# THE USE OF PROJECT BASED LEARNING AS A FIRST YEAR INTEGRATED TEACHING AND LEARNING MEDIUM

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## ABSTRACT

This paper describes how the "Mechanical Engineering Design & Professional Skills" module, offered at the First Year of Mechanical Engineering course at Taylor's University College, was used as a centrepiece to integrate the entire curricula. This is achieved through the introduction of a carefully selected design project that ensured students use the knowledge developed in other modules to complete. The design project described herewith is the design, construction and testing of a circulating water channel similar to that's used by Prandtl. The "Mechanical Engineering Design & Professional Skills" proved a very useful platform to integrate the curricula. Students' involvement and enthusiasm was obvious throughout the semester.

## KEYWORDS

Project Based Learning, Integrated Curriculum, Design Project.

## INTRODUCTION

Engineering is a profession that has continuously re-invented itself to respond to the ever changing economical and social needs. This dynamic nature is mirrored in engineering education as well where the latest learning and teaching theories are practiced. One of the most successful approaches to learn engineering is the problem-based-learning (PBL) whereby the problem is the starting point of the learning process. Project based learning was introduced almost twenty years ago in health sciences as a way to prepare students to handle ill defined, multi-disciplinary problems such as medical diagnosis [1]. Soon, mainly due to students' enthusiasm for this new approach it was introduced in other disciplines and, among others, in graduate design courses in engineering [2, 3]. This often resulted in deeper understanding of the explored topics [4]. As during the nineties emphasis shifted from taught to learned in the accreditation criteria, more and more design projects where included in engineering curricula, even in the first year of study [5, 6].

Although adopting the PBL approach across the curricula would be a desirable thing, often the lack of time and resources make this task unrealistic especially in the subjects that are traditionally taught and/or are exam based. This paper proposes the use of the design subject as a central platform to enhance the achievement of the learning outcomes of other modules. This is achieved without alterations to the modules at hand and is done with careful choice of a design project. The work is based on the syllabus of the first year mechanical engineering course offered at Taylor's University College- Malaysia.

## THE APPROACH

The School of Engineering at Taylor's University College offers a mechanical engineering course in collaboration with the University of Birmingham. In order for a student to advance from year 1 to year 2, a student needs to complete a minimum of 100 credit hours of the modules outlined in Table 1.

Table 1
Year 1 Mechanical Engineering Degree Courses

| Module Title | Code | Credits | Semester |
|---|---|---|---|
| Properties and Applications of Materials | PAM | 10 | 1 |
| Electrical, Electronic and Computer Systems | EECS | 10 | 2 |
| Modelling Concepts and Tools | MCT | 20 | 1 & 2 |
| Engineering Statics | ES | 10 | 1 |
| Engineering Dynamics | ED | 10 | 2 |
| Fluid Flow | FF | 10 | 1 |
| Thermodynamics and Heat Transfer | THT | 10 | 2 |
| Mechanical Engineering Design and Professional Skills | MEDPS | 20 | 1 & 2 |
| Computing for Engineers | CFE | 20 | 1 & 2 |

Apart from the "Mechanical Engineering Design and Professional Skills", the overall course was not designed to be delivered as project based curricula but rather it is mainly an exam based one.

The challenge was to introduce the project-based-learning approach with minimum changes to the curricula content or assessment style. This paper reports on how the "Mechanical Engineering Design and Professional Skills" module was modified to incorporate projects that involve the design, fabrication and testing of artefacts that requires the knowledge from other modules as well. This is shown schematically in Fig.1.

## THE PROJECT

The cohort was of 25 students and it was divided into 5 groups of 5 students each. Each group was given the task of building a re-circulating water channel that is similar to that used by Prandtl as shown in Fig. 2 and then using the channel to demonstrate basic concepts in fluid mechanics such as drag, lift, wake and turbulent flow. The project is to be carried out throughout the two semesters of year 1 and it was chosen because it can be used to enhance the learning outcomes of almost all the other modules.

The handout of the project is shown in Fig. 3 and a schematic of the original Prandtl's channel is shown in Fig. 4. The channel uses a manually operated wheel to circulate the water and force it across a fixed model. Seeding the flow with a suitable tracer allows for the visualisation of the flow structures.

