Blended and innovative teaching strategies for a first year mechanics course

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Abstract: *Engineering mechanics should provide an exciting challenge and give students a sense of satisfaction as they develop the fundamental insights and capabilities that they will carry into their professional lives. Unfortunately, what should give students an opportunity for professional development becomes, for many students, a difficult and unpleasant hurdle. Pass rates are often low and the result satisfies neither students nor staff. The objective of two lecturers sharing a first year mechanics course was to implement strategies to keep students interest and improve student performance; both objectives were achieved with great success.*

Introduction

Mechanics is one of the hardest courses for mechanical engineering students. In particular, the first year mechanics course moves at a fast pace and covers a huge amount of material in two subject areas: statics and dynamics. Within each subject there are many topics to cover which is of a compound effect, that is, a new topic draws upon the fundamentals of preceding topics. Universally, the major lament of lecturers of first year mechanics is that the students rapidly lose interest and hence fall behind, resulting in large failure rates, student disatisfaction with engineering and lack of enthusiasm for students to willingly participate in future mechanics courses. Furthermore, lecturers of first year engineering courses have previously relied upon students entering university with a good knowledge of basic mechanics. However, in recent years, first year engineering classes have significantly grown in size. As a result, there is a dramatic increase in the variability in the background of first year students, particularly in students' prior knowledge in mathematics and physics, which are basic requirements for mechanics (Clements, 2006). Recent studies in the UK have shown that changing curriculums in mathematics and mechanics at secondary schools greatly affects students' performance in first year university engineering mechanics (Lee *et al*. 2008). Student performance at university cannot be reliably predicted from performance indicators gained in school examinations (Adamson and Clifford, 2002).

The objective of two new lecturers to teaching this course was to implement strategies to (i) keep students interest and (ii) improve student performance, taking into account the variability in the background of students. This was achieved by taking the following action: (1) introducing a web-based on-line tutorial system with weekly exercises and assessment, (2) introduction of variety of group project tasks for better interaction among the students, (3) set-up of laboratory projects which were conducted by students independent from supervision, and (4) development of students written communication skills through the compulsory maintenance of a log book for the on-line exercises and formal pratical reports for the laboratory projects. These assessments were in addition to regular tests to reinforce lecture material. The various on-course activities and assessments were delivered in a well balanced time schedule to keep the students motivated and maintain their interest in the course.

At the end of the course, no scaling of marks was conducted and the students' performance in the final (and challenging) exam was outstanding. Student feedback stated great enthusiasm for both the web-based tutorial software system and practical hands-on with lab-based projects. It was obvious from marking the final exam that the majority of students had developed a clear understanding of the fundamentals of engineering mechanics in practical real-life examples. Furthermore, since one of the biggest criticisms of engineering graduates from industry is that graduates do not have well developed report writing skills, guidelines on how to write a report were given to students and feedback on their reports was provided. Student feedback stated that feedback on their reports was greatly appreciated.

Implementation of activities to encourage student learning and motivation

1. On-line web-based tutorial software system (Statics and Dynamics)

We introduced an innovative computer based tutorial system (Scott and Stone, 1998) for the first year mechanics course taught in the School of Mechanical and Manufacturing Engineering at the University of New South Wales. Using this system, the students were required to conduct and submit their practice and assessed tutorial questions using the on-line web-based system. Answers for both the practice and assessed questions required three components – the sign convention, the numerical solution to several significant figures and the units. Students were given practice and assessed questions on a weekly basis. Each student had identical questions but with different numbers. The on-line web-based tutorial system was tailored to meet the needs of the students and generate motivation. To achieve this, solutions to the practice questions were available immediately. Solutions to the assessed questions become available after a due date. The students could attempt the assessed questions as often as they wished before the due date without loss of marks if their answer was incorrect (in the original system, marks were lost for every incorrect answer). By removing the restriction on the number of attempts for the assessed questions greatly motivated the students to obtain good marks for the assessed component of the on-line tutorials, with the majority of students obtaining full marks for the assessed questions.

To complement the web based tutorial system, we instructed the students to neatly document all their working for the tutorial questions in a log book. The log book was a compulsory component of the tutorials. This trained the students to develop good habits in the layout of their problem solving skills, as well as enabled the students to efficiently revise their previously worked out practice and assessed tutorial questions.

Student performance in comparison to previous years demonstrates that the computer based tutorial system has assisted the students in gaining a significantly greater understanding of the course material. The students greatly appreciated and enjoyed the use of the web-based tutorial system. This is evident in their course evaluation surveys. The formal UNSW Course and Teaching Evaluation and Improvement (CATEI) survey feedback comments from the students showed that the students were very receptive to our teaching approach and attitude.

"I loved the online tutorial problems. They formed the majority of my study and homework time and so overall I found them a fantastic way to consolidate the material."

