Multidisciplinary Projects for Second Year Chemical and Mechanical Engineering Students

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***Abstract**: In the second semester of the second year of a Mechanical Engineering course, students are supposed to take a Module Outside the Main Discipline (MOMD). This module is chosen to be "Product Design Exercise" a module that is offered to Chemical Engineering students at the same stage. The aim was to expose students from both disciplines to an environment in which they are encouraged to interact with and engage team members with a relatively different background. The students were divided into eight groups all comprised of Chemical and Mechanical Engineering students, and they were offered different open-ended projects that were selected to exploit the knowledge developed by the students thus far and they were slightly skewed towards Chemical Engineering. The students demonstrated a high level of cooperation and motivation throughout the period of the project. Effective communication and closing of knowledge gaps were prevalent. At the end of the project period, students produced a journal paper in lieu of the project report.*

Introduction

The engineering accreditation criteria that advocate Outcome Based Education (OBE) and the calls from industry (Lang et al, 1999) that requires employment-ready graduates are driving the engineering curriculum to adopt more non traditional approaches. The core paradigm shift required is the move from the lecturer-centered learning environment to a student-centered one. A number of these non-traditional approaches are adopted by different institutions, including Problem Based Learning, Project Based Learning (Mills et al, 2003) and CDIO (Conceive-Design-Implement-Operate) (Crawley, 2002)

The School of Engineering of Taylor's University College adopted the project based learning approach as a long term strategy to educate its students. The results of this were not only achieving the requirements of the accreditation bodies and the industry and help produce cost-effective laboratory experiments (Shamel, 2008), but also sustaining the students' motivation and engagement in the course (Al-Atabi, 2009).

Although project-based learning normally takes place in groups comprising of students of similar disciplines and backgrounds, there has been attempts to deliver project-based content to multidisciplinary groups. Herzberg and Sweetman (2005, 2006) reported a new experimental course on flow visualisation that was offered to a mixed class of fine arts photography and engineering postgraduate students. The results from their experimental course illustrated that flow visualisation can be performed successfully by a wide range of people.

This paper describes the use of project-based learning (PBL) approach to educate multidisciplinary teams of engineering students. Where, in the second semester of the second year of a four-year undergraduate mechanical engineering course, students are supposed to take a Module Outside the Main Discipline (MOMD). This module is chosen to be "Product Design Exercise" a module that is offered to Chemical Engineering students at the same stage. The aim was to expose students from both disciplines to an environment in which they are encouraged to interact with and engage team members with a relatively different background. Two projects, namely; Develop biodegradable composite materials and Design and build solar water purifier have been selected in this study as a focus for the achieved learning outcomes.

Module Description and Operation

The objectives of the 11 week module were to emphasise the creative aspects of process engineering and to provide students with an understanding and exercise of product design in an engineering context. It also delivers the message that flair and imagination are essential attributes for a successful professional engineer. Students were required to work in teams to develop some products and they needed to plan and document the development progress including business plans.

The learning outcomes of this module are given below

1. Understand how teams can operate effectively when addressing open-ended tasks requiring creative and imaginative input.
2. Use brainstorming techniques, and refine the output to produce practical ways of developing the ideas.
3. Understand the importance of having a customer and markets for engineering ventures.
4. Write a business plan, including marketing strategy
5. Design a process and use engineering skills to make products with specific attributes and effects.
6. Present ideas convincingly by both written and oral means.

The students were divided into eight groups all comprising of Chemical and Mechanical Engineering students, and they were offered different open-ended projects that were selected to exploit the knowledge developed by the students thus far and they were slightly skewed towards Chemical Engineering. Forty-eight second semester second year chemical and mechanical students were guided into working groups of 5-7 students each group. Students use brainstorming techniques to generate ideas for new products and processes, which might be commercially or socially attractive. Each group then filters these ideas and develops one or more to the point of producing a business/development plan for its realisation. They are required to give attention to both commercial aspects of the project, and the engineering and processes technology involved. Quantification of these considerations is important and students will be encouraged to use appropriate equipment and protocols for the determination of those properties affecting product functionality. As well as experiencing the operation of groups in a broad, open-ended "ideas generating" environment, the students' written and oral presentational skills are enhanced and tested.

The students sitting for this module had prior experience with PBL during first year in engineering design subjects and second year first semester through other subjects. The school of engineering at Taylor's University College operations the PBL the technique in which a student will be involved in one project per semester to avoid overloading the students with many projects and create some frustration due to the students time management.
During the student-lecturers contact hours, the lecturers met with the students to answer any questions the students might have. In addition, the class encouraged to get group interaction, such as sharing materials and ideas in a creative manner, maximising student input and interaction.
The first two classes were focused on introducing the projects discuss the concepts and assist in projects planning. In addition, the lecturers mad it essential to the students to get signed approval for their budget and planning. Continuous assessment to the groups was done during the student-lecturers interaction to evaluate the students and to fine out their level of progress. Small groups were asked to develop group guidelines to assist them with the small group process during the course.

