Development of a cross discipline, experiential based, flexible delivery unit

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Abstract *¾ Engineering disciplines historically have high attrition rates in the early years due to predominance of engineering science where participating students appear unable to perceive the connection between theory and practice. This is a problem particularly prevalent with Full Fee Paying Overseas Students (FFPOS), who are often unable to conceptualise engineering problems. A group project based learning approach has been used to assist students to understand the application of complex theory to real engineering. Integrated student teams carried out the design, construction and calibration of a load cell. This was integrated with programming using Matlab and LabView languages. The project culminated in a group demonstration of the load cell accompanied by an oral presentation of the design, planning and manufacturing processes. The flexible investigation and design paralleled the more formal teaching process; utilising self paced learning and group interaction.*

Index Terms ¾ collaborative, co-operative learning, flexible delivery,

BACKGROUND

A new unit "Experimental Design and Analysis" was introduced into the School's curriculum in 2002 as a teaching and learning initiative. The impetus for the development of this unit has grown from a number of sources. The Institution of Engineers, Australia, recently announced a set of generic skills that were required to be developed in each engineering graduate from Australian Universities. These generic skills include such skills as "Ability to understand problem identification, formulation and solution", "Ability to function effectively as an individual and in multi-disciplinary teams" and "Ability to solve problems with minimal guidance".

A second driver for this project was the restructuring of the engineering degree program at the University of Tasmania, Australia. The engineering degree at the University covers six engineering disciplines in the first three semesters and it is only after first semester of the second year of the course that students choose a discipline in which to specialise. The disciplines are:

- Civil engineering
- Mechanical engineering
- Mechatronics engineering
- Power systems engineering
- Electronics and communications engineering
- Computer systems engineering

The new unit is the only one in the final common, semester that provides the students with an integrated experience of the broad spectrum of engineering disciplines before they are required to finally choose their specialisation. The unit was therefore designed to encompass some aspects of all engineering disciplines as well as providing some exposure to and experience of team work and group dynamics.

One of the difficulties in teaching aspects of engineering theory at second year engineering level, to non-discipline specific students, is that the students often perceive it to be irrelevant to real life engineering and of no practical application in their chosen field. New, complex concepts need to be represented to the students by illustration and exposure to tactile experience. The importance of the integration of the different engineering disciplines needs to be taught by example.

The present means of reinforcing theory is the use of laboratory work in an essentially demonstrator mode. While such an approach has been found to be of use in technical training (by rote) it is relatively inflexible and does not encourage any deep learning or understanding of the basic underlying engineering concepts.

The project was also intended to be a teaching tool to help reinforce engineering principles via collaborative learning [1] and to supplement the traditional training methods that also teach students what to think. One obvious and better alternative is to teach students how to think in an environment of inquiry [2]. To maximise outcomes in projects, such as described in this paper, students must collaborate with each other and juggle concepts and ideas. It was envisaged that individual students would pose questions to the group, which in turn would hypothesise, experiment, test and review the outcomes. The learning and teaching outcome is that the students are encouraged to discover a process for completing the project themselves through inquiry and collaboration [2].

The definition of collaborative learning adopted for the paper is *"an instruction method in which students work in*

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groups towards a common academic goal" [3]. In some circles, the teaching/learning approach adopted for the exercise described here is termed cooperative learning [4].

An additional criterion was to engage international students in the group learning process. The School has one of the highest percentage levels of Full Fee Paying Overseas Student (FFPOS) in Australia. The School ended 2001 with 202 domestic students and 102 FFPOS.

UNIT DESCRIPTION

Course work and project

As part of the recent restructuring of the engineering degree program at the University of Tasmania (UTas), the 12.5% unit entitled "Experimental Design and Analysis" was included in the first semester of second year engineering. This subject was designed to teach the relevant theory, with an emphasis on integrating six engineering disciplines: power systems, electronics and communications, mechanical, mechatronic, civil and computer systems engineering. In this subject students are expected to gain an understanding of the fundamental principles and applications of all areas of engineering, and how they relate to each other. The number of students varies according to UTas domestic and FFPOS intake but historically about 80 to 110 students would be expected to be enrolled in the unit each year.

The new and innovative approach in this unit involves small teams of four to five students in project based learning, which has been found to be an effective means of encouraging the development of and attitude towards life long learning skills. The group project approach used in the study was designed to enhance and promote self-management, project planning and communication skills in the participating students.