"The online tutorial questions were of extreme benefit. Had they been set from a textbook, I wouldn't have done them, but because they were online, I did. The worked solutions were a great idea, as is the multiple attempts for the Assessed Questions."

"The online tutorial system was an effective way of reinforcing the material learnt in class."

"The online tutorial system is very good, and the lectures were also well prepared and conducted."
"Online tutorial - it rules!!!"

2. Individual and group projects (Statics)

A project on truss analysis was introduced in the first week of the semester to enable students for greater participation in group work while performing an individual task. The project had two components; (a) analysis of a given truss shown in Figure 1 with 7 different parameters (L_1, L_2, L_3, P_1, P_2, P_3 and P_4) based on the students' 7 digit student number, and (b) a group task to investigate two real life trusses for analysis with set questions.

The individual component of the truss project was written in such a way that every student experiences a new example due to the parameters being set based on their student number. Details on the individual and group components of the truss project are given in Appendix 1. The unique way of evaluating their answer was through the development of an automated spreadsheet using macros in Microsoft Excel. This enabled the saving of a huge amount of tutor resources (at least 60 hours) for correcting the project submission of 250 students. The entire project enabled the students to work independently as well as work together with the allocated working groups for students using WebCT Vista. This task was to encourage and motivate student participation and discussion in and out of the class.

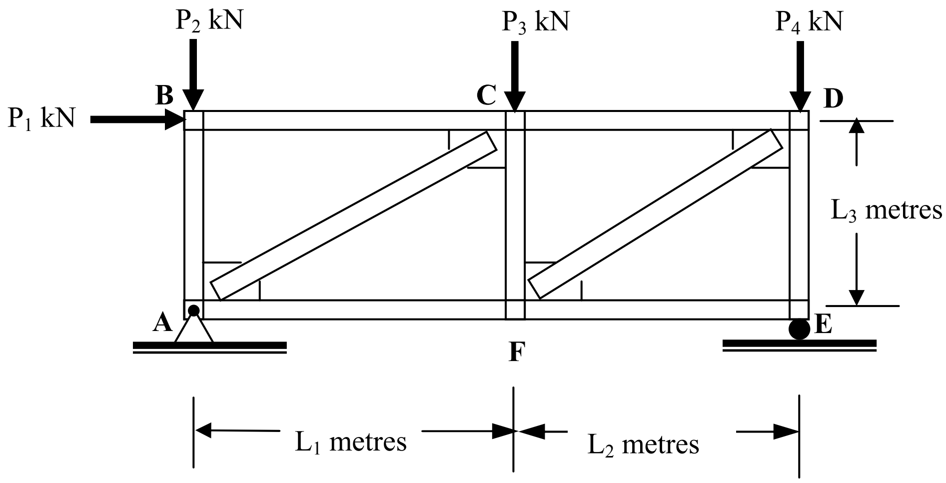


Figure 1: Typical truss diagram used for the group project

This group task was introduced early in the session which gave ample opportunity for the students to work in a group for a task which was fun, educative and creative. Since the formation of groups using WebCT Vista, the entire class bounced at least 1300 mails to discuss amongst themselves how to execute their allocated task.

3. Individual laboratory project (Dynamics)

In the dynamics component of the course, a hands-on laboratory project was introduced titled Motion of a Rolling Disk down an Incline, as shown in Figure 2. The project consisted of three parts; (i) the experimental component in which the students were required to take measurements, (ii) an analytical component in which the students were guided on derivation of an expression (of the time it took the rigid body disk to roll a certain distance down the incline), and (iii) a computational component in which the students were instructed to use a software package such as Excel or MatLab to graphically present their results. The students were given guidelines on the format of their individual practical reports, with the aim to develop their technical writing skills as engineers. The students were able to access the experimental rig and take measurements without supervision, which saved substantial tutor resource time. Students were given substantial feedback on their reports.

The students greatly appreciated their group and individual project work which is evident in the following feedback comments from the students in the CATEI summary:

"Useful knowledge for application. Develop my thinking and problem solving skills."

"Practical Applications of Statics and Dynamics were useful because the course is not just theoretical; it had some kind of use to the physical world."

"The best feature of this course was the labs."

