Elise, Panizo Mariafe, Fall 2013, "A Mixed-Methods Study of Cognitive and Affective Learning During a Sophomore Design Problem-based Service Learning Experience," *International Journal for Service Learning in Engineering*, Special Edition, pp.1-28. ISSN 1555-9033.

[5] Pierrakos O., Nagel Robert, Pappas Eric, Nagel Jacquelyn, Moran Thomas, Barrella Elise, Panizo Mariafe, Fall 2013, "A Mixed-Methods Study of Cognitive and Affective Learning During a Sophomore Design Problem-based Service Learning Experience," *International Journal for Service Learning in Engineering*, Special Edition, pp.1-28. ISSN 1555-9033.

[6] Pierrakos O., Robert Nagel, Heather Watson, Kyle Gipson, Elise Barrella, Eric Pappas, Robin Anderson, John Karabelas, Islam El-Adaway, Saami Yazdani, and Ron Kander, Feb. 2013, "All Problems Are Not Created Equal: Intentional Design of Learning Experiences Grounded on an Innovative and Versatile Problem Based Learning Model," *5th Annual Conference on Higher Education Pedagogy*, Blacksburg, VA.

[7] El-adaway, I., Pierrakos, O., & Truax, D. (2014). Sustainable construction education using problem-based learning and service learning pedagogies. *Journal of Professional Issues in Engineering Education and Practice*,*141*(1), 05014002.

[8] Nagel, R. L., Pierrakos, O., Pappas, E. C., & Ogundipe, A. (2011, January). The integration of sustainability, systems, and engineering design in the engineering curriculum at James Madison University. In *ASME 2011 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (pp. 833-843). American Society of Mechanical Engineers.

[9] Pierrakos, O., Watson, H., Kander, R., Russell, J., & Anderson, R. (2010, October). Special session—Not all problems are created equal: From problem-based learning theory to research on complex problem solving and implications for the engineering classroom. In *Frontiers in Education Conference (FIE), 2010 IEEE* (pp. T3A-1). IEEE.