CASE STUDIES IN PROBLEM BASED LEARNING IN ENGINEERING

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ABSTRACT
An overview of the Problem Based Learning - PBL concept in the third level education was presented and the implementation of PBL into Engineering and its implications were investigated. The significance of this relatively new educational concept, how it can be used, its strength and limitations were explored. The impact of the PBL method on the efficiency of Engineering educational process was also assessed. PBL in Engineering was found to address many of the labour market demands - working and learning in teams, presentation skills, negotiation abilities, research skills and critical thinking. However, PBL in Engineering did seem to limit the possibility of offering the students a more comprehensive image of the Engineering concepts. The use of a Hybrid model (PBL and Traditional method) was found to answer the problems associated with implementing PBL into the traditional Third level educational structure and to increase the efficiency of the learning and teaching process in Engineering. The findings also suggested that the Hybrid model provided students with a sound knowledge base along with problem solving, independent and critical thinking – essential features for a future Engineer.

1. INTRODUCTION

1.1 Problem Based Learning - Overview
Problem Based Learning – PBL as it is generally known today evolved from an innovative health sciences curricula introduced in North America over 40 years ago and has since spread across the globe and across most disciplines. It is a new method of teaching used mainly in the Third Level education based on the 'learn to learn'concept.
PBL was first developed as a small group, student-centred learning curriculum at the Mc Master Medical University in Canada (1960). The university introduced the tutorial process as central to their philosophy for structuring an entire curriculum reform promoting student centred multidisciplinary education as a basis for lifelong learning in professional practice [1].
PBL emerged as a concept in 1980 when Barrows [2], discovered through investigations into medical education that: 'Medical students and residents for the most part did not seem to think at all', which was a worrying finding. The traditional curriculum suffered from overloading students with an excessive emphasis on memorization.
Barrows together with another famous researcher Tamblyn (1980) [2] concluded that:

- Learning through problem situations -much more effective than memory based learning
- The medical skills that were most important for treating patients were problem solving skills rather than memorization

One of the most important points about problems in problem-based learning is that it is not a question that first the students receive inputs of knowledge e.g. lectures, practicals, handouts etc. and then "apply" this knowledge to a problem they are presented with later in the learning process. Problem-based learning is problem-based learning not problem-based teaching [3].A lecturer using a PBL approach is not concerned with what and how they are teaching. Rather

they are observing, looking, listening, stimulating and provoking student learning. The learning of the students is their focus not the teaching of the teacher [4].

1.2 Problem Based Learning in Engineering

Over the past few decades there has been increasing pressure on higher education worldwide to re-examine and make explicit its aims and outcomes. A move towards a market model which was responsive to market demands and forces in the wider society emerged [5].
Labour Market demanded for key skills. PBL seemed to address these issues by offering students opportunities to:

- Work and learn in teams
- Develop presentation skills
- Learn negotiation abilities
- Develop research skills
- Develop a critical thinking

This shift towards, and openness to, market forces has resulted in closer links between higher education and industry. The value here is in the centralization of activities in PBL curricula, which can prompt students to engage not only with skills for life and work, but also to develop an ability to critique, instead of fragmenting the nurturing of particular activities through skills training sessions [5].

2. Methodology

A brief and concise description of the PBL methodology could be: Problem Based Learning is a method of learning in which the learners first encounter a problem (or are presented with an 'ill' structured problem scenario), followed by a systematic, student centred enquiry process. Typically in PBL, students work in small groups with a faculty tutor who acts as facilitator of discussions and of learning rather than as a direct source of information. The purpose of using problems in PBL is to stimulate learning of information and concepts brought out by the problems, rather than to solve the problems.
A simplified conceptual model of the thinking process behind the PBL method is shown below:

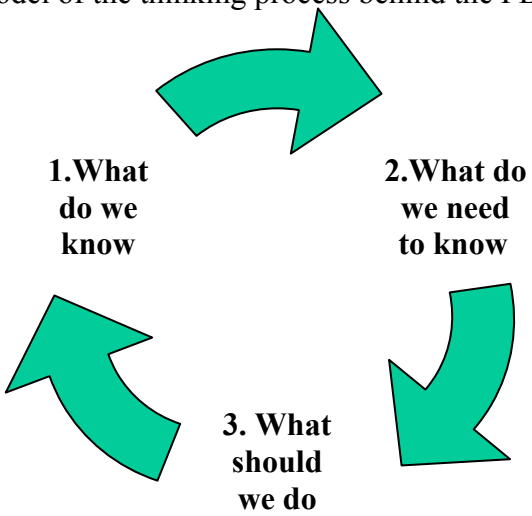

Figure 1. Conceptual model PBL

The basic questions that a student had to ask himself when first started to solve a problem with PBL - Figure 1, leaded to the emerging of the next simplified model of the PBL in Engineering:

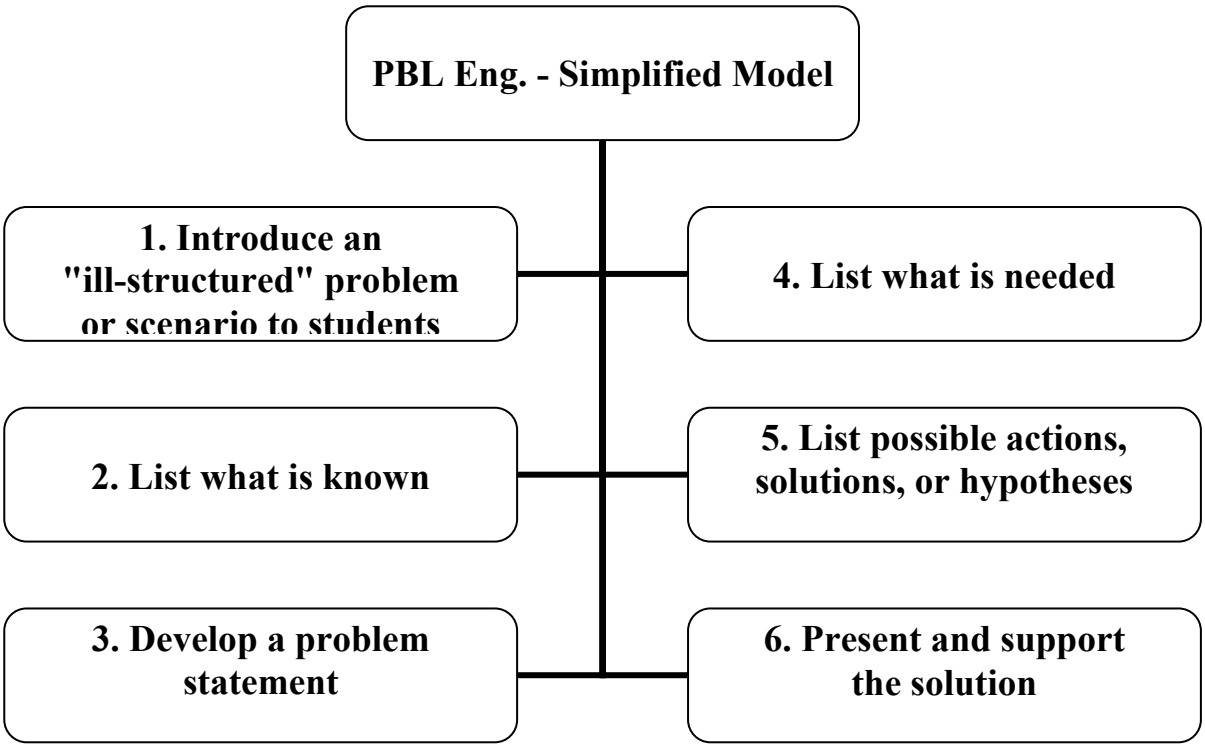

Figure 2. Steps in solving a PBL problem in Engineering

Starting with problems can be very motivating for students who may not see why they should be interested in inputs of bodies of knowledge but may become very engaged in researching these bodies of knowledge to address the learning issue they have identified themselves from working on the problem [3].

3. Results

3.1 PBL in Engineering - Example

This section presents a short curricular case study [5] which demonstrates the applicability and validity of the PBL method in Engineering.
Gimmer University (UK) was a traditional university with a reputation for academic excellence. In 1992 PBL replaced a conventional module on vibration for the third year BSc Mechanical Engineering course.