Typically the design process of this project would comprise the following steps

1. Understanding the concept of the original tunnel and gathering information that pertains to its materials and dimensions.
2. Identify areas of possible improvement to the original tunnel.
3. Selection of materials and methods of operation and preparing working drawings.
4. Constructing and commissioning the circulating channel.
5. Building the models to be tested in the channel
6. Selecting a suitable flow visualising technique.
7. Perform the tests

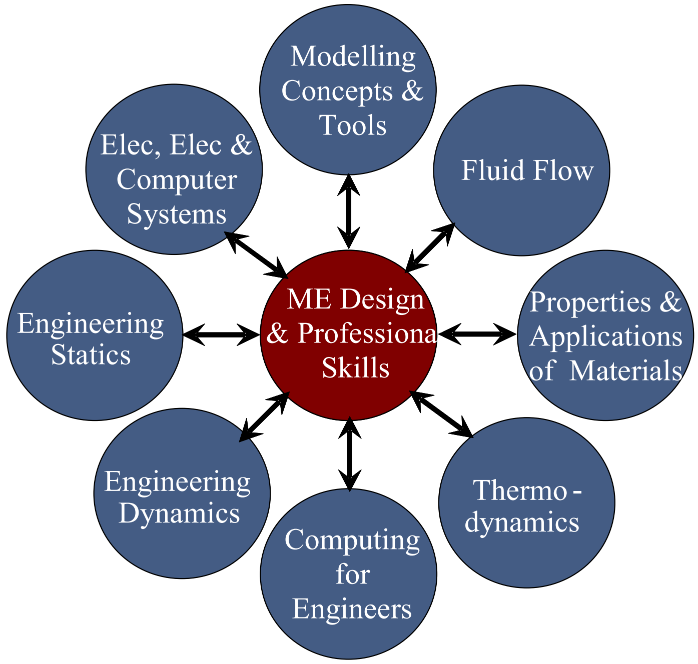


Figure 1. The use of “Design Module” as a centrepiece of a Project-Based-Learning approach.

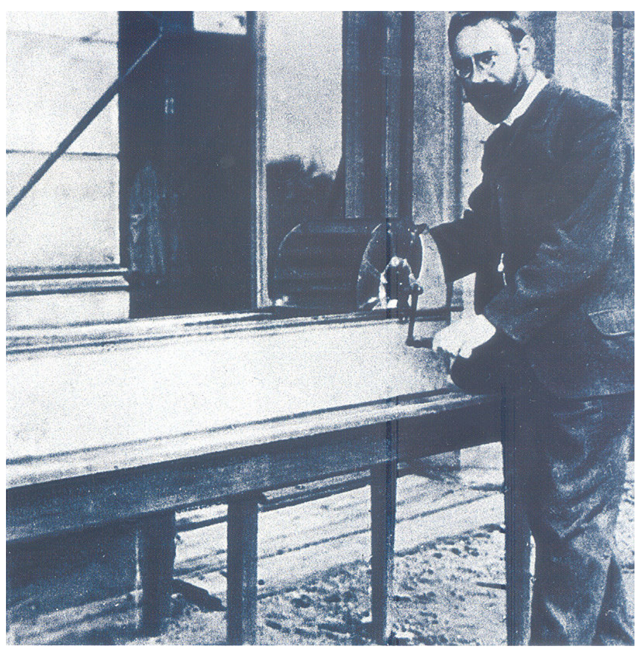

Figure 2. Prandtl and his water channel

**Mechanical Engineering Design & Professional Skills**

**Prandtl Channel Project**

Prandtl is considered one of the forefathers of modern fluid mechanics. He achieved a number of his discoveries using flow visualisation in a simple water channel. Your task would be to build a replica of that channel and use it to visualise the flow in the wake of square cylinders.

**Objectives**

1. Assess the design of the original Prandtl channel.
2. Suggest improvement to the design.
3. Construct the (improved) channel.
4. Test and calibrate the channel
5. Build different models to be tested in the channel.
6. Use flow visualisation technique(s) to assess the flow structures in the wake of these models.

**Time Allocated**

Tunnel design, construction and calibration: Semester 1
Flow Visualisation: Semester 2

**Assessment**

| | |
|---|---|
| Operational Model: | 50% (Group Effort) |
| Report: | 30% (Individual Effort) |
| Presentation: | 10% (Individual Effort) |
| Logbook: | 10% (Individual Effort) |

