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Aspects of Teaching Mechanical Engineering Design

KEYWORDS: BIGGS STUDY PROCESS, COURSE EVALAUTION, ENGINEERING DESIGN

ABSTRACT

Design teaching in mechanical engineering has two features which distinguish it from many other teaching areas. First, the majority of students have little or no background in technology and practical design. Second, virtually all design learning comes through the development of conceptual understanding, rather than from the learning of declarative knowledge. The objective of teaching mechanical engineering design is to provide a learning context in which students will achieve a basic level of competence in design. The challenge, then, for design teachers is to ensure that the learning context – the curriculum, teaching methods, and assessment provisions – is appropriate to the development of conceptual understanding of the design process, and through this, achieve the goal of design competence. The most important and yet most difficult teaching goal is to bring the conceptual change in students' understanding of the fundamental features of the discipline being studied. The focus of this paper is to look at some of the aspects associated with the teaching mechanical engineering design in new environment in which engineering schools are subject to resource constraints. The results indicate that there is a need for a closer look at teaching methods and assessment practices.

INTRODUCTION

The primary aim of teaching design for mechanical engineering students is to enable the students to achieve a fundamental level of competence in design. This involves creating appropriate learning environment for the students to develop concepts, creativity and critical thinking skills. It is also necessary for the students to develop both individual and team based skills. Design teaching requires that the recognition that the majority of the students may have little or no background in technology and practical design [1]. It is also necessary to understand that design learning generally comes through the development of conceptual understanding rather than from the learning of declarative knowledge. The challenge for design teachers, then, is to ensure that the learning context – the curriculum, teaching methods and assessment provisions - are appropriate to the development of conceptual understanding of the design process. This should facilitate students design competence against the environment in which universities are subject to resource constraints such as decrease in teaching times and increase in class size.

As widely identified by design educators, the most important and yet most difficult teaching goal is to bring the conceptual change in students' understanding of the fundamental features of the discipline being studied. The current second year mechanical engineering design course at the University of New South Wales (UNSW) has been designed to meet this goal by introducing basic concepts in creative design and design of basic machine elements, and to develop individual and team based skills.

This course was run for full year with one hour lecture and two hour tutorial for over two decades. Then there was a faculty wide restructure implemented at UNSW for all the courses in engineering from 2006 to run in one semester instead of two. This lead to the necessity of careful planning of the course as the students would have lesser time frame to conceive the concepts and generate successful design outcomes.

In the previous structure, the students were assessed on a team basis on the Weir Warman Design and Build Project and Competition. The project was proposed by the Institution of Engineers, Australia and participated by about 20 Universities in Australia and New Zealand each year. The project and competition was a two-tier event, with the most successful device at each university being eligible to compete in a national final, where the emphasis turns to competition and a quest for design excellence. The project had to be dropped in the new course structure as logistics of organising it became difficult due to shorter time frame.

It has been documented that assessment practices, curriculum, and teaching methods all influence the way students approach their subject learning [2]. Research into 'student approaches to learning' has distinguished three main approaches: 'deep', 'surface' and 'achieving' [3]. The 'deep' approach is linked to the intention to understand; to distinguish new ideas and relate these to previous knowledge. The 'surface' approach is extrinsically motivated, and is manifested in reproducing and rote learning strategies. The third approach, called 'achieving' approach, is described as being based on a desire to obtain the highest grades, whether or not the material is interesting, and to organise their study to achieve this end.

Whilst it is desirable that students develop an 'achieving' ethic to ensure successful completion of their course, attention needs to be focused on the other two approaches. The special demands of engineering design learning are such that it is crucial that learning experiences are provided which

will promote 'deep learning' and discourage 'surface learning'. Whilst most university teachers see this as nothing new, and would claim that their teaching practices are directed at achieving this goal, the reality is that often this not attained: 'A particularly depressing finding is that most students in most undergraduate courses become increasingly surface, and decreasingly deep in their orientation to learning' [4, p. 137]. Given this finding, it is believed important to include in the evaluation of learning outcomes in engineering design an effective instrument to measure changes in how students approach their learning.

