

## Explicit Research Skill Development within Problem/Project Based Learning Approach

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### Summary

Problem based learning was first introduced in the Medical School of McMaster University, Canada, in the late 1960s. This learning approach allows for active learning by students and allows for a dynamic interaction between students and facilitators, in contrast to traditional passive teacher-centred approach where the lecture is the prime source of knowledge that mainly rely on unidirectional transfer of knowledge from the expert (lecturer) to the novice (student) [1]. A large number of disciplines have subsequently moved to use this approach or a modified version [2] of this learning approach in the development of part of a course, a whole course, or a whole program [3]. The design of these problems is usually well structured as follows [4]:

- The student starts with clarifying terms and concepts which are not clear
- Then define the problem or possible sub-problems
- Based on the collected information analyse the problem or problems
- Provide a list of possible explanations
- From this list formulate learning objectives and set priorities to be addressed
- Then look for additional information outside the group set of knowledge
- Report back outcomes and synthesise possible solutions

The typical emphasis in problem-BL is the process of getting to the solution rather than the solution itself, while in case of project-BL the emphasis is both on the process and the final solution exemplified by engineering projects. This paper portrays project-BL as a superset of problem-BL and hence the PBL acronym is used interchangeably to imply either project-BL or problem-BL [5]. In some cases, PBL was used as a blanket approach to cover an entire faculty/division or a university [6]. Implementation of this learning approach took a variety of forms and evaluations of these approaches have been reported in numerous studies [6]. In these studies, it is widely reported that substantial preparation in terms of training potential facilitators is required [7] for PBL cases/problems to have positive impact when implemented in classes [8]. In addition, studies of

students' perspectives of limitations of PBL found that it does not accommodate for low achieving students because tasks associated with some of these problems/cases require higher order problem solving skills [1, 9]. Furthermore, one of the driving forces behind PBL is that it allows the development of active learners that develop autonomous learners/learning/decision making by building on skills that the student already have or acquire through attempting PBL cases. However, the process that a student can use to develop these skills and work autonomously is not well explained by the PBL approach.

One way to make clear and explicit the cognitive processes required in PBL is combining its approaches with the Research Skill Development (RSD) framework [10]. The RSD allows students to not only utilise their existing knowledge and skills, but also help them learn how to develop these skills and acquire knowledge through an explicit and easy to follow framework. The framework has six facets that have been identified from the literature and modified according to Bloom's taxonomy [11]. Based on this framework, the students [12]:

- embark on inquiry and so determine a need for knowledge or understanding,
- find/generate needed information/data using appropriate methodology,
- critically evaluate information/data and the process to find/generate this information/data,
- organise information collected/generated, and manage the research process
- synthesise and analyse and apply new knowledge, and
- communicate knowledge and the processes used to generate it, with an awareness of ethical, social and cultural issues.

The facets of inquiry should not be considered as linear and sequential; rather students will move recursively between them depending on the task or problem at hand. The RSD framework elaborates these six facets into a five-level continuum, of student autonomy, which ranges from the minimal autonomy of a closed inquiry that requires a high degree of structure or guidance (Level 1), to an open-inquiry within self-determined guidelines in accordance with the discipline (Level 5). The RSD framework is shown in Figure 1.

