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CDIO BASED CURRICULUM IMPLEMENTATION FOR ELECTROMECHANICAL UNDERGRADUATE COURSE

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Abstract

A novel approach to using Project Based Learning to transform the curriculum into CDIO curriculum is achieved by using carefully selected projects for the Engineering Design modules (which are Project Based by nature) and using these modules as platforms to encourage practical engagement in other concurrently offered modules that are traditionally viewed as theory based. As simple as it appears, this approach necessitates a high level of coordination on the part of the lecturers delivering the relevant modules in order to effectively achieve the required objectives. This paper describes how the Mechanism of Machinery module, offered in the third year on the second semester of a five-year Mechanical Engineering course, was combined with a theory-based module to create a CDIO environment without introducing any major changes to the theory-based modules' syllabus or assessment scheme. The students were divided into groups, and each group was tasked with developing, designing, implementing, and running a fluid-related project. The students demonstrated a high level of engagement and motivation while learning more about real fluids theory.

Key words: - mechanism of machinery, mechanical engineering module, CDIO, syllabus, standard, course learning outcome

Introduction

CDIO is an acronym that stands for Conceive - Design - Implement - Operate. It is a cutting-edge educational framework for developing the next generation of engineering leaders. The industry benefits because CDIO produces engineers with the knowledge, skills, and experience that it requires.

To better equip engineering students with technical knowledge as well as communication and professional skills, the CDIO approach employs active learning tools such as group projects and problem-based learning. Furthermore, the CDIO Initiative provides resources for member university instructors to improve their teaching abilities.

Engineering education programs throughout much of the 20th century offered students plentiful hands-on practices. Accomplished and experienced engineers taught courses that focused on solving tangible problems. In due course of time, due to rapid advancement in science and technology, engineering education drifted towards the teaching of engineering science. Teaching engineering practice was increasingly de-emphasized. As a result, industries in recent years have found that graduating students, while technically adept, lack many abilities required in real-world engineering situations.

There appears to be an irreconcilable conflict between two growing needs in undergraduate engineering education today. On the one hand, there is the ever-expanding body of technical knowledge that graduating students are expected to possess. On the other hand, there is a growing recognition that young engineers must have a diverse set of personal, interpersonal, and system-building knowledge and skills in order to function in real engineering teams and create real products and systems. (Crawley, 2001)

Innovative solutions that do not overburden students and lectures are required to resolve this conflict. To address the increasing gap between scientific and practical engineering demand and to meet the global requirements of professional Engineers, the CDIO curriculum was introduced. (Crawley, E.F.; Malmqvist, J.; Ostlund, S.; and Brodeur, D., 2007). The CDIO initiative promotes fundamental engineering education within the context of the product-system lifecycle, which can be thought of as having four metaphases: conceiving-designing-operating-implementing (Bankel, J.; Berggren, K.F.; Engstrom, M.; Wiklund, I.; Crawley, E.F.;Soderholm, D.; El Gaidi, K.; and Ostlund, S., 2005). This is typically accomplished through the use of active, hands-on, and project-based educational approaches in order to achieve integrated learning, in which disciplinary knowledge and CDIO skills are acquired concurrently. The CDIO initiative's philosophy is outlined by the 12 standards and syllabus it uses.

Gustafsson et al. (Gustafsson, G.; Newman, D.J.; Stafström, S.; and Wallin, H.P., 2002) presented a study of four first-year engineering introductory courses from different CDIO Program universities. The courses were discussed, with an emphasis on the student projects, and it was demonstrated that these introductory courses are an ideal testing ground for the CDIO approach, where new ideas can be tried, developed, and assessed to support CDIO skill learning. Al-Atabi and Chin (Al-Atabi, M.T.; and Chin S.B., 2007) and Al-Atabi (Al-Atabi, M.T.) used an introductory design course as the centerpiece to integrate the curricula of a first-year mechanical engineering undergraduate course.

