Promoting Engineering and Science via Community Based PBL Projects

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***Abstract**: An ongoing, long-term public awareness campaign is needed to raise the profile of engineers and scientists in the eyes of the general public to address the issue of declining enrolment in engineering and science in Universities in most industrialised countries. One way of promoting engineering and science to the general public is to exhibit the accomplishments of engineering and science students' projects in public institutions.*

In Semester 2, 2009, 2nd year EEE students at Victoria University (VU) worked with staff (client) at Scienceworks museum in Victoria to design, develop and deliver products for exhibition to promote Engineering and Science to the general public via their Learning in the Workplace and Community (LiWC) Problem Based Learning (PBL) projects. This paper describes the PBL projects and gives a summary of the interactions between the students and their client. The whole exercise has been well received by the students and the client. VU and Sciencworks Museum will work together again in 2010 and beyond to develop more projects to promote engineering and science.

Introduction

An ongoing, long-term public awareness campaign is needed to raise the profile of engineers and scientists in the eyes of the general public to address the issue of declining enrolment in engineering and science in Universities. Promotions and campaigns at VU in Australia include sponsoring and participating in the annual Engineer Australia's engineering week activities, media promotions, special events such as science and engineering challenge for secondary school students and award presentations at secondary schools in Victoria. Another way of promoting engineering and science to the general public is to exhibit the accomplishments of engineering and science students to the public.

In mid-2005, VU committed itself to convert all of its undergraduate engineering programs to PBL. This conversion to PBL was part of a strategy by the University to address declining enrolment numbers in engineering programs, and to meet requests from industry that universities should improve the personal and professional skills of their graduates. An analysis of the *Changing Paradigms* report (Business Council of Australia, 2006) "*shows the importance of not only the development of strong technical skills in the workforce but also those associated with communication, teamwork, problem solving, ongoing learning, creativity, cultural understanding, entrepreneurship and leadership. Furthermore, it raises concerns by businesses about the extent to which education and training systems are currently providing people with these capabilities*". One of the conclusions from a recent report on the views of final year engineering students highlighted "the mismatch between what they learn in university and what happens in the workplace" (Department of Education, Employment and Workplace Relations, Australia, 2008). The conversion to PBL pedagogy at VU has enabled the programs to simultaneously address the demands of external stakeholders and to compensate for the problems encountered by the traditional programs ensuing from the standards of prior education of students entering these programs. As part of this initiative the undergraduate engineering programs at VU adopted PBL for first year students in 2006, with an annual phased roll out of (Simcock et al, 2007) PBL into the later years of each program. The first co-hort of students educated using the PBL pedagogy graduated in May in 2010.

In 2007 VU made 5 commitments to guide the overall planning and implementation for achieving a distinctive and sustainable future for VU. Whilst they are all relevant, the most significant as far as

this paper is concerned is the second commitment which is that VU will make at least "*25% Learning in the Workplace and Community (LiWC) a universal feature of VU courses*". This is a landmark initiative which aims to provide "*a context for student learning which enhances the learning experience, improves employment and career outcomes, provides students with opportunities to contribute to their communities and prepares students to be future ready*" (Making VU, 2007), (Harman, 2010).

Problems are the very heart of the PBL paradigm. In the second year Electrical and Electronic Engineering (EEE) course the Problem Based Learning (PBL) problems are sourced from local industry and community organisations to introduce the students to fundamental project management, client negotiation, specification writing and also to produce a product in the form of a deliverable to the client. The client worked with the students and staff to ensure that the primary goal of achieving the various learning outcomes for the students is satisfied, as is the secondary goal of creating a product. Through this process the students satisfy Engineers Australia (EA) Stage 1 Competency Standards and fulfil the LiWC of VU (Engineers Australia PO5, 2006).

In semester 2, 2009, second year EEE students at VU were presented with a new challenge. Students were to work on community based projects and design, develop and deliver products for Scienceworks Museum under the guidance of their staff to promote Engineering and Science to the general public.

This paper describes the PBL projects and gives a summary of the interactions between the students and their client. The whole exercise has been well received by the students and the client. VU and Sciencworks Museum will work together again in 2010 and beyond to develop more projects to promote science and engineering to potential students in order to address the skill shortage in Australia.

Second Year Second Semester Problems – "Industry/Community Based"

2nd year EEE students have been involved with "industry and/or community" based projects in semester 2 since 2007 (Simcock et al 2009). The primary learning objectives are to develop the students' inter-personal, project management, fundamental business, negotiation and specification writing skills and to develop a finished product for the client. As part of the problem, both the students and the client have to sign a "Learning in the Workplace (LiW) Agreement" which set out the terms and conditions of the interactions between the students and the host organisation. The students and the client also need to negotiate Intellectual Property agreements for the projects.