This paper looks at the student approach to learning in the new system of curriculum and compares with the previous one and study if the change in the curriculum encourages the students to improve their learning outcomes.

I. THE STUDY

An investigation into learning strategies adopted by students in a second year mechanical engineering design course at UNSW was conducted. The aim of this investigation is to seek the responses of the students as how they feel and respond to the change in curriculum. The course was designed in such a way that the students initially learn the design process on an individual basis and are involved in creative design in a design project focusing on various elements on a step by step basis. They derive some design experience and knowledge from this exercise. Then they will be exposed to a team project in which they can apply their design concepts and experiences. The course was designed to encourage team work as a gateway for real world situation where designers need to work with people from various backgrounds.

II. COURSE DESCRIPTION

The second year design course in UNSW is a course designed to cater for all second year students in mechanical, manufacturing, mechatronics, aerospace and naval architecture programs and runs for a semester with a weekly load of three hour lecture and three hour tutorials. A design project is introduced early in the semester. The task is mainly to select items such as motors, belts, chains, bearings etc from manufacturer's catalogues after performing necessary calculations and design considerations. Components which are not usually proprietary items such as shafts are designed. It is a team based project.

The design project has a number of class assignments for which the students have to submit reports for grading. The number of class assignments had been reduced in the new system in view of student load and grading constraints. In addition the students were to attend allocated tutorial classes and attempt to solve tutorial problems in order to understand designing concepts of basic machine elements. The class assignments are designed to focus on the importance of communication and decision making skills. The course is also focused on developing computer aided drawing skills.

III. METHODS OF ANALYSIS AND RESULTS

The Course And Teaching Evaluation and Improvement (CATEI) Process survey used at the UNSW was administered to students at the end of the course. These surveys are given to students at the end of each session to ascertain their opinions on teaching resources and teaching effectiveness. Another survey chosen to investigate students learning approaches is the Biggs Study Process Questionnaire (Table 3) in which students are measured on the three learning approaches – 'Deep', 'Surface' and 'Achieving' [3].

IV. RESULTS

A. CATEI

This survey focuses on student perception on the course and its relevance (Table 1). It asks the students to identify the best features of the course and how to make improvement. The survey seeks responses from the students about the clarity of the aim of the course; feedback on their ongoing performance in the course; and whether the course is interesting and challenging, advancing student ability for independent learning and critical analysis, providing effective opportunities for active student participation in learning activities, developing thinking skills and appropriate assessment methods.

Although the same lecturer taught the subject in both old and new curricula student satisfaction on the quality of the course has dropped from 63% to 48% [5]. Obviously this was a significant concern to the lecturer and other staff members involved in the subject. It has to be noted that the participation rate in the survey of the new course was only 32.5% compared to 80% in the previous course. This is mainly because of the way the results were obtained. The survey in the previous course was done in the class and hard copies were collected and the responses were analysed. This was not followed for the new course as the university seeks the response electronically. It appears many students do not bother to attend to the survey. Hence the response in the new system is not quite representative. However, it is a point of concern.

Student rating of the course as challenging and interesting has a marginal difference from 79% to 71%. Their satisfaction with assessment requirements and methods used in the course has also dropped from 79% to 68%. They have indicated that the course was effective for developing thinking skills (73% to 74%). This is a good outcome for a design course but can only be regarded as unchanged.

B. Biggs Study Process Questionnaire

Table 2 shows the relevant mean values of the results obtained for the learning approaches adopted by the students in the years 2006 and 2009. The Table indicates how mean and standard deviation values of the different approaches adopted by the students compared with the norms [6]. It is clear that the students have inclined towards surface approach to learning in the new curriculum. They tend to adopt deep

approach to learning whilst they focus on obtaining the highest grades and organising their study to achieve this end. It is discouraging to observe that they have gone along surface approach in 2009 contrary to the approach in 2006.