A novel approach to using Project Based Learning to develop CDIO skills can be achieved by carefully selecting projects for Engineering Design modules (which are Project Based by nature) and using these modules as platforms to encourage practical engagement in other concurrently offered modules that are traditionally viewed as theory based. (Mushtak Al-Atabi, Abdulkareem Sh. Mahdi, 2011)

As simple as it appears, this approach necessitates a high level of coordination on the part of the lecturers delivering the relevant modules in order to effectively achieve the required objectives. This paper describes the use of the "theory of machine and mechanism" module, which is offered in the second semester of the third year of a five-year Mechanical Engineering course, in conjunction with a theory-based module, 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 module.

There are two sections of class of forty-five students was divided into four groups, and each group was tasked with developing, designing, implementing, and running a project related to the mechanism of machinery module. Throughout the course, students demonstrated a high level of engagement and motivation while learning more about real about mechanism of machinery.

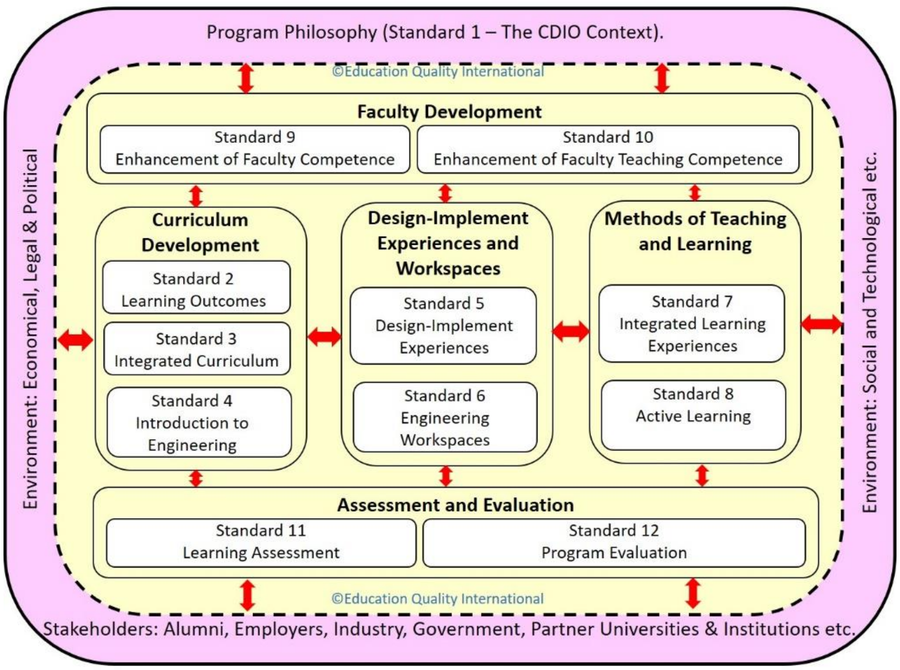

Figure 1: CDIO standards

	CDIO SYLLABUS TOPIC		EA GRAD. ATT.	WA GRAD. ATT.	QUT GRAD. CAP.
TECHNICAL KNOWLEDGE AND REASONING	1.1	KNOWLEDGE OF UNDERLYING SCIENCES	A	B	A
	1.2	CORE ENGINEERING FUNDAMENTAL KNOWLEDGE	A	B	A
	1.3	ADVANCED ENGINEERING FUNDAMENTAL KNOWLEDGE	C	B	A
PERSONAL AND PROFESSIONAL SKILLS AND ATTRIBUTES	2.1	ENGINEERING REASONING AND PROBLEM SOLVING	D	C	B
	2.2	EXPERIMENTATION AND KNOWLEDGE DISCOVERY	-	E	-
	2.3	SYSTEM THINKING	E,G	D	-
	2.4	PERSONAL SKILLS AND ATTITUDES	F,(J)	G,(M)	E,G,(D)
	2.5	PROFESSIONAL SKILLS AND ATTITUDES	I,(J)	J,(M)	F,(D)
INTERPERSONAL SKILLS: TEAMWORK AND COMMUNICATION	3.1	TEAMWORK	F	G	E,G
	3.2	COMMUNICATIONS	B	H	C
	3.3	COMMUNICATIONS IN FOREIGN LANGUAGES	-	-	-
CONCEIVING, DESIGNING, IMPLEMENTING AND OPERATING SYSTEMS IN THE ENTERPRISE AND SOCIETAL CONTEXT	4.1	EXTERNAL AND SOCIETAL CONTEXT	G	I	F
	4.2	ENTERPRISE AND BUSINESS CONTEXT	-	L	-
	4.3	CONCEIVING AND ENGINEERING SYSTEMS	E,H	F,K	B,F
	4.4	DESIGNING	E,H	F,K	(A),(B)
	4.5	IMPLEMENTING	E,H	F,K	(A),(B)
	4.6	OPERATING	E,H	F,K	(A),(B)

Figure 2: CDIO syllabus

Modules delivery

The modules selected for this project is “Mechanism of machinery which is mechanical design course. This module run simultaneously for 16 weeks during the second semester of the third year of a five-year mechanical engineering undergraduate programme. The students need to attend 5 hours of classes and tutorials for each module every week. The aim was to introduce as little modification to the existing mode of delivery and assessment as possible while ensuring the CDIO standards and Syllabus are addressed.