Figure 3. Handout of the Prandtl water channel project

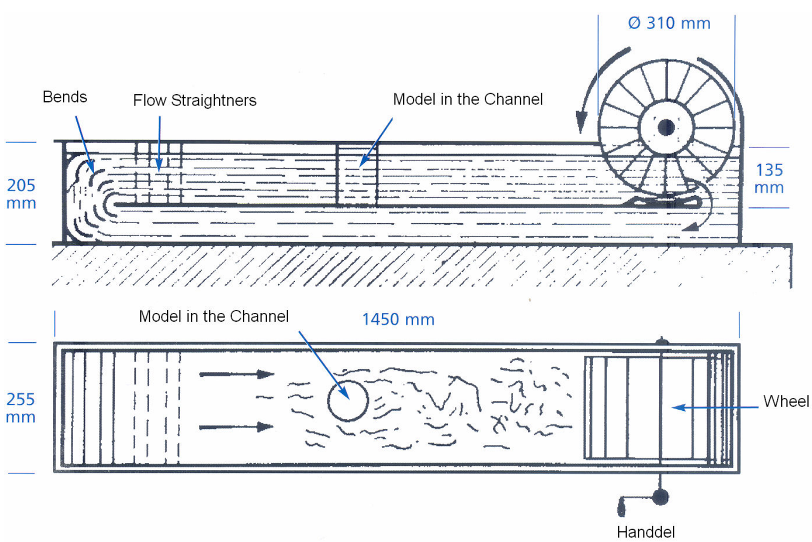


Figure 4. Schematic view of Prandtl water channel

Figure 5 shows a sample of the students' work. The design group decided to follow the same dimensions as chosen by Prandtl and given in Fig. 4. It was also decided to introduce tow main improvements on the channel, first to use a DC motor to drive the wheel rather than doing this manually as in the original channel and to use a transparent material to make the channel to allow for better visual access to the flow structures.

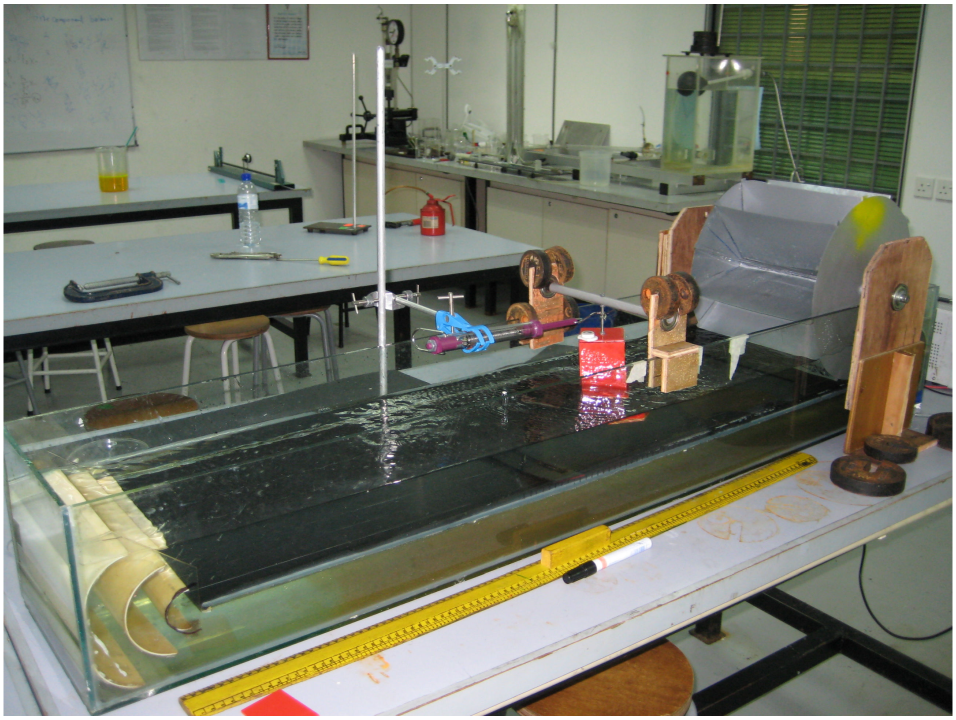

Figure 5. Circulating channel designed and built by the students

## FLOW VISUALISATION RESULTS

To visualise the flow structures, the water needs to be seeded with a suitable tracer. The tracer particles should have a density that is close to that of water and it should have good visual contrast with the background. The students tried two types of flow visualisation techniques namely the direct injection and Hydrogen bubble.

For direct injection, cosmetic glitter dust was used as a tracer. Figure 6 shows the vortex system behind a square cylinder that is visualised using a glitter dust. Figure 7 shows the wake of a semi-circular cylinder visualised using Hydrogen bubble technique.

The Hydrogen bubble technique was achieved using a submerged copper wire upstream of the cylinder and using a 24 Volts potential difference.