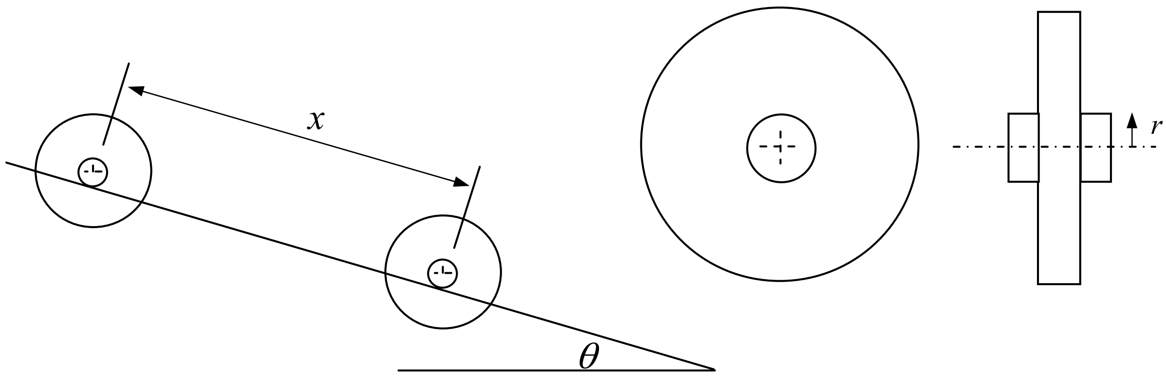


Figure 2: Schematic diagram of a disk rolling down an incline

4. Lab week task (lawnmower exercise for statics component)

In the School of Mechanical and Manufacturing Engineering at the University of New South Wales, a Labweek was organised to run during the mid semester break. In Labweek, all students were encouraged to participate in a collection of manual and theoretical exercises involving a lawnmower. These exercises included calculating the forces and torque generated by the combustion pressure in the engine. Combustion pressure was measured using a piezoelectric pressure transducer. Other forces such as friction, gravity and dynamic forces were neglected in the exercise (that is, components were assumed to be mass-less). Based on positive feedback of student experience and enthusiasm in the lawn mower exercise, a group project was developed for the first year mechanics course. This involved using mechanics principles to calculate and analyse the forces that had been neglected in the Labweek exercise. Students greatly enjoyed doing the mechanics project created from the lawnmower exercise, as it confirmed the physical and theoretical relation of mechanical engineering. Their enthusiasm was reflected in their feedback comments:

“The engineering week lawn mower exercise was a fun learning experience. The follow up tutorial task was good because it connected the theory with practical applications. This helped me understand why we were studying this course, which makes studying much easier.”

Impact of teaching approaches

The impact of our teaching the first year mechanics course involving a varied approach has improved student learning significantly. The impact on the student learning is evidenced through the improvements in pass percentages and increase in the average grade, as shown in the chart in Figure 3. Our innovative and inspirational teaching method has had a positive impact on (a) motivation and participation of students in the first year mechanics course, (b) verbal and written, both formal and informal student communication skills, and (c) improved student performance compared to previous years, as shown in Figure 3.

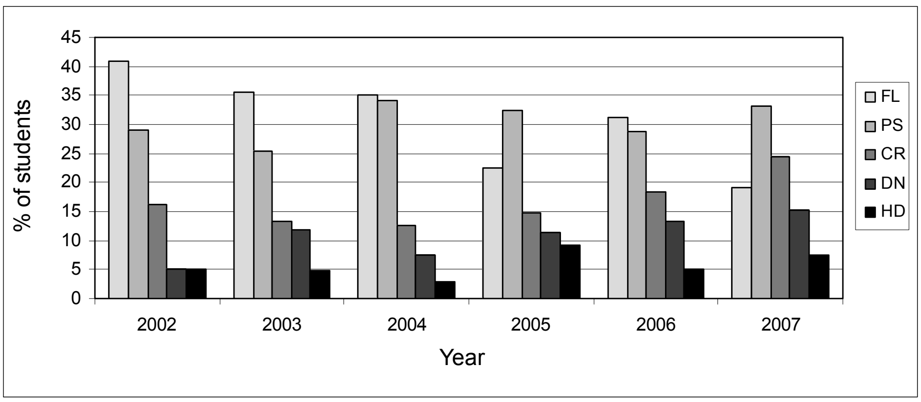


Figure 3: Percentage pass rates and grades for first year mechanics students

The CATEI feedback comments showed that the students were very receptive to our teaching approach and attitude.

"The two lecturers as each taught their respective topics well and used different methods appropriate to that subject matter."

"The course was well organised and set out. There was a clear assessment schedule at the beginning of session and information was regularly posted online to keep students up to date on events and on their marks."

The student evaluation using CATEI for the Engineering Mechanics (MMAN 1300) course reveals that most of the class (94%) have strongly agreed or agreed with the quality of the course. This demonstrates that the range of activities and teaching strategies adopted in delivering the course have motivated the students to perform better. A snap shot from the CATEI evaluation is presented in Figure 4.

