Interventional Strategy for Engineering Education

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Abstract

Dropping out of university study is common and causes huge problem to university teaching and administration. This problem is particularly acute in first year university teaching and measures to achieve high retention rate are important. The problem is compounded with the use of problem-based learning method which requires high degree of autonomy for students' learning process. Study shows that the quality of teaching, especially that of first year teaching, is of primary importance to maintain students' enthusiasm and interest in their study.

This paper describes the measures put in place to capture the students' interest in the teaching of a first year engineering subject. The measures are both pedagogic and administrative, resulting in a large number of students entering into Civil Engineering from a common first year engineering course. The measures include sessions to train tutors for small class teaching, the use of online administrative and assessment tools, curriculum changes and course design. The paper also describes the use of problem-based learning method for the teaching of this subject. However, caution is given for using this learning method for first year students and adjustment has been made for adaptation for first year engineering teaching. Analysis of the intake data shows the effectiveness of the measures since their introduction.

Introduction

First year retention rate has been the subject of much research by universities. It has been a common view that a large proportion of student dropout occurs during the first year of university study. Clark and Ramsay (1990) recommended a number of measures to increase retention rate at universities. They include (1) assistance to students, (2) forging links with parents and secondary schools, (3) comprehensive advising systems and improved teaching, (4) more resources, (5) overcoming attitudinal barriers, (6) involving parents and their children, (7) special assistance for specific groups. Although most of these measures are generally available and provided for by university services, such services may not be suitable to meet the needs for particular courses taught by departments. For instance, advising systems provided to students may only help the students overcome personal and emotional problems, but may not be able to solve their academic problems specific for certain courses. According to Seymour & Hewitt (1997), poor student retention rate and study persistence in science education is related to lack of personal interaction between students and faculty. Improvement of retention rate can be achieved through schemes such as mentoring and advising programs.

Fortenberry et. al. (2007) found that hands-on projects contributed significantly to the increase in first year retention rate. Study by Hartman and Hartman (2006) shows that to achieve higher retention rate, project-based interdisciplinary teamwork is important while their program does not differentiate much between male and female students. It is believed that small class teaching is essential in providing advantageous learning environment and facilitating interaction amongst peers of the students. The class sizes in Hartman & Hartman (2006)'s study do not exceed 35. Study by Budny et. al. (1998) shows that supplementary counselling and tutorial programs would improve the grade point average and hence the graduation rate of students. It has also been shown by Allen (1999) that motivation plays an important role in contributing to the students' success and persistence for minority students.

Background to engineering course design

A study by Power et. al. (1987) found that over 60 per cent of students did not know much about the university courses they chose. Obviously, there would also be the case for students who do not know much about the disciplines of engineering when they first start their course. The high dropout rate, some reported more than 40% in engineering (Budny et. al., 1998), in first year study had prompted the author to search for a way to achieve a higher retention rate for first year students. The common first year engineering course at Monash University provides the students an opportunity to select an engineering discipline at the end of their first year study when they have a fair amount of knowledge about all engineering disciplines available at Monash. In addition to the general core subjects in science and others, each engineering department at Monash is responsible for offering to students at least a subject in areas related to its own discipline. Often, anecdotal evidence shows that students' choice of engineering disciplines for start of their second year study is very much influenced by the quality of teaching provided by the different engineering departments in first year. Therefore, in our case at Monash, a way to achieve higher retention rate for students also has the benefit of attracting more high calibre students to study Civil Engineering.

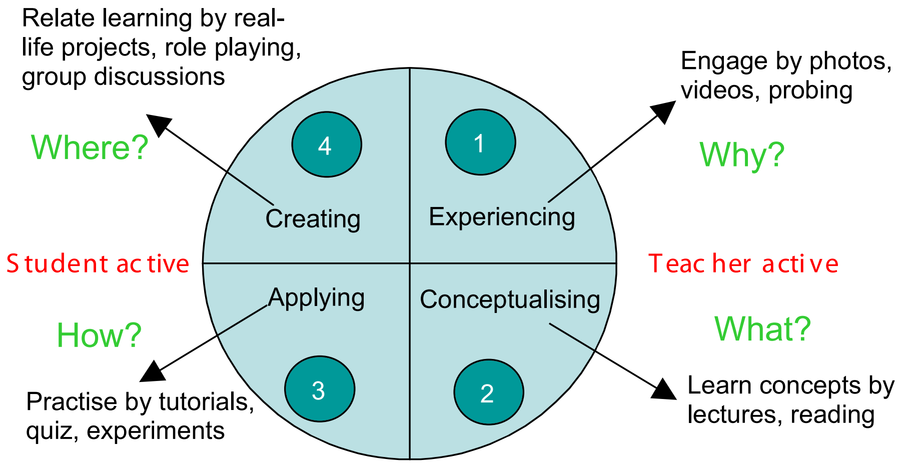
In this paper, an Engineering Structures course is described. This course, containing largely engineering statics in its syllabus and being offered by the Department of Civil Engineering in the common first year program, was designed to include special features that would be beneficial in improving the retention rate for students. These special features include the use of problem-based teaching strategy, weekly supplementary counselling for students, group work and hand-on projects, small class for engineering practice and special training sessions for tutors. In the context of the common first year engineering program at Monash, these features help students to increase the performance in the Engineering Structures course and, as a consequence, to attract more students to choose Civil Engineering as their major.