The group project required students to investigate the use of a load-cell as a counting device. This required teams of students to design, construct and calibrate a load cell and consisted of several phases: materials investigation and selection, programming, design, data collection, analysis and finally calibration and prototyping. Student teams obtained data on materials, strain gauges and amplifier properties using their own investigation skills; carried out their preliminary work in UTas laboratory space; completed analysis at their own pace and used the design process to integrate the project with academic teaching and instruction.

The group project enabled students to work as a team and be able to consult with technical and academic staff on a more informal and peer level basis. This improved dialogue between the different parties and established a more peer-orientated approach. In the context of the project, staff operated less in an instructive mode and more as external consultant engineers (facilitators) to each group.

Group work

Students were given some material on group work in the first lecture of the course, after the project had been initially defined. The Belbin test, which is a well accepted means of classifying individual traits [5] was discussed in class, mainly with respect to how the test could be used to optimise group members. Each student was asked to complete the test individually. This test was designed to highlight to the students, the different roles that people play in teams. Students were also advised to consider forming multidisciplinary teams due to the nature of the project. Having provided this introduction to the formation of teams, students were left to form their own teams. It was interesting to note that only two teams elected to form multidisciplinary teams (as documented in their final project reports).

STUDENT ASSESSMENT

There has been much discussion on the merit of various means of evaluating student work in Australia during recent times [6]. Issues such as over assessment, quality of assessment, equity and participation, web-based approaches and the balance between formative and summative assessment have been widely debated.

The assessment for the new unit was based entirely on course work, but using tutorial and assignment to ensure that individuals could differentiate themselves from the group. The assessment criteria stipulated in the student unit synopsis handed out in the first week of lectures were as follows.

Tutorial (individual)	10%
Test (individual)	10%
Progress report (group)	10%
Assignments (individual)	10%
Design report (group)	50%
Presentation (group)	10%

The approach adopted was considered to be a reasonable balance between group and individual activities, however it was intended to evaluate these aspects after final assessment was made of student grades in the unit.

PROJECT OUTCOMES

Impact on Student Learning

The modifications to the teaching program appear to have improved student learning in the following essential areas.

The project-based unit has enabled participating students to develop their communication skills by learning in context. The group work has encouraged them to use flexibility in approach, generate dialogue, and assist in their preparation for the real world of unstructured learning.

Since the work was project based there was a sharing of skills among the team members and development of the "team spirit" concept that is a very important aspect of professional engineering practice.

Students were able to enjoy self-paced learning, within general guidelines set by the School. Students were required to meet goals set over the semester to ensure that students did not lag too far behind their peer group, and thus subject themselves to undue hardship and distress.

Students enjoyed a more stimulating exploration of engineering principles and better resources for learning.

These outcomes were most clearly demonstrated by the final student presentations. Students were given 10 minutes to demonstrate the operation of their load cell, and give a short presentation on the design, construction and calibration aspects of the project. As all students completed essentially identical projects, the academic staff suggested to them, that they give the presentation a "sales pitch".

The student presentations demonstrated great innovation and variation. One group chose a television sales program style, with cuts to a group member interviewing people in the street using pre-recorded videos.

Student Perspective

A student questionnaire was developed and used in order to measure the effectiveness of this project from the student perspective. The questionnaire was completed by the students in the week following the group demonstrations and presentations of the findings of their projects. The questions and results of the questionnaire are provided in Table 1.

Questions one and two indicate that broadly, the students found that the project fulfilled its aim of both helping them to understand and apply the theoretical coursework, and that they achieved more as a group than they could have individually. The common problem of distribution of tasks within the group was highlighted by question 10, indicating a wide spread of opinion on whether the group work was spread evenly amongst members.

The overall response to the questionnaire was that students appeared very satisfied with the unit. Students indicated very positively that adequate time was allocated to the unit (question 4) and that group members worked and cooperated well together (question 9).

A more detailed statistical analysis of the questionnaire is being undertaken and that data will be available at the time of the conference.

TABLE I

UNIT QUESTIONNAIRE (RESULTS IN PERCENTAGES)

	Question	SA	A	N	D	SD
1	Working on the load cell project helped me to understand the application of the theory taught in the course	23.5	76.5	0.0	0.0	0.0
2	Working in a group allowed me to achieve a better result than I could have alone	23.5	55.9	17.6	0.0	2.9
3	I enjoyed presenting the results of my project to other students in the class	26.5	26.5	29.4	17.6	0.0
4	Sufficient time was allocated to the project over the semester	26.5	67.6	5.9	0.0	0.0
5	I felt that I could access extra information from technical and academic staff when I needed it	0.0	73.5	20.6	5.9	0.0
6	My group had sufficient time using the data trolleys and laboratory space to complete the project requirements	8.8	58.8	23.5	5.9	2.9
7	The laboratory sessions provided me with the skills and information required to tackle the group project	14.7	67.6	17.6	0.0	0.0
8	Presentation of the project allowed me to demonstrate what I had learnt in this subject	8.8	47.1	35.3	8.8	0.0
9	The group that I was a member of worked and cooperated well together	29.4	61.8	5.9	0.0	2.9
10	In my group all members made an (approximately) equal contribution to achieving the project goals	17.6	50.0	14.7	11.8	5.9

