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# Design Education for Second Year Mechanical Engineering Students

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ABSTRACT

The primary aim of teaching design for mechanical engineering students is to make the students 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. This paper looks at the student responses based on individual and team based tasks in a second year design course. The student surveys indicate very strong support for team based projects, with a high proportion of students agreeing that they gained many learning benefits as a result: importance of simple design, practical experience of design, and importance of organisation, skills in problem solving and how to work in a team. Overall, the student feedback indicates that they have to work individually to understand the concepts and collectively on a project to achieve a high level outcome.

## INTRODUCTION

Design teaching in mechanical engineering has two features which distinguish it from many other teaching areas. First, the majority of students has little or no background in technology and design [1]. Second, virtually all design learning comes through the development of conceptual understanding, rather than from the learning of declarative knowledge. The main 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 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 through which the goal of design competence is achieved.

As has long been recognised 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 has been designed to introduce basic concepts in creative design and design of basic machine elements, and to develop individual and team based skills. In addition, 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 is a two-tier event, with the most successful device on each University being eligible to compete in a national final, where the emphasis turns to competition and a quest for design excellence.

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 by Biggs 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 we provide learning experiences 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.

## I. THE STUDY

This paper reports an investigation into learning strategies adopted by students in a second year mechanical engineering design course at the University of New South Wales (UNSW). The aim of this study is to seek the response of the students as how they feel and respond to individual study methods to team work The course is 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

This is a second year mechanical engineering design subject which runs for a full year (two sessions) with a weekly load of one and a half hour lecture followed by one and a half hour tutorials. A design project is introduced early in Session 1 and continued into Session 2. The task in Session 1 is mainly to select items such as motors, belts, chains, bearings etc from manufacturer's catalogues after performing necessary calculations. In Session 2, components which are not usually proprietary items such as shafts are designed.

The design project has a number of class assignments for which the students have to submit reports for grading. The class assignments are designed to focus on the importance of communication and decision making skills. In addition, the students are tested on the 'Warman Design and Build' competition organised by the Institution of Engineers, Australia.

## III. METHODS OF ANALYSIS AND RESULTS

The Course And Teaching Evaluation and Improvement (CATEI) Process survey used at the University of New South Wales 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. In addition the student opinions were sought using another survey to evaluate the learning outcomes which they derive from the team based 'Design and Build' project. Another survey chosen to investigate students learning approaches is the Biggs Study Process Questionnaire [3] in which students are measured on the three learning approaches – 'Deep', 'Surface' and 'Achieving'.

## IV. RESULTS

### *A. CATEI*

This survey focuses on student perception on the course and its relevance. 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, appropriate assessment methods.

63% of the students agreed that they are satisfied with the quality of the course with 79% of them identified the course was challenging and interesting. They have indicated that the course was effective for developing thinking skills (73%). They are comfortable with assessment requirements and methods used in the course (79%).

### *B. Warman Design and Build Project*

Survey on the Warman project has been conducted every year for the past few years. Some questions as shown in Appendix were used and the graphical results are shown in Figures 1-4. It is clear that the students overwhelmingly identified the importance of organisation, need for simplicity in design, skills in problem solving, translation of design into product, recognition of design deficiencies and the practical experience they gain. Over 70% of the students supported the idea of including the Warman Design and Build project as part of the course, reflecting the development and understanding of skills in design as against the time and cost they invested on the project.

They have indicated that it is one of the best exercises in their first two years of mechanical engineering and one of the few hands-on practical components which are essentially what engineering practice is about – getting things to work.

### *C. Biggs Study Process Questionnaire*

Table 1 shows the relevant mean values of the results obtained for the learning approaches adopted by the students. The Table indicates how mean and standard deviation values of the different approaches adopted by the students compared with the norms [5]. It is clear that the students 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 encouraging to observe that they have not gone along surface approach to study the course.

## V. CONCLUDING REMARKS

The student response from CATEI survey clearly indicates that the course is designed to create learning environment for the students to develop skills for creativity and critical thinking on an individual basis. Also, the students have expressed strong support for team based projects, with a high proportion of them agreeing that they gained many learning benefits as a result: importance of simple design, practical experience of design, and importance of organisation, skills in problem solving and how to work in a team. Overall, the student feedback indicates that they have to work individually to understand the concepts and collectively on a project to achieve a high level outcome.

