# Moving Towards Problem Based Learning (PBL): Some Initial Experiences at AUT University

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***Abstract***
*A business case was first presented for the School of Engineering at AUT University, Auckland, New Zealand, to change the delivery schemes of all undergraduate degree programs towards a Problem Based Learning (PBL) approach, envisioning a raised institutional profile, improved completion rates, increased community or industry engagement, increased consultancy income, and improved staff retention. In preparation for the actual move towards PBL, a preliminary study was undertaken subsequently to consider issues such as staff training, resource development and risk factors. The role of a teacher as a facilitator and the educational philosophy behind it needed to be reviewed, in order to be able to formulate a staff development scheme. Curriculum and resource development aspects and the timeline for the implementation of PBL at AUT were also investigated and reported. This paper presents some of the highlighting features of this report.*

***Keywords****: Problem based learning, Implementation, Curriculum and Resource development*

## 1 The PBL business case for AUT

A business case was presented earlier for AUT, promoting a shift towards PBL from the more traditional teaching and learning system. It was envisaged that the initial investments in staff and resource developments incurred in shifting towards PBL would be returned by the program itself, apart from pedagogical and marketing benefits, when the business case for the School of Engineering to change the delivery of all undergraduate degree programs to a PBL approach was originally proposed. Further, raised institutional profile, improved completion rates, increased community/industry engagement, increased consultancy income and improved staff retention were expected to be typical of a PBL based delivery system.

Projections were made to change both Bachelor of Engineering and Bachelor of Engineering Technology programs over to PBL. The high level Gantt-chart provided outlines activities such as curriculum development, staff training and infrastructure development to be done during the course of development for the effective implementation of PBL. Budgetary allocations were proposed for initial training of pioneer staff, consultancy services from other universities and further training of other staff members. Project space requirements were calculated based on an intake of around 200 Effective Full Time Students (EFTS) and a floor area of around 1800 $m^2$ was expected to be built for studio development. Risk factors such as staff skill level, resources and commitment are also identified. There was however a need to assess issues related to the final implementation of PBL, considering aspects such as staff training, resource development and risk factors at greater depths, and this paper reviews some of the knowledge acquired in the process.

## 2 Shifting to PBL: Some previous experiences

A search of existing literature on the experiences of other universities in shifting to PBL from a traditional delivery method produced numerous examples in medical sciences, but very few in engineering related courses. Camp [1], while

discussing whether PBL is a paradigm shift or a passing fad, reviewed the early development and application of PBL in medical education, beginning with the Faculty of Medicine at McMaster University in Canada in the 1960's. Soon after, three other medical schools-the University of Limburg at Maastricht in the Netherlands, the University of Newcastle in Australia, and the University of New Mexico in the United States – adopted and adapted the McMaster model of PBL. The use of PBL in medical schools incorporated goals for students that are much broader than the acquisition and application of content and influence the student's learning experience. There was so much of a difference, any move towards PBL was considered as a "paradigm shift". The application of the model for student-centered, problem-based, small-group learning at other medical schools saw a gradual increase through the 1970's and 1980's. Of late, there is an explosion in the use of PBL in its various adaptations.

Camp [1] also presents an interesting viewpoint in that half-hearted implementation of PBL would have detrimental effects in the long run. Often, faculty are reluctant to relinquish control of the learning process, so that PBL is implemented in a way which keeps the teacher 'in charge" of what is learned, but packaged into cases and small group discussion. This is referred to as "problem-simulated" learning and not PBL, and it is not student-centered. Camp suggests that PBL will undoubtedly change in its implementation but remains a paradigm shift, if half-hearted attempts are avoided.

Des Marchais [2] presented some interesting observations based on five years of experience with a student-centered, problem-based curriculum at the School of Medicine of the University of Sherbrooke and reports that the PBL curriculum, though costly, is of a better quality than the previous one. In reviewing the PBL experience, two types of tutors were immediately identified: those who gave lectures on every possible occasion and those who thought that they must never talk. Constant tutor intervention undermined student confidence and inhibited the group from explaining the mechanism of problems and fixing their own learning objectives. Tutors who never intervene usually seemed unconcerned with group progress and not interested in the new method. Student response was in favour of tutors who actively guided mostly by asking appropriate questions at the most opportune moment. In the first moths of the program, inter-student friction frequently emerged in the form of distrust between team partners and uneasiness with the roles of group leader and secretary.