With this aim, our course was designed by following the philosophy of learning cycle as shown in Fig. 1. Indeed, the attributes which contribute to enhance students' interest in learning and consequently help increase the student retention rate as described in the 'Introduction' above are part of the learning cycle as depicted in Fig. 1. We found that by going through the four stages of experiencing, conceptualising, applying and creating in our course, the students would have been motivated and became more engaged in their learning. In the following, we describe the course elements which form part of the basic cycle of learning in the design of the course.

Problem-based learning

The Department of Civil Engineering at Monash adopts problem-based learning philosophy as its mainstay teaching method for all the subjects. This teaching method is known to enable students to have deeper understanding of the subject matter and to become self-starter learners. It gives the students a learning environment in which independent learning in a small group setting ideally simulates the realistic working condition in engineering profession. With experienced learners, this method works well and the students are more engaged and motivated in their study. However, this teaching method requires the students to go through a grieving process with strong emotion before confidence returns (Woods, 1994). The length of the grieving process depends on the degree of shock of 'change' the students are subject to. Our experience indicated that first year students took a longer period, up to a few weeks' time, to overcome the grief because of the transitional change they experienced from high school to university. To lessen the stress imposed on the students and to reduce the loss of time in a relatively short semester, we decided to have a closely monitored and guided problem-based teaching method for first year students. This modification includes more learning materials supplied to the students while retaining a high degree of flexibility in their learning. The flexibility with high degree of independence is increased at higher levels of the degree course.

Fig. 1. Basic cycle of learning



In the Engineering Structures course, the students are given two real-life engineering design projects with clear objectives. The aim is to enable the students to gain an insight into a complete structural design process. For instance, the students may be asked to design a truss bridge structure connecting two campus buildings. To complete the project, the students need to determine the location of the bridge, measure the site area, derive the dead and live loads from first principles, carry out structural analysis and finally choose the appropriate member size for the structure. Therefore, the content for this subject needs to include topics such as material properties, load estimation, use of design codes and engineering design tables for structural members, all of which are normally not included in first year Statics syllabus. The requirement for the students to submit a group design report enables them to work in small teams in a manner similar to their future work environment. We found that the students were enthusiastic in carrying out the projects and had tremendous satisfaction when the projects were completed.

Experiential learning

Students are more engaged in learning when the concept is connected to real life examples. Our teaching therefore includes many structural examples in the form of photos, videos and case studies. Students are always impressed and learn effectively when structural failures are discussed and analysed in details. One particular incident that we adopt to use as teaching material is the collapse of the suspended walkway at Hyatt Regency Hotel in Kansa City. Students are involved in the discussion of the original and modified design of the walkway and its implication when converting the design into visible shear force and bending moment diagrams. The effect of going through this incident on the students' learning is profound and the lesson learned from the failure is deeply engraved in students' memory.

Study should not always be dull and uptight. Sometimes there should be fun while learning. The Engineering Structures course has a practical component for which the students are required to build a paper bridge to support a road way across a virtual river. Specifications for the dimensions, the loads and rules for construction are given. The bridge will be tested for its strength when a steel cart runs over it. A competition is held in class so that the team which builds the lightest bridge is the winner. This task proves to be useful for students to make use of their knowledge in truss analysis and design while having an enjoyable fun day for the competition. A typical testing day for the bridges is shown in Fig. 2.

Fig. 2. Paper bridge competition

Assistance to students

Due to the transition from seconding school to university, first year students need more caring and counselling than those in later years. For the students enrolling in the Engineering Structures course, a twice-weekly counselling session is provided at a help desk during lunch time. Not only does this help desk answer students' technical questions, but also refers students to services for personal reasons. This help desk becomes popular, particularly towards the end of the semester when work deadlines are approaching. This help desk continues until the examination is over.