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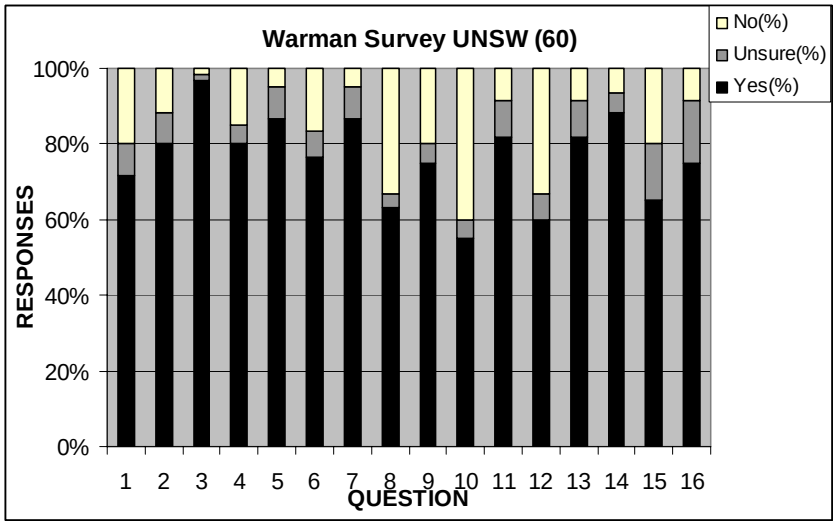


Figure 1: Warman Suvey 2006 (UNSW)

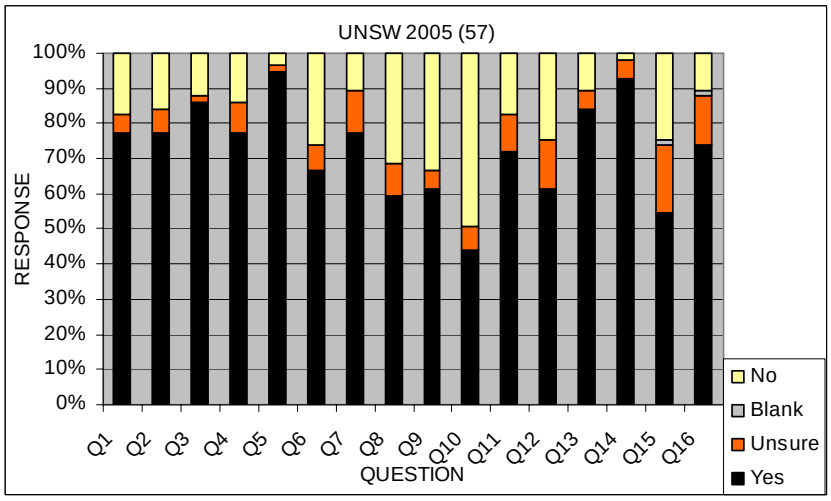


Figure 2: Warman Survey 2005 (UNSW)

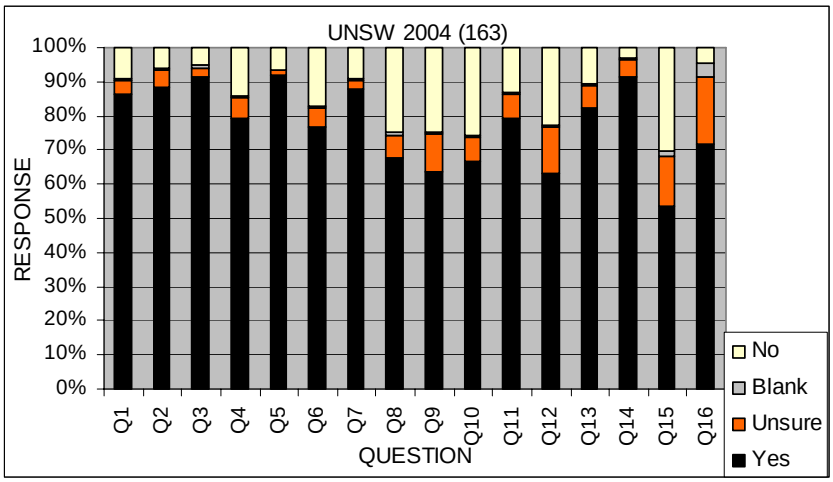


Figure 3: Warman Survey 2004 (UNSW)