SD= Strongly disagree
D = Disagree
N = Neutral
A = Agree
SA = Strongly agree

STUDENT GRADES

The distribution of grades achieved in the unit was as follows. UTas awards Pass (50-59%), Credit (60-69%, Distinction (70-79%) and High Distinction (80% +). The distribution for the new unit is provided in Table 2 and compared with the guidelines considered as appropriate for second year units by the Faculty of Science and Engineering.

TABLE 2
DISTRIBUTION OF STUDENT GRADES

Grade	% Student Cohort	Guidelines
Fail	0	Nil
Withheld	1	
Pass	3	Nil
Credit	20	Credit or better <55%
Distinction	34	Credit or better <55%
High Distinction	35	Less than 10%

Table 2 shows that the distribution of student grades did not fit the distribution expected by the Faculty or even the School. A request for information to defend these grades was made at the School assessment meeting. Results obtained by the same class of students in other subjects in the same semester were within the normal range of results indicated in the guidelines summarised in Table 2. More senior staff members in the School expressed concern about the assessment process used in the unit.

The grades were awarded to students on the basis of the group reports and work outcomes fulfilling criteria set during the year. It was found that the students achieved the criteria set for them, and in the final group reports and presentations of their projects demonstrated their enthusiasm for the subject through their innovative and entertaining project demonstrations and reports. The work produced by many groups clearly achieved the objectives of teamwork, and the results demonstrated that the teams had in fact produced a higher standard of work than most students would individually achieve. The Head of School will be required to provide a similar explanation to the Faculty as part of the normal assessment quality assurance system.

The criticisms of staff have, however, been considered, and the assessment procedures will be reviewed before delivery of the subject in 2003. It was considered that providing some more opportunities for individual assessment could help refine the unit. This may include individual assessment within the group work. This should not be at the expense of the group.

It is important to consider this unit, with the flexible teaching and group assessment, within the framework of the course year and degree program as a whole. Clearly it would not be beneficial to the course if all subjects were taught or assessed in the manner described in this paper. However, this unit is valuable and should not be discarded in favour of using traditional assessment of deep learning through summative end of year examinations in every subject. The project has allowed students to explore teamwork and a multidisciplinary engineering task in a flexible, and enjoyable way.

CONCLUSIONS

A new unit entitled “Experimental Design and Analysis”, introduced to the second year engineering course at the University of Tasmania, has been described. The course was designed to give students exposure to some of the multidisciplinary aspects of engineering, through a group project in parallel with formal lectures and tutorials.

The results of a student survey, and feedback from final presentations of the project, indicated that students enjoyed the project, and found that they achieved more in groups than they could have working individually. One aspect of the unit, which was highlighted both by the student questionnaire, and review of the student grades, was the difficulty of assessing individuals in a unit with a significant amount of group work. The student responses indicated that a significant number felt that there had been a disparity in the work allocation within the groups.

An increase the amount of individual assessment will be considered in the refinement of the unit for 2003. It is important that this does not come at the expense of the advantage of this unit in building group work skills in the students. Further discussion of effective group work and team building will also be incorporated into the unit.

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REFERENCES

[1] Jones, B., Valdez, G., Nowakowski, J., & Rasmussen, C. “Designing learning and technology for educational reform.” *Oak Brook, IL: North Central Regional Educational Laboratory.* 1994

[2] Candy, P.C. “Knowledge navigators and lifelong learners: producing graduates for the information society.” *Higher Education Research and Development Journal*, 17(3), 2000, 261-277.

[3] Gokhale, A.A.. “Collaborative learning enhances critical thinking.” *Journal of Technology Education,* 7(1), 1995, p7.

[4] Office of Instructional Consultation, University of California. (2000). “Differences between collaborative and cooperative learning.” http://www.id.ucsb.edu/ICResources/Colab-L/xxx.html.

[5] Belbin, R.M., “Management Teams - Why they succeed or fail”, 1981, Butterworth Heinemann

[6] James, R., and McInnis, C, “Strategically re-positioning student assessment”, Discussion paper, Centre for the Study of Higher Education, University of Melbourne, 3010, Victoria, Australia