V. CONCLUDING REMARKS

It is clear from CATEI student response that the overall satisfaction of the new course has to be improved. This is reinforced by the Biggs Study Process survey indicating that the students tend to adopt surface approach to learning. These findings clearly indicate that there needs to be a rethink in the aspects of teaching such as teaching methods and assessment practices to suit the new structure of the course and improve deep approach to learning.

Given the shorter time frame and resource constraints some steps have been already planned to address this for the forthcoming students in 2010. It includes more in-depth design exercises, interactive computer aided design, guest lecturers from industry and change in assessment methods. Reintroduction of Weir Warman Design and Build Project and Competition which was favoured by many students in the old program is also considered. However due to the current time frame structure, it is unlikely to be reinstalled.

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Table 1 UNSW CATEI Course Evaluation (Participation: 32.5%)
No. of students: 286

#	Question	Broad Agreement (%)
1	The aims of this course were clear to me.	68
2	I was given helpful feedback on how I was going in the course.	55
3	The course was challenging and interesting.	71
4	The course provided effective opportunities for active student participation in learning activities.	64
5	The course was effective for developing my thinking skills (e.g. critical analysis, problem solving).	74
6	I was provided with clear information about the assessment requirements for this course.	57
7	The assessment methods and tasks in this course were appropriate given the course aims.	68
8	In this course the content is organized and presented in a logical and coherent way.	46
9	Lecturer's handouts are a valuable aid to learning.	54
10	Overall, I was satisfied with the quality of this course.	48

Table 2: Learning Strategy Results (Biggs, SPQ)

	APPROACH								
	SURFACE			**DEEP**			**ACHIEVING**		
	Actual		Norm	Actual		Norm	Actual		Norm
Year	2006	2009		2006	2009		2006	2009	
Mean	17.94	24	21.87	20.33	23	22.10	22.93	20	20.42
Standard Deviation	3.68	3.28	4.54	4.16	4.31	4.47	4.54	5.32	5.32

Table 3: General Study Processes

(A = 5, B = 4, C = 3, D = 2, E =1)

		Always True		True ½ Time		Never True
1.	I think browsing around is a waste of time, so I only study seriously what's given out in class or in the course outlines.	A	B	C	D	E
2.	While I am studying, I often think of real life situations to which the material that I am learning would be useful.	A	B	C	D	E
3.	I summarize suggested readings and include these as part of my notes on a topic.	A	B	C	D	E
4.	I learn some things by rote, going over and over them until I know them by heart.	A	B	C	D	E
5.	In reading new material I often find that I'm continually reminded of material I already know and see the latter in a new light.	A	B	C	D	E
6.	I try to work consistently throughout the term and review regularly when the exams are close.	A	B	C	D	E
7.	I tend to choose subjects with a lot of factual content rather than theoretical kinds of subjects.	A	B	C	D	E
8.	I find that I have to do enough work on a topic so that I can form my own point of view before I am satisfied.	A	B	C	D	E
9.	I try to do all of my assignments as soon as possible after they are given out.	A	B	C	D	E
10.	I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.	A	B	C	D	E
11.	I try to relate what I have learned in one subject to that in another.	A	B	C	D	E
12.	After a lecture or lab I reread my notes to make sure they are legible and that I understand them.	A	B	C	D	E
13.	I learn best from lecturers who work from carefully prepared notes and outline major points neatly on the blackboard.	A	B	C	D	E
14.	I find most new topics interesting and often spend extra time trying to obtain more information about them.	A	B	C	D	E
15.	I test myself on important topics until I understand them completely.	A	B	C	D	E
16.	I find it best to accept the statements and ideas of my lecturers and question them only under special circumstances.	A	B	C	D	E
17.	I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes.	A	B	C	D	E
18.	I make a point of looking at most of the suggested readings that go with the lectures.	A	B	C	D	E
19.	I am very aware that lecturers know a lot more than I do and so I concentrate on what they say is important rather than rely on my own judgment.	A	B	C	D	E
20.	I try to relate new material, as I am reading it, to what I already know on that topic.	A	B	C	D	E
21.	I keep neat, well-organized notes for most subjects.	A	B	C	D	E