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# STUDENT LEARNING STRATEGIES IN MECHANICAL ENGINEERING DESIGN

S. Kanapathipillai, N. Feng and D. Magin

## Abstract

The study reports findings from administration of the Biggs SPQ instrument to two cohorts of students (1993 and 2004) enrolled in a mechanical engineering design course. A substantial decrease in ‘surface’ approaches to study was found in 2004, but there was virtually no change in the ‘deep’ approach scores. Findings are discussed in relation to changes made to teaching and learning context over this time, and to the suitability of the SPQ instrument.

*Key words: Learning strategies, Biggs Study Process Questionnaire*

## 1. Introduction

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 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, 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.

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’ (SAL) 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 an ‘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 organize 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, we believe it is important to include in the evaluation of learning outcomes in engineering design an effective instrument to measure changes in how students approach their learning.

## 2. 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 study compares the approaches to learning adopted by our current students (2004) with those found for students in the comparable subject a decade earlier (1993). The instrument chosen to investigate students learning approaches is the Biggs Study Process Questionnaire [4] in which students are measured on the three learning approaches – ‘Deep’, ‘Surface’ and ‘Achieving’.

The study has two main aims. The first is to find out whether the course and teaching changes which have been introduced over the last decade have resulted in achieving the goals of promoting conceptual understanding (as indicated by ‘deep approach’ scores), and in reducing surface approaches to the study of mechanical engineering design. The second aim is to assess whether the Biggs Study Process Questionnaire (SPQ) instrument is sufficiently reliable, and sensitive to changes in the teaching-learning environment, to warrant its future use as a standard evaluation tool in engineering design courses.

## 3. 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 which the students have to submit 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 ‘Design and Build’ competition organized by the Institution of Engineers, Australia.

In 1993, 25% of the overall mark in Session 2 was allocated for this program so that students have an active role in such a program to exhibit their skills; a formal examination (25%) was run at the end of each Session and the class assignments (50%) were also assessed.

In 2004, a formal examination (40%) was run at the end of each Session; 30% of the overall mark in Session 2 was allocated to the ‘Design and Build’ competition and the class

assignments (60% worth in Session 1 and 30% worth in Session 2) were also assessed. Each class assignment was graded promptly and comments were passed on to the students before their submission of the following assignment. It facilitated the students to address any shortcomings in their preparation of the assignments. This step was not strictly followed in 1993.

## 4. Methods of analysis and results

The shortened 21 item Biggs SPQ was administered to students at the end of session 2. Student responses were analysed to provide scores on each of the three main approaches. The data were analysed to provide means and standard deviations for the two groups on the three scale scores, and the differences compared. In addition, reliabilities were calculated using the conventional Cronbach alpha method [5]. In addition, results from a student opinion survey used by the Faculty of Engineering at UNSW are reported. These surveys are given to students at the end each Session to ascertain their opinions on teaching resources and teaching effectiveness.

### 4.1 SPQ results

Table 1 displays the means and standard deviations of scores for the two cohorts, based on responses from 45 students in 1993, and 89 students in 2004. No significant change between the two cohorts was found in the Deep Approach scores. However there is a substantial and statistically significant, drop in the Surface Approach scores. The 2004 students had a mean score which was 0.80 standard deviations lower than those obtained in 1993 ( $p < .001$ ). This is considered a quite large difference. The scores for the 2004 students on the Achieving approach were significantly higher than in 1993, representing an increase of 0.8 standard deviations ( $p < .001$ ).

Table 1: Learning Strategy Results (Biggs, SPQ)  
Comparable second year mechanical engineering design subjects

SUBJECT		APPROACH		
		SURFACE	DEEP	ACHIEVING
MECH2100 (1993) N = 45	Mean	21.04	21.46	18.95
	Standard Deviation	4.11	4.41	5.08
MECH2102 (2004) N = 89	Mean	17.94	20.33	22.93
	Standard Deviation	3.68	4.16	4.54

The reliabilities for the ‘deep’ and ‘achieving’ scales were found to be highly satisfactory. For the ‘deep’ scale, the reliability coefficients were 0.75 in 1993 and 0.67 in 2004; and for the ‘achieving’ scale were 0.78 and 0.70 respectively. According to Biggs et al.[4, p.142] reliability coefficients above 0.6 are quite acceptable for the SPQ. However, the reliabilities for the ‘surface’ scale scores (0.57 in 1993 and 0.52 in 2004) were slightly below this criterion (table 2) .

Table 2 SPQ scale scores: Reliability coefficients 1993 and 2004

	Cronbach alpha reliability coefficients		
	SURFACE	DEEP	ACHIEVING
MECH2100 (1993) N = 45	0.57	0.75	0.78
MECH2102 (2004) N = 89	0.52	0.67	0.70

## 4.2 Student opinion surveys

Analysis of the student responses indicates that student ratings of this subject continue to improve over the last several years. In 2004, over two thirds of the students expressed their satisfaction on lecturer’s effective communication and also stimulation of interest in the subject. Over 70% of the students felt they were encouraged to learn independently and develop their own understanding of the subject area. 85% agreed that links between subject area and other areas of the profession have been explained.

## 5. Discussion

The changes made since 1993 were implemented to produce a teaching-learning context which would promote deeper understanding and discourage surface approaches to design learning. There has been a reduction in the use of surface learning approaches, but no evident change in promoting deep approaches to learning.

We cannot claim that the reduction in undesirable surface approaches has been brought about by these changes, since we have no way of measuring the extent to which students entering the university in 1993 differed from their 2004 counterparts in terms of their expectations and preferred learning approaches. However, recent research findings have confirmed that ‘...elements of the learning environment which are under teacher control can, and do, positively influence the way students approach their study, and the learning outcomes they may achieve. Thus, interventions, if appropriately conceived and implemented, can and will ‘make a difference’ [6, p.44]. What can be said from our findings is that the reduction in surface approaches was substantial, and consistent with changes made to the teaching-learning context.

The second aim of the study was to find out whether the Biggs SPQ instrument would be sufficiently reliable, and sufficiently sensitive in detecting change over time to warrant its regular use as an evaluation tool. Whilst the reliabilities of the ‘surface’ scales were lower than found in other major studies, our overall judgment is that the SPQ does provide a useful

tool for our purposes. Further, in finding changes between the two cohorts of almost one standard deviation for the surface scores (0.8 s.d.), and similarly for the achieving scores (0.8 s.d.), the instrument appears quite capable of detecting change at a statistically significant level for the size of our classes.

## 6. Concluding remarks

Developing students' understanding of the design process is a major challenge for teachers within engineering design courses. There is the challenge of implementing productive ways of teaching and assessing students' design skills and conceptual understanding; and that of finding and employing instruments which can adequately monitor how successful the course experience has been in meeting this challenge. We are convinced that the Biggs SPQ is an effective tool for measuring changes in our students' approaches to learning, and plan to use this instrument at the beginning and end of the semester in our second-year mechanical engineering design course each year. We believe the SPQ would be suitable for use in this way in many other design teaching contexts, and recommend to our engineering design colleagues that they consider trialing this instrument in their design courses.

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