Research Project-based Learning (RPBL) in Higher Education

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Extended Abstract

Introduction

A new pedagogy experiment based on the well-known and well-practiced problem-based learning (PBL) approach was used in teaching an advanced level postgraduate course on heat and mass transfer. Students were expected to do self-learning based on carefully chosen problems; in order to come up with the solutions, students had to form groups to carry out appropriate searches on their own. The idea was to let the groups of students (in our case groups of two students) carry out independent and original research projects on transport phenomena and learn all aspects of carrying out a research project from start to finish in just four months.

Methodology

In the current case the course was entitled “Mass Transport” (the module ME6203 at National University of Singapore) which covered topics like coupled heat transfer and reactions. ME6203 was taught by the senior author (Arun S. Mujumdar) who made changes to the lecture material and also modified the sequence of lectures to ensure students had a head start when they initiated their project. The selection of projects was carried out by the lecturer and his team of research scholars six months prior to the start of the module. This is not only to ensure diversity but also to be sure that the required research could be completed within the time available. For each project, at least the two most relevant references were provided as well.

In the classroom, the lectures focused on basic concepts of conservation law, control volumes vs. systems, initial and boundary conditions, analytical solutions, dimensionless groups, scaling of equations and more. Most projects required use of an appropriate tool such as Fluent and MATLAB. Each group was assigned a mentor to provide guidance as required. Students were allowed to discuss the problems and solutions with their respective mentors and the module instructor. However, they were also expected to be as independent and original as possible; of course, there would be variations in the projects as it was impossible to ensure that all projects were of equal complexity or difficulty.

At the end of the course, students had to submit a technical report which follows the format of a standard journal article. They also had to prepare PowerPoint presentations of about 20 minutes with 10 minutes for fielding questions and discussion. Our personal impression is that in the course of participating in these projects, most students effectively experienced going through the entire process they would need to go through during their PhD research. They even had the opportunity to deliver their paper in a conference-like setting complete with an external Chairman and Co-Chairman. In terms of the evaluation, numerous criteria were taken into account. With some extra effort and continued mentoring, work on some of these topics was extended and published as research articles in peer-reviewed journals.

**Student Feedback**

The student feedback was very encouraging. Research project-based learning was a new experience for all the students and all of them appreciated it very much. The survey conducted by our team working on this pedagogy project included several questions about critical and independent thinking abilities, lifelong learning as well as its usefulness in their graduate studies and development of analytical abilities. Figure 1 shows the results of the student feedback for selected questions which clearly shows the positive response to this exercise.

![Figure 1. Student feedback collected from the survey.](image)

*The survey wanted to find out students’ responses to the following questions:

Q1 This exercise provided me opportunity to think independently and critically;

Q2 This exercise improved my ability to read papers critically and enhanced my analytical ability;

Q3 This project has motivated me for life-long learning;

Q4 The experience I got during this project was very helpful for my doctorate/master of engineering research work*
As mentioned earlier, the students’ response to this effort was overwhelmingly positive, which was also apparent from some selected comments mentioned below:

- “Prepare the fresh Ph.D students on the learning journey of their research life.”

- “The module provided me a fruitful learning and research experience. The techniques I learned included the concept of modeling, critical analysis on the modeling results, writing academic papers, and presentation on the research result. All the experiences are very helpful in my Ph.D candidature period.”

- “This experiment was very helpful for any fresh research student to involve themselves in critical thinking and analysis of the results. It also makes learning a fun-filled event.”

A few students also expressed some concerns and provided useful feedback to improve the course:

- “It could be purely focusing on this simulation work instead of having regular classes and exams.”

- “The content of the module is quite heavy as in a very limited time (several weeks) we need to learn a completely new concept, understand it and implement it in a research subject. It is quite challenging to gain a clear understanding of the subject in the course period.”

**Conclusion**

RPBL represents a paradigm shift in teaching graduate students. When they participate in a learning activity which applies RPBL, they go through all key aspects of what is needed to complete a PhD thesis. The only consideration is that it requires a major effort on the part of faculty members and mentors who need to be extremely passionate and motivated about teaching. The authors would like to specifically point out that such an exercise can be effectively implemented only in small graduate classes. The success and quality of the research outcome from our RPBL exercise is evident from the fact that four research papers based on these projects have already appeared in high-impact journals within a year of completion of these projects (An et al., 2012; Shaker et al., 2012; Kurnia et al., 2013; Mohan et al., 2014). Of course, much additional work by all concerned was required to make this possible.
References


