

Adopting Problem-based Learning in the Teaching of Engineering Undergraduates: A Malaysian Experience

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Abstract - Teaching undergraduates at tertiary level is surely not an easy task what more when your students are engineering undergraduates who need to be competent not only in the content area but the generic skills as well. Surveys suggest that the generic aspect demand equal if not greater emphasis in order to produce competent marketable graduates. However, in Malaysia many undergraduates come from an exam-oriented schooling system that lacks the ingredient to develop both the content and generic skills. To “add salt to injury” Universiti Tun Hussein Onn Malaysia (UTHM), is a new university and half of the academic staff members are young and new to the teaching profession whose teaching approach have been greatly influenced and dependent upon the conventional way they had been taught themselves while studying at school and university – lacking in varieties and mainly lectures! Realizing this alarming situation, in 2005, UTHM formally embarked on a bold yet challenging journey into the world of Problem-based Learning (PBL) involving 30 academic staff from the various faculties who were to become pioneers and form the PBL Task Force of the university. Despite the uncertainty of venturing into new territory these mixed of young and senior lecturers dedicate themselves into making mastering PBL by attending training sessions both locally and abroad, conducting talks with experts in the field, participating in module development workshops and finally putting into practice what they have learned in their own classes for a whole semester. Our findings reveal that not only did the students benefit in the content area but also greatly gain in the equally crucial aspect of human resource development that is the generic skills like leadership, analytical thinking, conflict management, decision making and many skills. They also said that despite the greater amount of work undertaken it was compensated by the huge volume of knowledge, skills and positive values they acquired without which they would have been deprived if learning was mainly using the conventional way that they were used to.

Index Terms – problem-based learning, engineering undergraduates, experience, generic skills

INTRODUCTION

The need for inclusion of Problem-based Learning (PBL) in engineering classes especially have been the result of the numerous feedback and complaints received from stakeholders of higher learning institutions especially the job industry (Ministry of Human Resource Malaysia, 2005). Unsatisfactory remarks and complaints of poor quality and performance of a significant number of Malaysian graduates are imminent and have raised concern among the government, industry and parents. In consequence, this has led to the gradual process of curriculum review not only at the primary but the tertiary level as well. It seems that many trained graduates despite the many years of studying still lack the necessary requirements needed by the industry in terms of knowledge, skills and attitude or value. An online survey involving 3300 human resource personnel and bosses conducted by a Malaysian employment agency from March 29-31 2005 found these worrying factors for unemployment among graduates in the country which are as follows:

TABLE I
FACTORS FOR GRADUATE UNEMPLOYMENT IN MALAYSIA

Num.	Factors	%
1	Weak in English	56
2	Bad Social etiquette	36
3	Demand too much pay	32
4	Degree not relevant	30
5	Fresh graduates too choosy	23
6	No vacancies	14

(Source: UNIMAS, 2005)

The main reasons for their unemployment are thus mainly due to poor communication skills especially in the English language, attitude and curriculum related factors. These unemployed graduates also lack of mastery in their core disciplines and especially the equally important generic skills (GS) required for the job market. The later includes effective

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communication skills, IT skills, inter-personal skills, analytical skills, adaptability and several other crucial skills needed of a competent “ready-to-work” graduate..

To overcome these problems, the Malaysian government have launched several post-graduation human resource and skills development program for unemployed graduates through the help of the various government agencies including institutions of higher learning as well as the industry (Economic Planning Unit Malaysia, 2006). Recently, the Ministry of Higher Education launched a national project named “*Penerapan Kemahiran Insaniah di Institusi Pengajian Tinggi Malaysia*” or “*Integration of Generic Skills at Institutions of Higher Learning Malaysia*” (Ministry of Higher Education, 2006). For this, a common module on GS was developed and being used by all public institutions of higher learning in Malaysia.

On another aspect, we are also aware that the lack or poor mastery of core and generic skills among the students could also be blamed to an extent on the part of the teachers or lecturers. Because the schooling system in Malaysia is rather exam-oriented aspects on mastery of deep understanding and generic skills were given less attention. It has been the trend among both parents and teachers in Malaysia that they panic for the “As” their children should get and in the mad scramble for this many “As” that crucial element of GS required by all disciplines in life tend to be neglected leaving the child helpless and struggling trying to survive the first semester at tertiary level where they get their first taste of highly independent learning experience of life. To make matters worse, many of the lecturers teaching them also went through the same learning setting of “spoon feeding for examinations” when they themselves were in school and university thus creating a “vicious” cycle that demands immediate corrective measures if the full philosophy of engineering education is to be attained.