McLoughlin [3] discussed the structures required to support and manage a PBL curriculum once established, rather than the challenges involved in changing from a traditional to a PBL based curriculum, based on experiences at the Dublin Dental School and Hospital. One of the concerns raised is that some disciplinary areas perceive a loss of control on the content, that may lead to a reduction in the amount of teaching. For example, within programmes training health professionals in the basic sciences, the concern seemed to revolve around whether students learn a sufficient amount of the basic sciences to underpin their learning in the biomedical and clinical sciences. Another key concern was the availability of the resources to support a PBL curriculum. Reduced budgetary allocations and pressures to increase student intake means serious implications for the availability of physical resources, library materials as well as staff time.

Another problem identified was that well integrated problem-based rather than discipline-based curricula are not easily suited to the application of credits for courses and facilitating student transfers from one university to the other. The contextual learning paradigm of PBL requires an interdisciplinary approach requiring both horizontal and vertical integration within the curriculum, and necessitates central overall control of the curriculum. The requirement for small-group, self directed learning leads to the need for seminar rooms, trained tutors and library facilities, all of which require considerable administrative and financial support. While there are some issues with timetabling, getting and retaining tutors with good subject-matter expertise as well as qualities such as ability to communicate well with students in an open and emphatic manner is also a problem.

Bernstein *et al* [4], based on questionnaires administered to students and staff and multivariate analysis of data to evaluate shifts in student's attitudes after initial direct experience with PBL, came up with the conclusion that students and faculty are likely to change their attitudes in a positive direction regarding the effectiveness of PBL, after direct experience. Khoo [5] investigated the implementation of PBL in Asian medical schools, and concluded that strong support from the academic administrators in the introduction of PBL into the curriculum and careful training of both faculty and

students appear to be key factors to ensure the successful implementation of PBL in Asian medical schools. An interesting observation is traditional quality of Asian students, believing that challenging the authority of the teacher might lead to conflict, as they expect teachers to tell them exactly what to read and assign clearly defined tasks. In addition, Asian students also are reluctant to speak out, either due to the Confucian socialization or sometimes language problems. As a considerable population of AUT students is Asian, these observations need to be taken into account while implementing PBL, and a special course may be considered for Asian students, to overcome these difficulties.

Reporting on the implementation of a PBL curriculum in an Argentinean Medical School, Carrera *et al* [6] identified the following obstacles:

- PBL's goal of producing well-rounded general physicians didn't seem to be working well with students intending to think about a specialization from the beginning. Whether this becomes an issue or not will only become apparent when the actual structure of the program and the progression into different pathways are made more clear.
- A student population of varied backgrounds and capabilities seemed to have resulted in those with significant deficiencies to drop out for not being able to participate effectively in group activities. This comes as a surprise, as PBL is expected to increase tetention rates.
- Lack of a suitable number of fully trained tutors and reluctance of older faculty to change over to the PBL style
- Lack of funds for a system that requires more money in terms of appropriately equipped rooms, and well-stocked libraries, trained tutors etc.

Project based learning is concerned with the application of existing knowledge to new situations and acquisition of practical skills in the process, whereas problem based learning requires acquisition of knowledge to address a particular problem. Rojter [7], while discussing the introduction in 2006 of PBL into engineering courses in schools of Electrical, Architecture, Civil, and Mechanical Engineering at Victoria University argues in support of a pedagogy which embodies constructivism, but this is not a property of a definitive PBL model. An interesting conclusion was that the learning outcomes emanating from PBL, though producing graduates not only with a more hands-on approach but better communication and team-working skills, there is ample evidence many other skills such as ability to work independently, think critically are sacrificed. The author feels that the constructivist approach is the right educational tool in engineering education for professional practice in the post industrial world and that educational constructivism is certainly not limited to PBL teaching. Traditional course structures can also incorporate constructivism, by a process of continual tinkering with curricula and subject syllabi and allowing for greater flexibility than the prescriptive PBL methodology.

The literature reviewed in this section mostly identified the experiences and possible problems that may arise while implementing PBL, based on available reports, The intention of this is to prepare the management and teaching community for possible consequences, and to begin thinking of solutions for these problems, from the start. The issues of the actual implementation process will be presented next.

