CDIO CURRICULUM FOR MECHANICAL ENGINEERING UNDERGRADUATE COURSE

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Abstract

A unique approach to the use of the Project Based Learning to transform the curriculum into CDIO curriculum is achieved through the use of carefully selected projects for the Engineering Design modules (which are Project Based by nature) and use these modules as platforms to encourage practical engagement in other concurrently offered modules which are traditionally viewed as theory based modules. Simple as it may look, this approach requires a high level of coordination on the part of the lecturers delivering the concerned modules to ensure that the required objectives are effectively achieved. This paper reports on the use of the “Engineering Design and Professional Skills” module, offered at the second semester of the second year of a four-year Mechanical Engineering course, in conjunction with a theory based module namely: “Flows with Friction, Drag & Lift” offered at the same semester, to create a CDIO environment without introducing any major changes to the syllabus of the theory based modules or to their assessment scheme. The students were divided into groups and each group was assigned the task of conceiving, designing, implementing and operating a fluid related project. In brief, the “Flows with Friction, Drag & Lift” provided the theoretical backbone for the project, while the “Engineering Design and Professional Skills” module provided the platform through which the project management and team work skills are developed and the progress of the projects is monitored. The students exhibited a high level of engagement and motivation while gaining a better understanding of the real fluids related theory.

Keywords: CDIO, Project based learning, Drag and lift, Engineering design.
1. Introduction

In contemporary undergraduate engineering education, there is a seemingly irreconcilable tension between two growing needs. On one hand, there is the ever increasing body of technical knowledge that it is felt that graduating students must command. On the other hand, there is a growing recognition that young engineers must possess a wide array of personal, interpersonal, and system building knowledge and skills that will allow them to function in real engineering teams and to produce real products and systems [1].

In order to resolve this conflict, innovative solutions, that do not overload the students and lectures, are required. The Conceive-Design-Implement-Operate (CDIO) initiative is one of the widely accepted solutions to achieve these objectives [2]. CDIO initiative advocates an engineering education that stresses the fundamentals, set in the context of the product-system lifecycle, which can be thought of having four metaphases: Conceiving-Designing-Operating-Implementing [3]. This is done normally using educational approaches that are active, hands on and project-based in order to achieve integrated learning, where acquiring of disciplinary knowledge and CDIO skills takes place simultaneously. The philosophy of the CDIO initiative is outlined by the 12 standards and the syllabus it adopts. These standards and syllabus are listed in Fig. 1 and Table 1 respectively.

Gustafsson et al. [4] presented a study of four first-year engineering introductory courses, from different universities that participate in the CDIO Program. The courses were discussed with an emphasis on the student projects in them and it was shown that these introductory courses are an ideal testing ground for the CDIO approach, where new ideas can be tried, developed and assessed to support the learning of CDIO skills. Similar approach was reported by Al-Atabi and Chin [5] and Al-Atabi [6] where an introductory design course as centrepiece is used to integrate the curricula of a first year mechanical engineering undergraduate course.

A unique approach to the use of the Project Based Learning to develop CDIO skills can be achieved through the use of carefully selected projects for the Engineering Design modules (which are Project Based by nature) and use these modules as platforms to encourage practical engagement in other concurrently offered modules which are traditionally viewed as theory based modules.

Simple as it may look, this approach requires a high level of coordination on the part of the lecturers delivering the concerned modules to ensure that the required objectives are effectively achieved. This paper reports on the use of the “Engineering Design and Professional Skills” module, offered at the second semester of the second year of a four-year Mechanical Engineering course, in conjunction with a theory based module namely: “Flows with Friction, Drag & Lift” offered at the same semester, to provide an integrated Project Based Environment that addresses the CDIO standards and syllabus without introducing any major changes to the syllabus of the theory based modules or to their assessment scheme. A class of thirty five students was divided into five groups and each group was assigned the task of conceiving, designing, implementing and operating a project that is related the “Flows with Friction, Drag & Lift” module. The “Engineering Design and Professional Skills” module provided the platform through which the project management and teamwork skills are developed and the progress of the projects is monitored, while
“Flows with Friction, Drag & Lift” provided the theoretical backbone for the project. Throughout the course, the students exhibited a high level of engagement and motivation while gaining a better understanding of the real fluids related theory.