It is on this basis that in January 2005 Universiti Tun Hussein Onn Malaysia decided to embark on the implementation of PBL (Reference). To ensure its success, this monumental project was entrusted to the Center for Teaching and Learning (CTL) whose main roles among others is to help the University upgrade its academic performance through teaching and learning activities. In line with the philosophy of education of this university that states that “The education and training in this university is a continuous effort to lead in market oriented academic programmes which are student-focused through experiential learning to produce well trained human resource and professionals who are catalysts for a sustainable development” (UTHM, 2005) this on-going project is aimed at improving the teaching standard of the university but most importantly produce graduates who are competent not only in the core discipline or subject matter of expertise but the GS that is greatly lacking among the students.

This paper shall present the outcome of our first attempt at adopting PBL in our classrooms. It shall narrate the

preparations made prior to the experiment including details of trainings and workshops on the part of the lecturers.

PROCEDURES

For any major project of great importance to be successful and what more at University level it is crucial that it gets the endorsement and support of the top management (Mosby). At UTHM, we are fortunate in the sense that this project is actually a priority of the University and all assistance both monetarily and in terms of human resource and infrastructure are being generously catered for.

The very first thing on the agenda was for us to get introduced to PBL and lots of it. Earlier in 2004, as head of project and CTL of the university I attended a PBL seminar organized by Universiti Malaya. The seminar was attended by several international experts in PBL among them Dr Lynda Wee from Republic Polytechnic Singapore and Egon Mosby from Aalborg University Denmark both of whom we were to be working together closely in the coming months to come.

In early January 2005, our then Deputy Rector for Academic Affairs, Profesor Ir Dr Zainai Mohamed* while on a trip in Europe, decided on a half-day visit to Aalborg University Denmark (AAU) to get a glimpse of PBL. It was then that we decided to invite Associate Professor Mona Dahms from AAU to help us with PBL via workshops and a seminar. Prior to inviting AAU, we actually started off with a 3-day Training-of-Trainers (TOT) workshop on “*Jump Start to PBL*” involving 30 selected academic staff members comprising of both the young and seniors. Dr Lynda Wee then from the Republic Polytechnic, Singapore (RP) conducted our very first formal introduction to PBL. The workshop was a success and despite the initial vagueness of the whole idea of PBL among half of us but by the end of the workshop we managed to come up with our first draft of related PBL modules for our respective disciplines.

A month later, CTL conducted another TOT workshop for the 30 PBL Task Force members. This time we received the assistance of Professor Dr. Edariah Mohamed from the Faculty of Medicine, Universiti Teknologi MARA Malaysia (UiTM) whom we had the opportunity to meet at a 3-day PBL Workshop in Medicine jointly organized by UiTM and University of Melbourne, Australia a month earlier. In the workshop, participants received useful inputs on PBL but this time from the perspective of the medical discipline which we feel is very rich, detailed and has proven successful. The only thing for us was to try understand and adapt wherever possible the underlying principles of PBL to our engineering needs.

As mentioned earlier, the PBL introduced by Dr Lynda Wee, PBL was from the perspective of Education Management. Despite the disparity between management and medicine we were actually looking for and trying to grasp the intrinsic principles and process of PBL itself rather than its end product. As mentioned by Dr Alwis, the Director for

Academic Affairs of Republic Polytechnic, Singapore PBL is an idea and not necessarily a technique (UTHM, 2005). Associate Professor Mona Dahms from AAU stressed that PBL at Aalborg University is a philosophy. She further said that it does not matter how and what technique one adopts in the teaching process but what is most important is that students are trained to master the crucial aspects of effective communication, deep understanding, analytical thinking and other necessary GS, knowledge and positive values required of them.

In May of 2005, CTL conducted a "Seminar and Workshop on Problem-based Learning in Engineering 2005". Associate Professor Mona Dahms (AAU), Dr Alwis (RP) and Associate Professor Dr Khairiyah (UTM) were the guest speakers and facilitators. This time around all the experts come from purely engineering discipline - Electrical, Mechanical and Chemical engineering respectively. Thus, for an engineering university like UTHM, the input gained was most relevant and very enriching. Note that AAU has a very unique curriculum which is totally Project-oriented Problem-based Learning (POPBL) and has been adopting the system for about 28 years (Aalborg University, 2004). Meanwhile, the curriculum at RP is totally PBL (Republic Polytechnic Singapore, 2007) and as for Universiti Teknologi Malaysia (UTM) PBL at this stage is still "a technique" just like the one being adopted by UTHM at this moment.