## 3 Facilitation

Implementing PBL means a drastic change in the role of the teacher from teaching to facilitating, in a student-centered learning context, with more weight placed on the process of learning knowledge rather than teaching it. While the role of a teacher as a facilitator and the educational philosophy behind this are involving topics of educational science, some key aspects of facilitation are reproduced here, in order to highlight one of the key areas of change, when moving from a traditional system to PBL. Kolmos *et al* [8] differentiate between supervision and facilitation as follows:

***Supervision*** *is a contract-based, time-defined, supporting and initiating and professionally managed process in which a more experienced colleague with the integration of professional knowledge acts in such a way that the colleague increases the ability to perform in relation to the subject's methods. In other words, the supervisor is the master in this sense.*

On the other hand, ***Facilitation*** *is the process of creating conditions within which other human beings can, so far as possible select and direct their own learning and development. The facilitator is concerned with the psychological growth of the person.*

Facilitation suggests more openness towards the student and contains a more balanced relationship between teacher and student. It signals open space. There is a further quality to this that facilitation is situated, meaning that the role of teaching is to decode students and use appropriate tools and strategies to improve their learning at that time. Project facilitation is a common role for most teachers, even in traditional systems, but there is always the uncertainty of the degree of control and where to draw the line of personal involvement.

Constructivism is a theory that says that people construct their own understanding and knowledge of the world, through experiencing things and reflecting on those experiences. In the classroom, the constructivist view of learning usually means encouraging students to use active techniques to create more knowledge and talk about the learning process. Good teaching skills actually reflect effective learning. A constructivist teacher poses problems of emerging relevance, structures learning around primary concepts, seeks and values students' points of view, adapts the curriculum to address students' suppositions, and assesses student learning in the context of teaching.

PBL is one of the most practical means of implementing constructivist approaches in teaching. According to Kolmos *et al* [8], the PBL model includes principles within three dimensions: cognitive learning, collaborative learning and content. A cognitive learning approach points to learning around problems, carried out in projects. The contents approach means interdisciplinary learning, spanning across traditional subject-related boundaries and methods. Collaborative learning is team-based learning and underpins the learning process as a social act, where learning takes place through dialogue and communication. The PBL model at Aalborg University is characterized by open problem based learning and student controlled project work.

Challenges to a facilitator are to be aware of how they teach, why they teach that way and how their teaching is perceived by students, and equip the students to take control of their own learning. The role of teaching is to facilitate students' learning rather than conveying knowledge and it is important to create a reflective learning culture. Facilitators should be qualified in both the subject area and in helping students develop process skills like communication, management and group dynamics. The most difficult part in facilitation is to be able to read or decode students' knowledge and practice in order to contribute to their learning processes.

Three levels of involvement are characterized for a facilitator: Facilitator acts like a group member, dialogue based facilitation and consultancy. The first level leads to the facilitator taking over the project. The second type leads to facilitator maintaining some distance from the group. The third is passive at the beginning and is only active when the group asks for facilitation. Four types of facilitation are identified and described as follows:

a) Product facilitation: characterized by traditional master-apprentice relationship and exemplifies facilitators ownership towards the final project report
b) Process facilitation: The student's current learning process and ideas are emphasised. The goal is to support progression in student's learning
c) Laissez-faire facilitation: More indifferent and superficial type of facilitation and reflects either leaving the project to student's inclination or lack of involvement
d) Control facilitation: Characterized by students being examined during the whole project period. Every aspect of the project is thoroughly examined by the facilitator.

In actual practice, facilitation style will be a mix of some of these types.

## 4 Staff development for PBL

The previous section identified a completely different role for the teacher in a PBL environment, as a facilitator. It is a difficult task to realize the need to transform into this new role, as most teachers develop a highly individualistic personality around their teaching. Most have a profound confidence in their methods and the effectiveness of the same in shaping the understanding of their students. These stances emerge from their prior learning experiences, and their often taken-for granted notions of learning and teaching [9]. PBL needs to be an integral part of the philosophy of an organization. The issue is one of ownership, without which the chances of failure are high. The first and foremost requirement is to be open and ready to change and realize any inherent weaknesses without any bias. All this requires systematic training in pedagogical approaches to engineering education leading to a practical realization of the scientific relevance of the need to change. This section presents examples of staff

training programs conducted elsewhere and their relevance to AUT, so that a suitable approach can be developed for the local conditions.