The mechanism of machinery module is assessed continuously through the coursework. The learning outcomes of the module are listed below.

Table 1: course learning outcome

	Course Learning Outcome (CLO): At the end of the course the student will be able to do:	
	CLO1	Apply the basic components of mechanisms, analyze the assembly with respect to the displacement, velocity, and acceleration at any point in a link of a mechanism and design cam mechanisms for specified output motions
	CLO2	Apply the basic concepts of toothed gearing and kinematics of gear trains
	CLO3	Analyze the effects of friction in machine elements
	CLO4	Analyze the force-motion relationship in components subjected to external forces and analyze of standard mechanisms

CLO5	Analyze the undesirable effects of unbalances resulting from prescribed motions in mechanism and the effect of dynamics of undesirable vibrations.

Mapping of the course Learning Outcomes to the program Learning Outcomes, Teaching Methods and Assessment:

Course Learnin Outcomes (CLO)	Program Learning Outcomes (PO)																				
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Teaching Methods				Assessment				
													L	T	P	O	Test	Quiz	Assignment	Project	Lab-report
CLO1	√	√	√		√			√				√	√	√			√	√	√		
CLO2	√	√	√		√			√				√	√	√			√		√		
CLO3	√	√	√		√			√				√	√	√			√		√		

Projects offered

Project introduction

Of course, Potato chips currently represent one of the world's most popular snack foods. From its accidental birth in 1853, the potato chips market has evolved with time and currently represents a multi-billion-dollar market. Owing to their easy affordability and cheaper price even for the premium products, potato chips are popular among all age groups. Currently, the growing young population (below 15 years) represents a key segment for the potato chips market. Major factors driving the global demand of potato chips are growing urbanization, rise in disposable incomes and rapidly changing lifestyles. Chips are the most popular variety of snacks on various occasions. In food production domain one of the key tasks is to maintain the high production rate and hygienity.

Considering the production of potato chips, it is time consuming task and also labor intensive if conventional method of producing chips is followed i.e. using separate machinery for each individual task. As more time is consumed while processing chips from one machine to another, we have concentrated into the cutting mechanism of potato only. 5 mechanisms design concept are generated and you are expected to design the concept, prepare part drawing and assembly drawing (by any modeling software) and show the prototype by cartoon or any scrap materials you can find around.