- Reason: In the past students tended to avoid examination questions requiring problem solving abilities
- The aim: Move away from the transmission of knowledge towards the development of professional skills

Before the problem based learning module commenced, the students attended an introductory session that was designed to help them to choose whether to take the course as one of their third

year options. The module comprised six problems situations which were dealt with in three pairs, each pair phase lasting six or seven weeks. The problem situations were organized in this way so that each group of students engaged with one problem situation acted as consultants and considered the other in the role of clients. The 'consultant' students were required to hand in a group report offering their solution.
As clients, the students had to devise their own criteria to evaluate the issues of the other problem situation so they could assess the consultant group answer and report effectively. Having read that report they then prepared a brief critique on it. At the end of each phase oral presentations took place with a staff member present. These took the form of a meeting during which one group represented the consultant and the other the client; the roles were then reversed for the second problem. This pattern was then repeated to cover the further two pairs of problems.

3.2 PBL in Engineering - Assessment

Students were assessed on: Consultants reports on three problems, Client reports on three problems, oral presentations of the reports, one solution to an example on a particular topic, one-hour test of 'understanding' at the end of the course - to check the students 'grasp' of the basic principles of the subject. More weight, in terms of marks, was given to the later problems because the earlier problems were designed to be more formative.

3.3 Hybrid Model in Engineering (PBL & Traditional Teaching) - Example

The Hybrid Model (PBL & Traditional Teaching) represents perhaps a more feasible approach for developing problem based curricula at larger and more traditional schools. An example of a 'hybrid model' is the Mechanics of Solids and Materials module from Trinity College Dublin, Mechanical and Manufacturing Engineering Department.
The First Semester was taught using the Traditional Teaching Method. The Second Semester was run entirely on PBL which incorporated an Independent teaching and learning module with an integrated comprehensive web course called: 'Learning through failure'
The Assessment consisted of: exam questions - traditional format and reports and exam questions on real life engineering cases using knowledge gained throughout the years
The blended educational approach (PBL & Traditional Teaching) proved to be very efficient enabling students to achieve a sound Engineering base along with the benefits gained through independent studies.

3.4 Advantages and Disadvantages PBL in Engineering

Although PBL has so far been underestimated in terms of its overall use value in higher education, there are clear signs of its growth and increasing popularity. By simulating real life engineering cases PBL is clearly recognized as helping developing independent and critical thinking, team working and presentation skills, improving motivation for learning, enhancing long term retention knowledge. It should be specified also that the cost of running PBL curricula is comparable with that of running traditional ones for classes sizes up to 100 which shows once again that the method could be easily implemented into the existing educational structures.

One disadvantage of the method is that PBL can be seen as a method of 'giving' students skills, and limiting the possibility to offer them a broad and sound knowledge base in Engineering.

4. Discussion and Conclusion

PBL in Engineering is an effective way of delivering education in an integrated programme and offers several advantages over traditional teaching methods. Students involved in problem-based learning acquire knowledge and become very efficient in problem solving, self-directed learning, and team participation. The method also helps students managing and dealing with real life engineering scenarios and develops independent and critical thinking - essential engineering features, required by the labour market.

Problems in implementing PBL: Students familiar with the traditional classroom are likely to be uncomfortable with the PBL format for some time. It will be up to the teacher to convince students that they are researchers looking for information and solutions to problems that may not have one' right answer'
Also the academic staff needs time to become informed about the need for change, the nature of the change and its consequences. They will need opportunities to contribute to the new curriculum. They will also need opportunities to practice the newly acquired skills.
Another argument against PBL is that it can be very difficult to change to PBL when some or most of the students and /or staff are products of didactic teaching methods.

Studies [6] indicated that the retention of knowledge over a long period was increased and the transfer of concepts into practice was enhanced for the PBL students. In addition self-directed study skills improved for the PBL students. However in the same study traditional methods of education produced higher scores on basic general knowledge than problem-based learning methods. So there are some things that PBL is more effective for and other things that traditional methods are more effective for.

The blended educational approach (PBL & Traditional Teaching) proved to be a very efficient method enabling students to achieve a sound Engineering base along with the benefits gained through independent studies.

5. References

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