Fig. 1. The CDIO Standards.
2. Modules Delivery

The two modules selected for this project are “Design & Professional Skills” and “Flows with Friction, Drag and Lift” which is an advanced fluid mechanics course. These two modules run simultaneously for 11 weeks during the second semester of the second year of a four-year mechanical engineering undergraduate programme. The students need to attend 4 hours of classes, labs, and tutorials for each module every week. The aim was to introduce as little modification to the

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existing mode of delivery and assessment as possible while ensuring the CDIO standards and Syllabus are addressed.

The “Design & Professional Skills” module is assessed continuously through the coursework. The learning outcomes of the module are listed below.

i. Present work to a high standard, both orally and in writing.

ii. Work effectively within a team.

iii. Perform information gathering and research effectively.

iv. Appreciate the strategic management, legal, social and ethical issues related to development of new products.

v. Assess risk, health & safety, and environmental issues with a strong emphasis on sustainability related to a design or manufacturing project.

vi. Demonstrate a working knowledge of the essential elements of project management and be able to produce a project plan for a project of moderate complexity.

vii. Design and build a product or a system of moderate complexity.

On the other hand, “Flows with Friction, Drag and Lift” is assessed via a coursework component (40%) and a final exam (60%). The learning outcomes for this module are listed below

i. Understand the phenomena involved in the development of boundary layers in flow next to a flat plate and separation of flow around shaped bodies, including the role of turbulence

ii. Calculate the friction and form drag on bodies immersed in flow, including the drag on flat plate with transition layer

iii. Understand and perform design calculations for the basic lifting surfaces

iv. Understand the physics of lift and perform the basic calculations for lifting bodies including the use of polar diagrams for the flight cases

v. Perform experimental assessment of frictional effects in flow including the measurement of velocity profiles.

These two modules are delivered and assessed jointly and the 40% coursework component of the assessment of “Flows with Friction, Drag and Lift” is now assigned to the group project offered at the “Engineering Design and Professional Skills”.

3. Projects Offered

In order to achieve the objectives of creating a CDIO curriculum, the following projects were offered:

i. Conceive, Design, Implement & Operate a Small Wind Turbine using a Standard Airfoil

ii. Conceive, Design, Implement & Operate a Small Wind Turbine using a New Airfoil Design

iii. Conceive, Design, Implement & Operate a Small Wind Turbine using Blade Fitted with Wing Tip Sails

iv. Conceive, Design, Implement & Operate a Small Wind Turbine using the Magnus Effect
v. Conceive, Design, Implement & Operate Models of the Malaysian Traditional Kites.

A sample handout for these projects is given in Fig. 2. Table 2 shows how different items of the CDIO syllabus are linked to the correspondent learning outcomes developed by the two modules considered in this study. It is clear that the learning outcomes of “Flows with Friction, Drag and Lift” are well linked to the disciplinary aspects of the syllabus while CDIO skills part spreads nicely along the learning outcomes of the “Design & Professional Skills” module. It is important to notice here that the integrated delivery of these two modules transformed the curriculum into one that lives up to the CDIO standards (outlined in Fig. 1).

![Fig. 2. Sample Handout for the Projects Offered.](http://jestec.taylors.edu.my/instructions.html)
4. Results and Discussion

The experiment of integrating the delivery of existing modules to achieve CDIO objective was very successful. All the groups managed to concur the technical and non-technical difficulties and complete their respective projects on time. In general, students performed very well in both modules (including the final exam component of the “Flows with Friction, Drag and Lift”). This indicates that the research and hands-on work they performed to complete their project successfully helped them acquire a deeper understanding of the theoretical principles and this is the whole idea behind the CDIO. Using this integrated mode of delivery, most of the CDIO standards were addressed. The level of students’ enthusiasm, engagement and motivation was very high throughout the semester. Figure 3 shows samples of the students’ projects.

5. Conclusions

In order to achieve CDIO standards and develop CDIO curriculum using existing academic modules, a theory based module “Flows with Friction, Drag and Lift” was offered in an integrated manner with a project based module “Engineering Design and Professional Skills”. The integration was achieved through the provision of carefully selected design projects that address the requirements of both modules in a balanced manner. The experiment was a great success as the students performed very well in both modules, which serve as an indication of the achievement of the learning outcomes. The students exhibited a high level of engagement, motivation and commitment throughout the semester.

Table 2. A Matrix Linking CDIO Syllabus to the Learning Outcomes Developed by the Two Modules Considered in this Study.

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Fig. 3. Samples of Students’ Projects.

References