The Faculty of Engineering at Monash also provides special English training, including report writing and presentation skills, for all students. This service has been found particularly useful for students with English as their second language.

The Monash University online teaching management system enables the students to get information, conduct discussion, communicate with lecturers and tutors, and manage their progress of study. Two online practice assessments, which give instant feedback for students' assessment results, are also provided to the students.

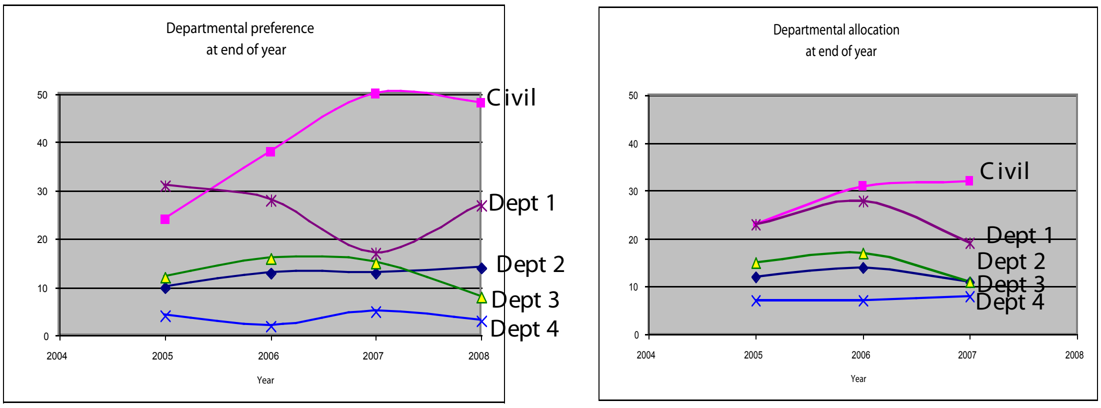
Tutors

Students enrolling in the Engineering Structures course are required to attend weekly tutorial class. This tutorial class is important for students to gain more in-depth understanding of the concept taught in lectures. To facilitate interaction and discussion between tutors and students, we place emphasis on small classes with a maximum of 20 students for each tutor. All tutors need to go through a 2-day training provided by the Faculty. In addition, a senior tutor is available to give the tutors a briefing on the subject matter during the week prior to the class. In this way, the teaching in all tutorial classes is consistent and the quality ensured. The tutors are usually chosen from currently enrolled postgraduates who take up this job as part of their postgraduate training.

Results

In the past, teaching of engineering statics was a monotonous and disengaging task. Students were taught with arbitrary assumptions without knowing how those assumptions are derived and the purpose of carrying out those calculations. Some years ago, changes were made as a result of a review of the syllabus. It was decided to adopt fully the philosophy of learning cycle for the Engineering Structures course and to implement the student assistance schemes as described above. The effect of this interventional strategy has been strikingly imposing, resulting in high demand for the Civil Engineering course at Monash and attracting high calibre students into the department. The results are shown in Fig. 3.

Fig. 3. First preference for choice of engineering disciplines



(a) Students' first preference	(b) Places allocated

Fig. 3(a) shows the first preference of engineering disciplines indicated by students at the end of their first year study. It shows that the demand for Civil has been steadily increasing since 2005 when the interventional strategy was first implemented in 2006. Over the years from 2005 to 2008, the first preference for Civil has increased by 100%, from about 25% to about 50% of the total second year engineering intake, topping the preference choice amongst all departments.

When actually allocating the students, some adjustments had been made because some departments placed pre-requisites for their courses although these pre-requisites are minor. For the Department of Civil Engineering, in principle there was no pre-requisite for entry. However, because of the high demand, not all students could be admitted into Civil and some re-distribution was made as shown in Fig. 3(b). Nevertheless, Civil still had the highest intake. The re-distribution was based on the average marks of the students who chose Civil. Students with higher average marks would be admitted into Civil first. In this way, Civil was able to attract many high calibre students to its course.

Conclusion

An interventional strategy for assisting students to improve their learning environment has been implemented in an engineering statics subject since 2006. This strategy includes providing weekly help desks, training of tutors, use of problem-based teaching method, and a revised curriculum based on the philosophy of learning cycle. The implementation of this strategy has proved highly successful, increasing the first preference for studying civil engineering by about 100%. The high demand for Civil has attracted high calibre students to the Civil Engineering course.

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