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

1. Potato cutting machine by four bar mechanism
2. Potato cutting machine by slider crank mechanism
3. Potato cutting machine by scotch yolk mechanism
4. Potato cutting machine by quick return mechanism
5. Potato cutting machine by toggle mechanism

Figure 3 shows a sample handout for these projects. Table 2 shows how various CDIO syllabus items are linked to the respective learning outcomes developed by the modules studied in this study. The learning outcomes are clearly linked to the disciplinary aspects of the syllabus. It is important to note that the integration of the modules transformed the curriculum into one that meets CDIO standards (outlined in Fig. 1).

ELECTROMECHANICAL ENGINEERING DEPARTMENT

Theory of machines and mechanism

by Maereg A.

Group assignment (50%)

Date 5/6/2022

General direction: *a full design and autocad drawing should be submitted two week befor the final exam day/ september 20/2022*

Of course, Potato chips currently represent one of the world's most popular snack foods. From its accidental birth in 1853, the potato chips market has evolved with time and currently represents a multi-billion-dollar market. Owing to their easy affordability and cheaper price even for the premium products, potato chips are popular among all age groups. Currently, the growing young population (below 15 years) represents a key segment for the potato chips market. Major factors driving the global demand of potato chips are growing urbanization, rise in disposable incomes and rapidly changing lifestyles. Chips are the most popular variety of snacks on various occasions. In food production domain one of the key tasks is to maintain the high production rate and hygienity.

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Assessment method

1. Part drawing……..10% august 16 will be submitted
2. Assembly drawing…15% august 23 will be submitted
3. Prototype ………….25% September 15 up to 20 will be submitted
4. Extra invention applied….10% bonus

TOTAL …………………..50% plus 10% bonus

Figure 3: project given

Table 2: learning outcome developed and the CDIO syllabus matrix linkage

	CDIO syllabus name	Mechanism of machinery
1.1	Knowledge in underlying science	CLO1
1.2	Core engineering fundamental knowledge	CLO3,CL4, CLO5
1.3	Advanced engineering fundamental knowledge	
2.1	engineering reasoning and problem solving	
2.2	Experimentation and knowledge discovery	CLO5
2.3	System thinking	
2.4	Personal skill and attribute	
2.5	Professional skill and attribute	
3.1	Teamwork	
3.2	Communication	
3.3	Communication in foreign language	
4.1	Social and external context	
4.2	Enterprise and business context	
4.3	Conceiving and engineering system	
4.4	Designing	CLO4,CLO5
4.5	Implementing	CLO4,CLO5
4.6	Operating	CLO4,CLO5

Result and discussion

The experiment of integrating the delivery of existing modules to achieve the CDIO goal was a huge success. All of the groups were able to overcome technical and non-technical challenges and complete their projects on time. Students did exceptionally well (including the final exam component). This indicates that the research and hands-on work they did to successfully complete their project helped them gain a deeper understanding of the theoretical principles, which is the entire concept behind the CDIO. Most CDIO standards were addressed using this integrated mode of delivery. Throughout the semester, students' enthusiasm, engagement, and motivation were extremely high. Of course, CDIO standard number 8 for engineering work space was quit challenging. Because the students were unable to get in the machine shop and workshop to manufacture /implementation phase of the CDIO syllabus 4.5/ the design they had designed. it is useful to indicate the CDIO based curriculum need high resource.

Figure 4: students implementing and operating their final project

Conclusion

In order to achieve CDIO standards and develop CDIO curriculum using existing Addis Ababa science and Technology university (AASTU) academic modules, a theory-based module of Mechanism of Machinery was offered. The integration was accomplished through the provision of carefully selected design projects that balanced the requirements of the modules with some backwards. The experiment was a huge success because the students performed exceptionally well, indicating that the learning objectives were met. Throughout the semester, the students demonstrated a high level of engagement, motivation, and commitment.

Acknowledgement

I highly acknowledge my students for the success of this wok and for their completion of the project specially Yared Kenenisa and Blen Mengistu for their valuable coordinating the students next to AASTU Eelectromechanical Engineering department.

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