Finally, having gone through some intensive 6-month training and basic module development workshops from the various disciplines it was time for the task force to try out what they have learned. Despite the hours of training in the beginning there was still uncertainties among many of us who had vague knowledge about PBL and how our students and colleagues would respond to this new way of teaching and learning. Despite the fear of failure and not really knowing whether there is really "light at the end of the tunnel" it was a risk that we all had solemnly agreed to initiate and the followings are some of the outcomes of our pilot project in PBL.

FINDINGS

This section shall discuss the initial findings of our pioneer project. Due to limitation of space, this paper shall only focus on the performance of two of the faculties involved.

- **The Faculty of Civil and Environmental Engineering**

The Faculty of Civil and Environmental Engineering started off their PBL session with their undergraduate students from the 2005/2006 Semester 1 cohort. They chose the subject *Solid and Hazardous Waste Management* and identified two different topics for the purpose which are *Proper Management in Hazardous Waste Handling and Treatment* and *Clinical Waste Disposal: Comparing the Technology*. The class comprised of eighteen students and they were divided into three groups of six each. Other than the main

facilitator of the subject there were five other colleagues two whom out of wanting to learn the uniqueness of PBL voluntarily assisted in the implementation of the PBL sessions. The group conducted two different sessions covering each topic within a two-week period. Triggers like the ones below were used to initiate the lesson:

- **Trigger 1:**

The man who saw the incident then lodged a report to Department of Environment. A group of investigator from DOE was in order to investigate the incident at site location. A team member of DOE officers discovered that more than 250 containers were dumped in the river. After the containers were collected, it strongly believed that all the drums containing hazardous and toxic substances due to the strong chemical smell. The sample then was brought to the Chemistry Department to identify the type of waste. From laboratory results, the department confirmed that the substances found in the container are nitric and sulfuric acids, waste containing arsenic and chromium (VI). As an environmental engineer in DOE, you are requested by the head of department to write a report on illegal dumping of hazardous waste above including the suspected responsible party on doing that and suggest the treatment of those wastes because DOE will take the responsibility to absorb the cost of the wastes treatment.

At the end of the four-week period, the researchers (Haslina Hashim et al, 2005) found the "experiments" all successfully carried out. The findings of this study were encouraging considering that it was a pilot project both on the part of the facilitators and the students. Results show that the students really enjoyed the experience of working as a team member compared to learning conventionally using lectures. It is important to note that being a multiracial society Malaysians come from different backgrounds comprising of students from the various races (Malays, Chinese, Indians, Ibans, Kadazans and other ethnic groups. In spite of these differences the students proved that they could perform more effectively as a team which was very encouraging. In addition, the PBL sessions gave them the opportunity to better familiarize themselves with inquiry learning and search for materials via the Internet, books and journals within the limited time given. In most instances, it is common for lecturers to face the problem of getting students to conduct inquisitive or discovery learning who are dependent upon the lecturer for notes and other learning materials. As for assessment it was based on the merits they accomplished during the PBL sessions with regard to their workload, nature of problem solving project, individual and group participation as well as aspects of creativity in their presentation. In conclusion and most encouragingly, at the end of the semester the students achieved better grades in the related subject whereby they showed improvements in both

tests and the final examination as compared to the previous semester when PBL was not around yet.

- **The Faculty of Electronics and Electrical Engineering**

As a first attempt in Problem-Based Learning (PBL) at the Faculty of Electronics and Electrical Engineering the lecturer Afandi Ahmad chose a subject on microelectronic for the purpose (Afandi Ahmad, 2005). The objective of the PBL lesson was to enable students design a 4-bit Carry Lookahead Adder (CLA) using both top-down and bottom-up approaches. Ten undergraduates were involved working as a team to accomplish the task. Each of the team members were given specific tasks towards achieving a common goal of coming up with the required CLA design. Throughout the two-month duration, undergraduates were expected to, learn new Computer-Aided Design (CAD) and Electronic Design Automation (EDA) tools, determine the most suitable methodology flow and prepare the presentation and the documentation of the project. To begin with, the following trigger was used to initiate the lesson:

“You are required to design, simulate, and verify a design of 4-bit carry lookahead adder. All the design should be implemented via bottom-up design (using L-Edit by Tanner) and top-down design (using either VHDL or Verilog with Altera platform). For bottom-up design, choose the nMOSFET's to have aspect ratios of $(W/L)_n = 8$ and the pMOSFET's with aspect ratio of $(W/L)_p = 12$ ”

Upon completion, a 4-bit CLA codes and a 4-bit CLA layout are made available. Simulations on both end products were shown. Both simulations were then validated against initial specifications and verified among themselves. Besides, the designs comparisons were also made on aspects of minimum area used, fastest speed and least amount of transistors.