The Description of the Three Actual Problems for 2nd Year EEE Students in 2009

A brief description of the projects proposed by Mr Andrew Lewis from Scienceworks Museum is as follows:

Project 1: Robotic Rubbish Bin

This project involves the design and development of operating systems for a robotic miniature wheelie bin. The robotic wheelie bin will be introduced into public accessible spaces within the building during quiet times at Scienceworks Museum. It will roam throughout the foyer and galleries, asking for rubbish etc and muttering 'ouch' or 'whoops' each time an obstruction is encountered. When the lid is lifted, the machine will stop to enable the rubbish to be deposited and not restart until the lid is closed.

During the semester, a team of students have been researching on ultrasonic sensors, motor drives, microcontrollers, and voice recorder; developing a sensor system capable of detecting obstructions of varying height and boundary areas; designing an automatic steering system capable of redirecting the machine once an obstruction is encountered; designing motor drive circuits incorporating a clutch capable of providing positive drive over a variety of floor surfaces; selecting sound recorder and player in response to different scenarios; designing an integral rechargeable power supply; allocating all pins and program the PIC microcontroller for the automatic operation of the robotic rubbish bin;

and defining mechanical configuration of the whole system. The team of students also need to incorporate all circuitry into the miniature wheelie bin provided by Scienceworks Musuem.

Project 2: Watch Dog

This device serves as a proximity alarm to alert staff and discourage visitor access behind display barriers and restricted areas. It consists of a life size model of a watch-dog, stationed in the corner of the display at Scienceworks Museum. An attempt to enter the space will initially prompt a low growl, rising in ferocity if the person persisted. Complete entry to the space will set the dog frantically yapping.

During the semester, one team of students has been working on the aspects of the project including researching different types proximity sensors, voice recorders, amplifiers, and PIC microcontrollers; designing and building a sensor circuit using ultrasonic sensors to detect proximity, developing sound effects and install an audio unit including an amplifier and a speaker; allocating all pins and programming the PIC microcontroller for the automatic operation of the watch dog and designing and configuring the whole system so that it can be inconspicuously housed within the body of the watch dog casing.

Project 3: Donation Machine

Specification for this device is very broad and is heavily reliant on the creativity and ingenuity of the designer. The machine would be located within a high volume visitor circulation space. The enclosure and visible elements should have sufficient attraction and appeal as to prompt the visitor to put something in to make it work, with the outcome being both humorous and engaging. The options might include providing a convoluted pathway for the coin to follow involving ramps, see-saws, spirals, counter-balances, conveyors etc. The inclusion of electronic and electro mechanical elements should increase the complexity and unpredictability of the pathway. A ventriloquist doll may be used to provide audible and visible feedback in response to a coin being deposited. A dummy hand may be included that takes the coin and deposits it in a concealed receptacle, accompanied by the sound of much jingling and jangling. A 'peppers ghost' type illusion where the coin, once inserted into the enclosure, suddenly vanishes before the person's eyes might also be included.

Assessment

The assessment in the subject was tailored to meet Engineers Australia Stage 1 Competency Standard for Professional Engineers (Engineers Australia PO5, 2006). There are three units in Engineer Australia professional engineer stage 1 competency. These units are: PE1 Knowledge Base, PE2 Engineering Ability, and PE3 Professional Attributes.

The students formed their own teams of 5 or 6 members. They also determined the role of each member within the team. The students negotiated all the project milestones with the client (staff at the Scienceworks Museum). In addition to their client, each team has two academic supervisors to cover both engineering and language and communication (L&C) aspects. Across the whole subject, the teaching team included three engineers and one L&C staff member. The teaching team determined the "learning milestones" for all teams involved. These were in the form of team and/or individual oral presentations, reflective articles, technical reports, project documentation and project demonstrations. The students also had an individual portfolio documenting how they had met the learning outcomes identified above and how the problem had allowed them to consolidate their construction of knowledge and develop/enhance their skills for lifelong learning. To facilitate this, rubrics were designed to provide more direction for students and better alignment between the learning outcomes and the assessment. The rubrics described what would be required to demonstrate competency at the various grades for each learning outcome. The rubrics could then be used as a tool to guide students to ensure their portfolio justified their claims to Stage 1 competency. This process and the detail contained in the rubrics are described in (Shi, et al., 2007). The breakdown of each component of the unit is as follows:

1. Feasibility report – **10%**
2. Progress Team Presentation **-5%**

3. Final Technical Report -**10%**
4. Final Team Presentation/Demonstration of completed product -**10%**
5. Reflective Essay and Log Book documenting semester activities -**5%**
6. Participation in Team Meetings / Workshops – **10%**
7. Portfolio & Defence Exam – **50%**

Evaluation and Student Feedback

Quantitative Feedback

Student Evaluation of Teaching (SET) and Students Evaluation of Unit (SEU) were conducted to obtain quantitative feedback of the LiWC PBL projects. The survey was conducted after the students had submitted their final reports. There were 22 students enrolled in the subject and 20 students participated in the survey. The results are shown in Table 1 and Table 2 below with 5 as the highest mark. The SET result shown in Table 1 was obtained from those students who did project 2. The result demonstrates that the students are relatively satisfied with the project and their supervisor. The SEU feedback on how the learning activities were planned and managed received a grade of 3.8 and 3.6 out of 5, respectively. The result is not surprising as there was not enough time for the staff members at VU to plan the projects in advance during the non teaching period between the two semesters due to changes in the unit coordinator and administrative structure in the School. Some students doing the robotic rubbish bin project believed that they had committed too much time to this subject due to the complexity of the project and this is reflected in the response to question 11 which has a grade of 3.6 out of 5. The robotic rubbish bin project is more technically challenging for 2nd year students due to the mechanical construction involved.