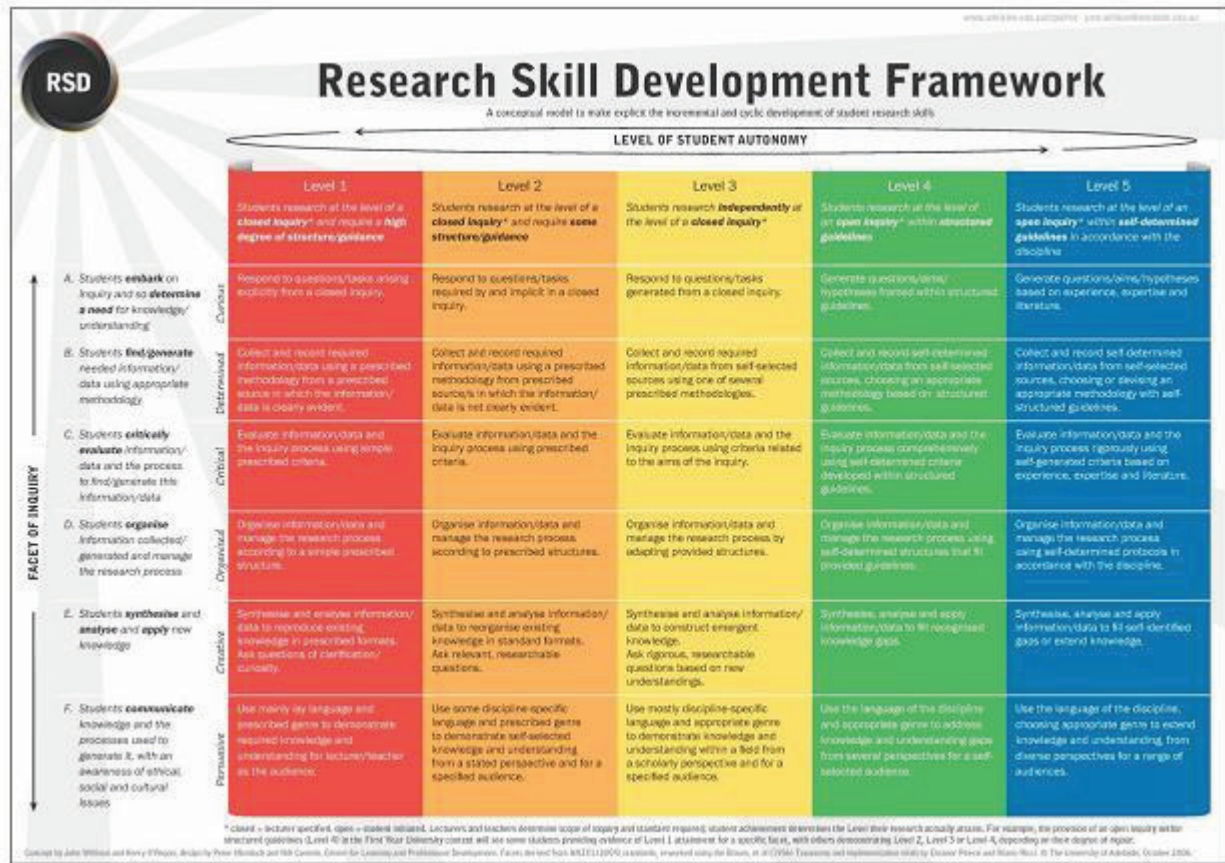


Figure 1: Research Skill Development Framework [12].

By combining the explicit nature of the research skill development framework discussed above with the problem based learning it allows student to not only find information or use current skills, rather have a better understanding on how these skills and knowledge can be develop in the context of increasing autonomy required by students. Furthermore, the interaction between RSD and PBL is not only restricted to Engineering discipline rather to other disciplines where research skills are a needed part of student centred learning.

In the case of Electrical and Computer Engineering (ECE) higher education the above framework has been applied over a number of years albeit in an incremental way. The primary venue for the application of the framework is in junior as well as senior design (final year) projects. In addition, it was also applied to the minor thesis component of Masters of Engineering program at the University of Adelaide. In the case of junior projects they tend to be group oriented while the senior ones are carried out either by an individual or a group of students over two semesters

In both sets of projects, the students embark from a short statement of the problem to be solved then continue on the inquiry path that involves an iterative process and which culminates in a full specifications document that details what needs to be achieved. This includes any new concepts that need to be learnt. Finding/generating the necessary information/data and critically reviewing/analysing it is a substantial phase of the

project execution. This phase requires the student to organize the information and use it to propose and evaluate a variety of designs. This process inculcates the fundamental skills of conducting research.

The body of knowledge that the student consolidated, regarding the problem that needs to be solved, is then applied to perform complete synthesis, verification and validation of the system. A comprehensive report is then compiled and an oral presentation is delivered. The level of success with this approach depends on a number of factors including the student ability, nature of the design problem, and instructor commitment. The choice of the design problem is very important and a year level dependent. At senior years, the problem must have an open-ended component in order to encourage conducting research and seeking new solutions.

Implementing a reward scheme that encourages successful undergraduate students to publish their work in conferences, journals ... etc has a very positive impact on the research skill development process. In case of Khalifa University, this rewarding process coupled with active encouragement of the instructors, resulted in 10%-15% (depending on the cohort) of undergraduate students on ECE programs publishing at least one paper in a peer reviewed conference out of their project work.

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