According to Afandi Ahmad (2006), throughout the project, a majority of the students confessed that they gained a lot both in terms of theory and the practical aspects. Obviously, this is so much in tandem with the PBL philosophy of training students to ‘learn to learn’. Being able to immediately and directly apply the learnt subject is one of the critical aspects of applied learning technique and the students have just done that with success. Besides, it has also better enhanced the students’ problem solving skills, management and communication skills, leadership skills, effective teamwork and various other generic skills required of competent engineers.

The given problem excites the students’ curiosity to know more and this resulted in the exploration for new ideas and finding solutions to the given problem with the help of newly introduced software and techniques that they have just learned. There were lots of brainstorming and discussion sessions whereby students within and among the groups were able to exchange useful information and ideas which were

helpful for the completion of the project. The students also improved on their study skills like conducting library research, making references, extracting of information and they through simulations they were also exposed to the future and real life job market.

The followings are some of the many feedbacks received from the students as regards Afandi’s PBL pilot project (Afandi Ahmad, 2006):

- **Students’ Feedback 1**

To me, the initiated Problem Based Learning or PBL is one good learning method since it encourages the students to think and 'learn to learn'. Besides, the PBL had actually gives the students a little bit of something on the real world (industry) problems. The given problem excites the students' curiosity to know more. However, i have to agree with my friends about the limited and packed time frame for us to actually go through everything. About the passenger or 'hantu' thing, it is avoidable but it's hard to do so. Like I said before, the PBL let the students to experience the real thing... and in this case, the 'hantu' is real. You will keep on finding this sort of people in the future too. After all, this is how it looks like in the real world. But what the hell, the learning process sure is a success and a nice experience to remember. Thanks Mr. Afandi

- **Students’ Feedback 2**

The implementation of the PBL leaves huge implications in education and teaching technique. It can be described as a double edged sword which presses more on indirect learning methods and informal education. In my opinion, PBL should be implemented on the 1st, 2nd or in 3rd year students so that it will gives them a direct exposure of what to expect during the final year project or PSM. PBL can be made more interesting by keeping abreast with the latest development and technology used in industrial sector today. Members of the group should consist of students with different academic background (weak, average and good) so that nobody felt to be left behind and resulting in greater outcomes.

In general, the PBL project has resulted in the students becoming more proactive, creative, innovative and more responsible towards their academic development. To conclude, one can say that the method really brings out the talents in them.

DISCUSSIONS AND CONCLUSIONS

The findings of these studies as well as that of the others at UTHM (UTHM, 2006; Ahmad Esa, 2007) and other

universities (Republic Polytechnic, 2007; Aalborg University, 2004) clearly indicate the effectiveness of PBL in educating engineering students to become more competent not just in the content area but the generic skills too. Using PBL students get the opportunity to work on real life or simulated real life problems making the learning experience much more meaningful. Not only can the students comprehend what they learn but PBL has given them the opportunity to understand deeper and put into practice what they have acquired more effectively which they would have been denied if using conventional means. In addition, the joy of discovery learning is brought back to life which is the very basic of what and how learning should be just as how Mark Twain had enjoyed his “learning experience” by the Mississippi when he said “I never let schooling interfere with my education”

On the part of the lecturers facilitating the PBL classes, they discovered that their teachings have been made fun and challenging. It has definitely made their jobs more rewarding seeing the students play a more active role in their learning process only to discover that they have improved in their mastery of the content area and generic skills.

This study is not without its weaknesses. In spite of the encouraging results as regards learning and teaching it has however highlighted several aspects that needed adjustments for PBL to become more effective. For instance, several students complained of heavier workloads when they first learned the PBL way. Despite realizing that it is only normal for them to feel the “weight” of learning since the conventional way of learning using merely lectures that does not require them to bear the burden of garnering input on their own, and if ever, minimally, we acknowledge the importance of introducing PBL gradually and that it should be done right from their very first semester of study.

Throughout the two-year period of experimenting with PBL we have also discovered that prior to introducing PBL at tertiary level, it is advisable that cooperative or collaborative learning be introduced first to get the students acclimatized to effective group learning considering that they have been so used to the exam-oriented and conventional ways of learning at school level.

While this study does not claim generalisation across subjects, it undoubtedly support the thesis that PBL greatly enhances the learning experience. In the words of Nor Haslina Hashim et al, (2006), “If students have the privilege to choose their method of learning, this research suggests that they are more ‘agreeable’ to PBL instead of the Conventional Method.”

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