Table 1: Student Evaluation of Teaching (SET) – Semester 2, 2009

Question	
Q1: The teacher was effective in communicating with the class.	4.8
Q2: This teacher knew the subject matter.	4.6
Q3: This teacher responded well to my needs and questions.	4.8
Q4: This teacher's class was well organised.	4.6
Q5: This teacher provided useful feedback on my work.	4.8
Q6: This teacher created a learning environment that I learned easily from.	4.4
Q7: This teacher knew about services at VU.	4.4
Q8: This teacher sought feedback.	4.4
Q9: I am satisfied with this teacher.	4.8

Table 2: Student Evaluation of Unit (SEU) – VEB2200 Semesters 2, 2009

Question	**SEU/5**
Q1: It was clear what this unit was about.	4
Q2: I had a clear idea of what was to be completed in this unit.	4.1
Q3: I understood what was expected of me.	4.3
Q4: The learning activities were useful in this unit.	4
Q5: The learning activities were well planned in this unit.	3.8
Q6: The learning activities were well managed in this unit.	3.6

Q7: The content in this unit was up to date.	4
Q8: The assessment tasks were well planned in this unit.	4.1
Q9: The assessment tasks were strongly linked to the unit outcomes.	4.1
Q10: The assessment assisted my learning in this unit.	4.2
Q11: I am satisfied with the teaching in this unit.	3.6

Qualitative Feedback from Both Students and the Client

In addition to obtaining quantitative feedback on the community based PBL projects, qualitative feedback was also obtained from both students at VU and staff member at Scienceworks museum.

The following quote from students' reflective journal and portfolios are unsolicited testimonials to the value of community based projects:

"Unlike the other PBL projects we have done so far in this project we had to deal with a client and we had to negotiate with him regarding some practical issues of the project. The students who are doing the Scienceworks projects were invited to Scienceworks to explore around it and to get on basic picture of the place where we are supposed to put our designs."

"To succeed in an engineering industry it is very important to keep developing skills and techniques. It is even more important to develop techniques and be able to apply them in real life situation. What separates great engineers from the rest is the ability to undertake and learn new techniques and be able to apply them. …Our project for this semester was a community based project in which we were given 3 options to choose from as offered by Scienceworks museum. A successful completion of this project required us to further develop the skills already gained through earlier PBL projects as well as learning new information and being able to apply it".

"I have learnt valuable skills from doing the watch dog project which will be useful for me in the future as I develop myself as an engineer."

"Thanks to the Watchdog project I was successful in gaining a lot of new skills and techniques as well as improving old ones."

The following email feedback is from Mr Andrew Lewis from Sciecnworks Museum:

"Hello Juan,

Thank you for your email and the opportunity to hear the students' presentations last week. It was terrific to see how enthusiastically they had embraced the projects and the amount of work they had put in to them."

"We look forward to providing you with more projects next year and we'll start thinking of possibilities. As far as your management of the projects and the student's professionalism was concerned, I have been more than satisfied. Communication channels remained open at all times, information and updates were provided in a timely manner and the quality and thoroughness of their technical presentation and reports has been excellent. I wish that a lot of my suppliers were as comprehensive when supplying information relating to their installations."

Conclusions

Three PBL student projects undertook in Semester 2 of 2009 with local community Scienceworks Museum as the client were described in this paper. All of these projects provided students with the opportunity to apply theory to real world practice and to promote Engineering and Science to the general public. Despite the fact that the majority of the work was conducted at VU, the projects were nonetheless real world, and fully deserving of their place in the VU "Learning in the Workplace and Community" initiative. It can be seen from the quotes from student documents that this type of problem has significantly increased student engagement in the process and it has enhanced their learning experiences. Not only were the projects provided students with great learning experiences, the client fully appreciated the benefits that the products will be displayed in the Scienceworks museum to

inspire the next generation to become engineers and scientists.

Problems were also identified regarding the complexity of the projects. The practical and theoretical knowledge required for 2nd year EEE students for the robotic rubbish bin project appear to be too challenging. The students were allowed extra time and the project has been extended to their 3rd year PBL unit.

Due to the initial positive responses from both students and the staff from Scienceworks Museum, VU and Sciencworks Museum are working together on more projects in semester 2 of 2010. It is envisaged that VU and Scienceworks Museum will develop more projects to keep the program sustainable beyond 2010 as the teaching team has successfully obtained the Learning and Teaching Performance grant from the Faculty of Health, Engineering and Science at VU for developing the projects for 2011.

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