Training for PBL is still an underdeveloped area and the role, satisfactoriness and, effectiveness of methods are unclear [9]. A two phase approach was followed for staff training when the School of Nursing and Midwifery at the University of Dundee introduced a PBL curriculum in 1997. The first phase involved circulation of papers and key references relating to PBL, creating opportunities for debate, to allow staff to raise concerns and conducting an introductory workshop to introduce PBL to staff. The overall aim of the first phase was to provide a foundation upon which to begin to develop sufficient facilitators for the first cohort of students. Phase two comprised a 3-day workshop that varied in terms of content, depending upon the needs of those attending. These 3-day sessions were repeated four times over a period of ten months, so that the school had enough PBL facilitators to support three intakes of students. The incremental approach ensured sufficient supply of facilitators in time to support the introduction of PBL, and an environment conducive to effective learning. Analysis of the post training feedback results suggests that many felt confident in dealing with difficult group dynamics and believed they were prepared to become more of facilitators and less of teachers.

The Sherbrooke experience [10] in preparing faculty to teach in a problem-based learning curriculum is one of an intensive training program spanning several years and made effective by much advanced planning and preparation. The Sherbrooke office of Medical Education offered four such training programs from 1984 to 1990, first a 2-day introductory workshop on educational principles and their application in medical education; second, a 1-year basic training program in medical pedagogy, requiring more than 100 hours of participation; third, an introductory workshop on PBL; and fourth, a comprehensive 3-day training program in PBL tutoring followed by a 1-day-a-year refresher workshop. The development model followed is also exemplary, in that experts in related fields were invited to develop and give the first version of a program to some faculty members. The second version was delivered by the local faculty members under the supervision of the external experts and with constructive feedback. Subsequently local educators repeated the program with the help of other faculty members. The school now counts on 15 educationally trained full time teaching physicians.

While the Sherbrooke model is an excellent example to follow, it is too late for AUT as the time remaining is only one academic year, considering the plan to implement PBL during 2011. The other model on the other hand, is too short and depleted of any serious training element, and might result in a half-prepared faculty. The main time consuming part is the one year training in medical pedagogy. If this part can be converted into an accelerated delivery model, the training program can be fit into the overall structure of the Sherbrooke model. The following is the essential structure of the training program suggested:

- A 2-day workshop on educational principles: the goal is to arouse teacher's interest in engineering education and in the student-centered approach
- One-month basic training in Engineering Pedagogy: Aimed at changing traditional attitudes so that participants place more emphasis on the process of learning than that of teaching
- Introduction to PBL Methodology: One day workshop offering initiation into the methodology of PBL.
- Tutor Training program: Comprehensive three day training aimed at training teachers in their new role as small group PBL tutors. Its goals are to help teachers more deeply assimilate the PBL methodology, understand tutoring tasks and acquire the skills needed to perform

Again the incremental approach of the University of Dundee [9] coupled with that of Sherbrooke can be the model for the overall delivery of the training program. The following are the essential stages:

- By early 2010, form an external training team by employing experts from outside
- Select a group of 8-10 teachers, mainly responsible for delivery to the first cohort of PBL students in 2011.
- Let the external team design the training program as the first batch of teachers observe.
- Deliver the training program to the first batch by mid 2010
- The first batch of teachers then becomes trainers and delivers the training program for the second batch of teachers by the end of 2010, under the supervision of the external experts.

This will ensure a handful of facilitators ready to implement PBL by early 2011 and the others actively working on the second year PBL curriculum. Apart from a sophisticated training system, there is also

a need to reconsider staff evaluation methods. For example, there is always a demand on teachers to be research active and produce Performance-Based Research Funding (PBRF) outputs and the introduction to PBL might be further stressing for some teachers. Also there is a need to develop some incentives to those involved with PBL development and implementation. It is worth mentioning the Maastricht model in this context [3]. The Maastricht Faculty of Medicine has developed a system of documenting educational activities in full time equivalents for teaching in individual departments and, importantly, in decisions on promotion of individual faculty members. Academic status and promotion is dependent on devoting at least 15% of time to education and research respectively, with tasks such as tutorship being distributed evenly among staff. The experience at Victoria University [11] represents a similar situation and through the faculty's commitment along with the contribution by some key staff members, it was reported that the entire process of training the faculty, preparing the curriculum and infrastructure were successfully achieved within a period of one year, resulting in a permanent shift towards PBL.