Brainstorming

In the brainstorming phase, the lecturers moved around the groups of students to observe group performance and ask questions to stimulate thinking. The lecturers also assisted the students to focus their discussion on the assigned project to keep within the allowed timeframe and available resources. Because the supervising lecturer was able to allocate only a limited period of time to spend with each group, the groups were asked to come to meetings prepared with the questions. The groups were asked to record their discussions in a logbook and present them to the corresponding lecturer (project supervisor) end of the course.

Projects Offered

The following projects were offered, and the students were allowed to choose on a first-come-first-served basis:

1. Design and build low cost steel bioreactor.
2. Design and build glass bioreactor.
3. Develop nano-particles based method to enhance enzyme reactions.
4. Develop biodegradable composite materials.
5. Design and build solar water purifier.
6. Design and build solar milk Pasteuriser.
7. Design and build synthetic jet mixer.
8. Develop a method to model the drug delivery to a tumor.

Educational Outcomes

The running of this module was a big success. All the group members managed exhibit effective communication skills both when communicating with each other and with external parties such as suppliers, lab technicians and lecturers. They went through the different team stages (forming, storming, forming and performing) to complete their respective projects and presented them in the Engineering Fair organised at the end of the semester. Figure 1 shows snapshots of some of the projects presented in April 2009 engineering fair.

The groups were instructed to develop marketing collaterals and plans in order to market the outcomes of their projects to prospective "clients". The definition of the client in student perspective is the visitors to their booth and/or supplier (potential sponsor) to their project. Hence, a total project cost was one of the key parameters the students focused during the course. Engineering design method approach was followed in this course and the students were implementing the method steps in a creative manner. The later steps include: Define Problem, Problem Statement, Gather Information, Concept Generation, Concepts Evaluation, Product Architecture, Configuration Design, Parametric Design, and Detailed Design

In order to emphasise the importance of technical writing skills, each group produced a written article following the "Instructions to Authors" of the periodic journal published by the School of Engineering at Taylor's University College, namely, Journal of Engineering Science and Technology, a poster and a logbook.

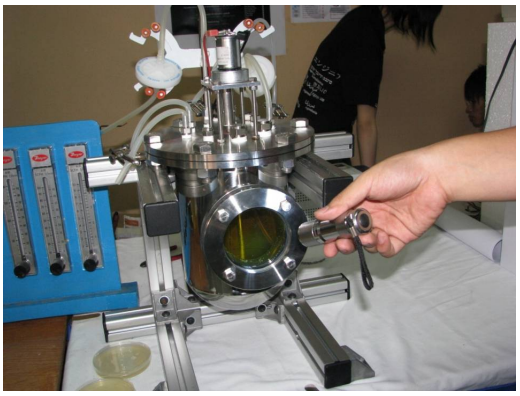
In this paper, two groups namely; group four and five are discussed. Group number four linked the school of engineering with a medium industry interested to bring the project one step forward by establishing research collaboration. The company offered to provide, for free, the necessary raw materials to the school to conduct further testing. In addition, they were interested in employing one of engineering graduate to work as research and development officer in their company. A student survey was conducted to evaluate the industrial communication skills shows 54% of them had high level. In return, when the survey was given to the industry, the later one confirmed about same percentage of student communication level. This indicates student communication skills achieved a satisfactory stage that the students can achieve at second year.

Group number five won two prizes as the best product design exercise and best engineering design. These prizes were sponsored by the partners of the School of Engineering.

The students learnt and enhanced their fabrication skills, research methodology approach, and the presentation skills. They are also presented their work in National Chemical Engineering Symposium 2009 (NACES'09), Malaysia in a technical presentation session. Figure 2 shows a snapshot for group representatives (two students) presenting the work.

a. Tumour model

b. Synthetic jet mixer



c. Steel bioreactor

d. Water solar purifier

Figure 1: Snapshots of some of the student's projects

Figure 2: Student Presenting their Work at the National Chemical Engineering Symposium 2009 (NACES'09)

Conclusions

A project-based module, i.e. "Product Design Exercise", was offered to a class comprised of both chemical and mechanical second year engineering undergraduate students. Besides the development of the module's learning outcomes, working with students from different background encouraged the students to communicate effectively, especially when it comes to technical jargon. It is believed that running multidisciplinary classes is a very useful technique to prepare the students for the working life where they need to work and interact with people from various technical backgrounds.

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