## DISCUSSION AND CONCLUSIONS

While working on this project, the students were exposed to variety of challenges and needed to solve a series of design problems that required them to practically engage various aspects of the course. Although fluid flow, material selection and electrical circuit design were the highlight of this project, knowledge developed in other modules like statics and dynamic was useful in achieving the project objectives.

Using the project based learning proved to be an effective way in integrating the First Year Mechanical Engineering curricula. The use of the project was instrumental in sustaining a high level of motivation and engagement in the course among the students.

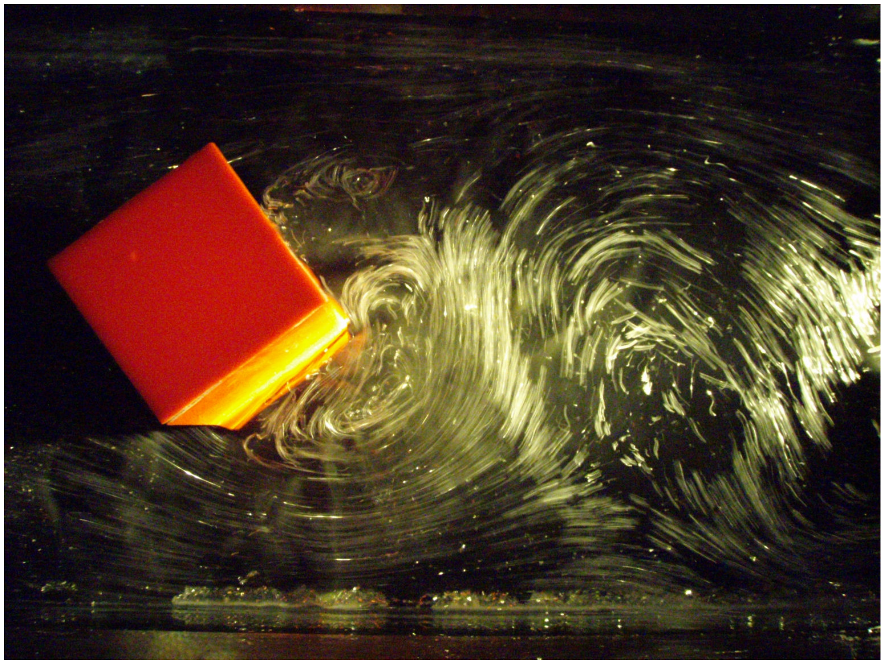

Figure 6. Vortices in the wake of a square cylinder visualised using glitter dust

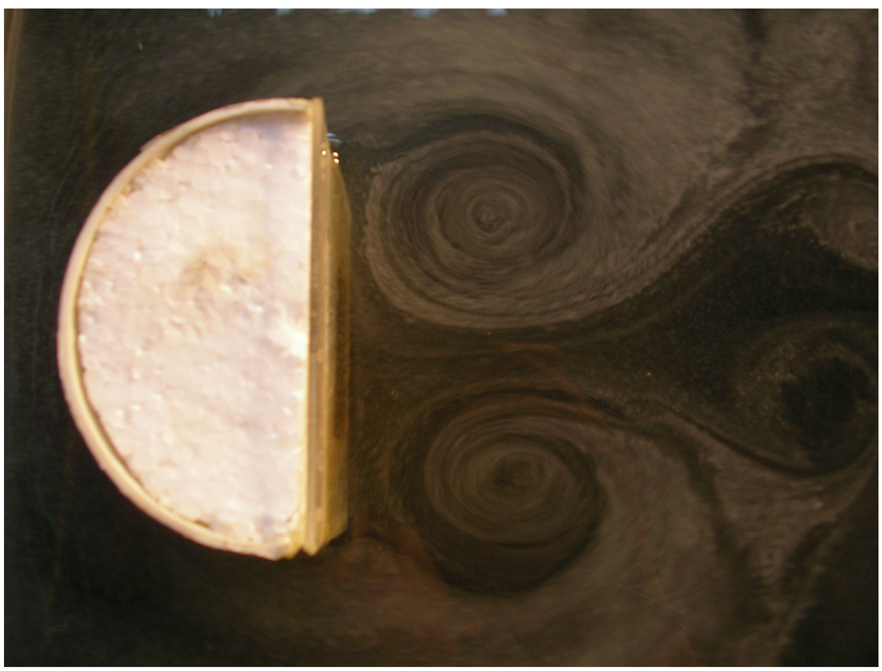

Figure 7. Wake structures behind a semi-circular cylinder using Hydrogen bubble technique

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