## 5 Curriculum and resource development

Curriculum change is based on some impetus occurring for a change. At AUT, the impetus for change is the possibility to establish a different image in the educational industry of New Zealand, as projected in the business case. Johnstone and Biggs [12], while discussing the implications of PBL on accounting curricula, proposed the following stages for the curriculum reform:

- Evaluation of various curriculum options and selecting one
- Obtaining the resource commitment by the administrators
- Revising faculty reward systems to incorporate the time necessary to convert the curriculum
- Planning for implementation: defining curriculum goals, objectives, content, expectations of students, and student evaluation mechanisms
- Implementation: formal adoption by school administration, internal monitoring of student and faculty satisfaction, and external monitoring by consultants and via professional examination performance by students

Planning for implementation is the most crucial of all these steps. Stojcevski [11] described the technological advances and developments which have taken place within the School of Electrical Engineering, Faculty of Health, Engineering and Science at Victoria University Melbourne Australia, to support the transition from traditional lecture-based teaching and learning to problem-based teaching and learning. The model of the PBL curriculum developed and employed typically constitutes a 50% distribution between traditional and PBL courses in the delivery of the first year. The nature of relationships between different schools and interactions seemed to have significantly improved with the team teaching approach used in PBL and Engineering Practice Courses.

The course structures for the subsequent years followed similar pedagogical forms and considering the funds, infrastructure and other developments, this was viewed as a permanent shift towards PBL. Another important lesson to be taken from the Victoria example [11] is initiating the process of accreditation of the new curriculum very early in the curriculum development process. There must be a clear correlation between the outcomes of the activities designed and the graduate attributes prescribed by local accreditation bodies such as the Institution of Professional Engineers New Zealand (IPENZ). A careful mapping of the learning outcomes against graduate attributes, as detailed by Stojcevski [11] is an essential stage to pass through.

The next thing to consider in the implementation of PBL is resource planning. Being a traditional university school so far, AUT School of Engineering has a typical infrastructural form of class rooms, galleries and computer and other labs. Further, most of these rooms are shared by programs of different schools across the faculty. There is very little space in terms of exclusive ownership by the school. This will put further pressure on the management while moving forward with the building of studio space. The AUT business case projects an area of 18 $m^2$ to be allotted to a group of around six students. The project space requirements as projected in the business case for the first three years, assuming an average intake of 200 students in each cohort are as shown in Table 1.

**Table 1**: Project space planning presented in the business case for PBL

| | YEAR 1 | YEAR 2 | YEAR 3 |
|---|---|---|---|
| EFTS | 200 | 400 | 600 |
| Student teams (EFTS/6) | 33 | 66 | 100 |
| Project space | 600 $m^2$ | 1200 $m^2$ | 1800 $m^2$ |
| Project supervisors (Student teams / 4) | 8 | 16 | 25 |

While accepting the fact that this space is not available currently, half of the requirement for the first year was expected to be made available by converting some existing laboratories. Additional space procurement was anticipated in terms of converting some class rooms, but all this needs to be coordinated carefully, as some of these rooms are shared from a common pool, demand very high level careful planning and organization with the central resource planning team.

Again, considering the experiences at Victoria University, Stojcevski presented a model for the floor plan of typical PBL studios. Each PBL studio needs to be equipped with a personal computer that is connected to the internet and a local printer. It was stated that these are essential for critical research, report writing and students' reflection, the essential elements of a PBL system. This model may be taken into consideration while designing and developing the studio spaces at AUT.

## 6 Conclusions

The pathway to PBL is not an easy one and there are no guarantees of success. Only by rigorous planning and attention to detail can the desired outcomes be achieved. The transition process must commence this year by informing staff of the intentions and conducting some debate. In 2010 training will be provided and it is expected that staff will be prepared and will have sufficient support to start teaching in the new environment in 2011.

Robust, defendable assessment procedures, especially for assessing group work, remain to be developed. If self and peer assessment are to be incorporated, then the assessment processes must be very carefully constructed and closely monitored.

The risks of changing to PBL may well be less than the risks of not making the change. With the current tendency of employers to demand students with a range of skills other than core engineering skills, there is a real danger that a university that does not change will fail to meet market expectations.

If staff are properly prepared, and if the programme is designed so that students can explore their potentials, and if staff and students complete their work without becoming overloaded, then there is every opportunity for a successful transition.

There will inevitably be difficulties along the path, but by adopting ongoing review and continuous improvement philosophies there is a very strong prospect that PBL will be the dawn of a new era for AUT.

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