Workshop: Project-Enhanced Learning in Engineering Science Education

Razi Nalim; Manikanada Rajagopal; Robert Helfenbein

Abstract

Early drop out and poor retention rates are a major challenge to engineering education, which in many institutions have prompted a focus on improved first-year experiences. Retention and contributing learning challenges persists into the middle years, particularly when students confront the first engineering science courses in their major field. Students often perceive these courses as too abstract, intended to weed them out, and not meaningfully connected to their professional aspirations. A proven approach to improve student learning, self-efficacy, motivation, and retention is the use of active learning, including problems and projects [1-4]. Despite evidence of the benefits of active learning, engineering schools and faculty members have inadequate incentives to experiment with non-traditional approaches [5].

Keywords

Project enhanced learning, Engineering science education, Engineering science courses, Student learning, Active learning, Engineering schools, Faculty members

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Section I.

Background

Early drop out and poor retention rates are a major challenge to engineering education, which in many institutions have prompted a focus on improved first-year experiences. Retention and contributing learning challenges persists into the middle years, particularly when students confront the first engineering science courses in their major field. Students often perceive these courses as too abstract, intended to weed them out, and not meaningfully connected to their professional aspirations. A proven approach to improve student learning, self-efficacy, motivation, and retention is the use of active learning, including problems and projects [1]–[2][3][4]. Despite evidence of the benefits of active learning, engineering schools and faculty members have inadequate incentives to experiment with non-traditional approaches [5].

Over the past decade, the presenters and colleagues developed a particular model called project-enhanced learning (PEL) for core engineering science courses at the sophomore and junior levels. The project component enhances and does not replace traditional deductive exposition that most teachers find indispensable in these courses [6]–[7]. The requisite characteristics of project implementation in PEL evolved with experience. Critically, any intervention such as a project must be adoptable by the typical instructors of these courses, who may have career goals and incentive structures that limit teaching time commitment. Instructor willingness to add a project component in addition to traditional methods depends on project attributes that must be carefully constructed to minimize additional workload to the instructor as well as the student. Such a project component of engineering science courses at the sophomore and junior levels must be structured and mapped to the traditional topic sequence, and thus cannot be as open-ended as a senior level design project.

As reported previously [8], [9], the PEL approach not only improved learning of the targeted engineering science content, but also enhanced peer-to-peer interactions, revealed student misconceptions, improved student motivation, and inculcated design skills and professionalism. The major benefits are improved learning in target courses, and potentially greater retention of students in engineering. Attendant learner benefits are improved self-efficacy in target courses, sense of belonging in the discipline, enhanced communication and team skills, and project management skills. Benefits for the instructor include early feedback on student difficulties and misconceptions, and the relatively low workload required for the structured project.

In 2010, Indiana University – Purdue University Indianapolis (IUPUI) received a grant from the National Science Foundation (NSF) to implement and disseminate PEL in engineering science courses, as well as to identify barriers to adoption and to train faculty members. The grant activity aims to expand the PEL model to multiple courses at IUPUI and other institutions.

Project experiences were implemented in three different courses, based on initial experience in a course on *Thermodynamics*. PEL was introduced in two other courses: *Probabilistic Methods in Electrical and Computer Engineering*, and *Dynamics* in the mechanical engineering curriculum. One or two major projects based on systems, objects, or activities that are familiar to the students are designed and assigned to apply key course topics.

New instructors were initially reluctant to add the project to an already packed syllabus, but those who agreed to attempt it found that the tightly integrated project required very little extra grading effort. They also observed improved learning of the subject matter. Students were motivated to learn how to complete the project without errors, asking questions when something did not seem right, unlike with traditional piecemeal homework. Often, an online discussion forum for the project revealed student misconceptions and prompted early intervention to correct the errors.

Section II.

Goals of the Workshop

The workshop is aimed at giving instructors an opportunity to evaluate and adapt the project-enhanced learning (PEL) model, which instructors at multiple institutions have found feasible and beneficial during the NSF-funded implementation program. The workshop format requires participants to actively work in groups on generating project ideas and materials for a course of interest. The expected outcomes are familiarity with the PEL methodology and rationale, increased interest in adapting PEL or other active-learning strategies in engineering education, and ideas for a project component in one or more courses.

Section III.

Content of the Workshop

Project-Enhanced Learning (PEL) will be presented as an active learning strategy that integrates abstract concepts and deductive mathematical analysis with a concrete and meaningful project experience. The PEL experience is intended to motivate and anchor student learning and provide low-load feedback and assessment to the instructor. The workshop is intended to virally propagate an easily adaptable educational practice that is sustainable for the typical harried instructor. The experiences of project implementation (over the past ten years) and PEL dissemination make the proposed instructor-researcher team well equipped to lead this workshop.

The organization, planning, and implementation of PEL are modeled on past successes and resources available from educators who developed the method. The experiences of early adopters will be shared. Participants will review the strategies and implementation techniques of PEL, including the alignment of the most challenging course topics with project tasks, use of an on-line project discussion forum, substituting project tasks for traditional homework, and giving students ownership while managing workload and divergent thinking. Pairs or small groups of workshop participants will be formed to actively carry out a workshop 'project' to develop PEL for some common engineering science courses chosen by interest of the audience. Each group will brainstorm for project ideas for their course, and develop a feasible project outline, task structure, solution verification, and assessment approach for the project. Groups will reassemble to discuss their reactions, opinions, and ideas.

Section IV.

Workshop Agenda

The following workshop agenda is based on a three-hour time allocation, and the goal of completing a 'project' task of developing PEL materials by each participant. It can be adapted to a different time allocation with a more or less ambitious agenda.

1. Retaining learning in students, and retaining students in engineering – what seems to work? [15 min]
2. Project-Enhanced Learning: Why and How? [15 min]
3. Minds-on learning by action – in pairs or small groups of participants:
    1. Consider a traditional 'syllabus', with stated course topics and outcomes [15 min]
    2. Brainstorm on possible and feasible project concepts [30 min]
    3. Identify project tasks mapped to course outcomes [15 min]
    4. Break and inter-group conversations [15 min]
    5. Outline project guidelines for students; how to simplify and focus tasks [30 min]
    6. Assess solution space for the project, and grading workload for the instructor [15 min]
4. Briefly report group experiences [15 min]
5. Review lessons learned and critique methods [15 min]

Section V.

Description of the Anticipated Audience

Workshop participants are likely to be engineering faculty members interested in new learning techniques in challenging and analytical engineering science courses, with the objective of improving learning and retention of students in engineering. Graduate students and post-docs with interest in engineering or similar STEM education can benefit as well.

Authors

Razi Nalim: School of Engineering & Technology, Indiana University - Purdue University Indianapolis, Indianapolis, USA

Manikanada Rajagopal: School of Engineering & Technology, Indiana University - Purdue University Indianapolis, Indianapolis, USA

Robert Helfenbein: School of Education, Indiana University - Purdue University Indianapolis, Indianapolis, USA

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