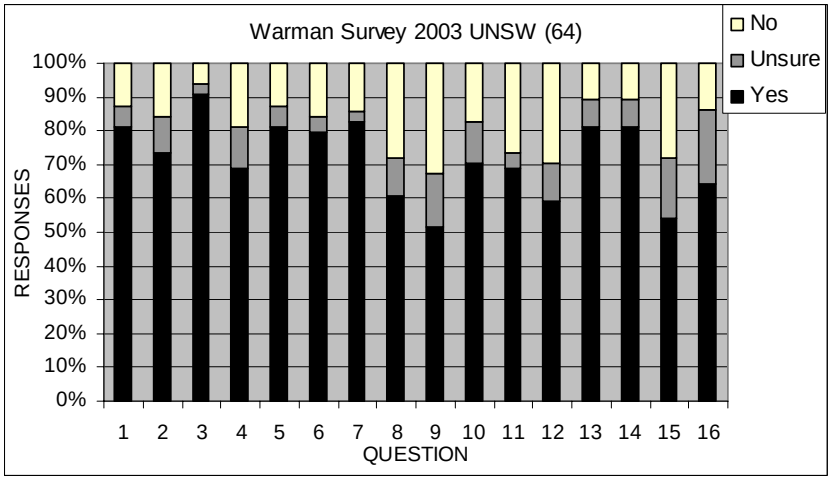


Figure 4: Warman Survey 2003 (UNSW)

Table 1: Learning Strategy Results (Biggs, SPQ)

| | APPROACH | | | | | |
|---|---|---|---|---|---|---|
| | **SURFACE** | | **DEEP** | | **ACHIEVING** | |
| | Actual | Norm | Actual | Norm | Actual | Norm |
| Mean | 17.94 | 21.87 | 20.33 | 22.10 | 22.93 | 20.42 |
| Standard Deviation | 3.68 | 4.54 | 4.16 | 4.47 | 4.54 | 5.32 |

# APPENDIX

STUDENT OPINION QUESTIONNAIRE
2006 WARMAN STUDENT DESIGN & BUILD PROJECT AND COMPETITION

Dear Student,

In this questionnaire we seek your views on the experience of the design and build project in which you participated earlier this year. This information will be used to assist in evaluating the learning outcomes which resulted from participating in the project and, for some of you, in the National Final in Sydney and to guide future developments in design and build projects. The questionnaire is ANONYMOUS. Please use a pencil to mark your response on the computer answer sheet provided. Comments on the project, the way it is run, its benefits and difficulties, or any other aspect, would be valuable and greatly appreciated.

School of Mechanical & Manufacturing Engineering, University of NSW

For questions 1-14: Use the code: A = Yes; B = No; C = Unsure.

Did your experience in participating in the 2003 Warman design and build project result in significant learning in each of the aspects listed below?

1. How to work in a group
2. How to carry out a project
3. Importance of organisation
4. Importance of initial concepts and calculations
5. Importance of simple design
6. Skills in organisation
7. Skills in problem solving
8. Estimating the time required to complete a project
9. Putting theory into practice
10. Importance of cost consideration
11. How to translate design into product
12. Need for a prototype
13. How to recognise design deficiencies
14. Practical experience of design
15. Has your participation in the Warman student design and build project resulted in any fundamental change in what you now understand to be good design?
    (A = Yes; B = No; C = Unsure)
16. What is your view on the inclusion of the Warman design and build project as part of your course, considering the benefits you may have gained in developing an understanding of and skills in design as against the time and cost you have invested in the project?
    - A Support continuation of the design and build project as part of your course
    - B Do NOT support continuation of the project as part of the course
    - C Unsure whether it should continue as part of the course.

If you feel you are able to identify one or two aspects during the design and build project which stood out as being particularly valuable in developing your understanding of the design process and/or skill in design, please describe these concisely. Brief comments on Questions 15 and 16 will also be most helpful.

THANK YOU.