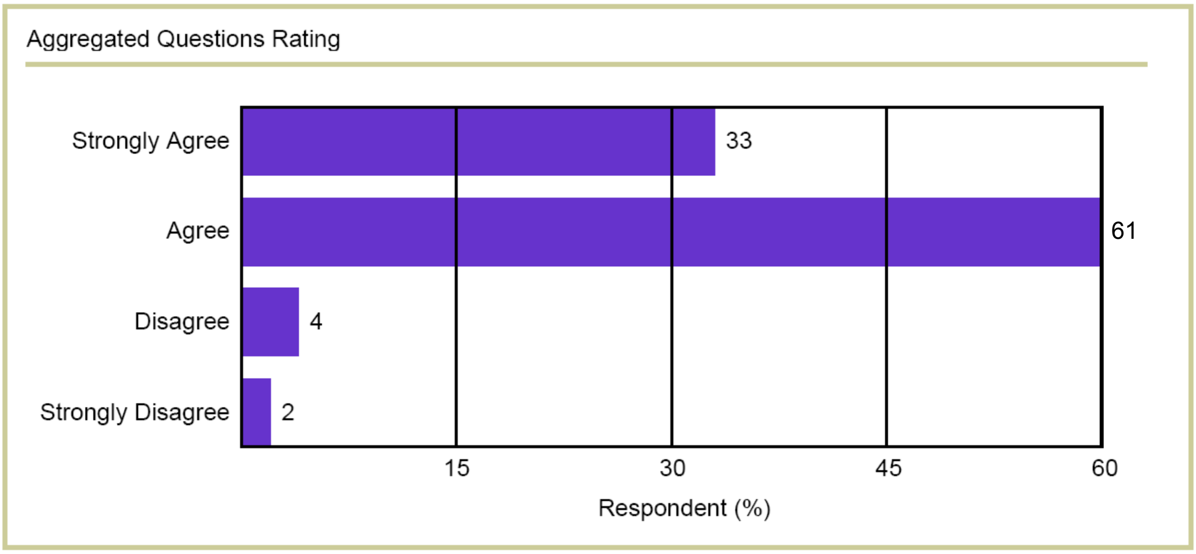


Figure 4: Student satisfaction with the first year mechanics course

Conclusions

The objectives of two lecturers sharing a mechanics course in first year engineering for the first time was to implement a variety of learning strategies to keep students interest and improve student performance. The strategies took into account the large variability in student background in mechanics. Furthermore, another objective of the strategies was to develop and improve students written communication skills, which was shown to assist both local and international students. This was achieved by providing clear guidelines on how to write their practical reports, as well as providing substantial feedback on their reports. Independent student learning was fostered by instructing students to conduct both individual and group based projects as well as tutorial questions without direct assistance from tutors.

References

Adamson J. and Clifford, H. (2002). An appraisal of A-level and university examination results for engineering undergraduates. *The International Journal of Mechanical Engineering Education*, 30(4), 265-279.

Clements, D. (2006). Prior knowledge of mechanics amongst first year engineering students. *Proceedings of Mathematical Education of Engineers V*, 11-12 April 2006, Loughborough University, UK.

Lee, S., Harrison, M., Pell, G. and Robinson, C. (2008). Predicting performance of first year engineering students and the importance of assessment tools therein. *Journal of Engineering Education*, 3, 44-51.

Scott N.W. and Stone B.J. (1998). A flexible web-based tutorial system for engineering, maths and science subjects. Global Journal of Engineering Education, 2(1), 7-16.

Appendix 1: Truss analysis project

The project has individual and group components as described in parts 1 and 2, respectively.

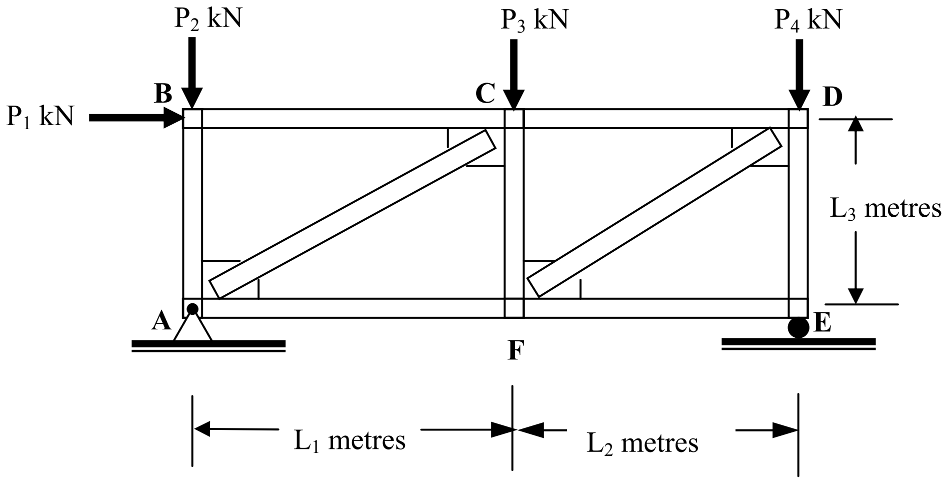
Part 1: Analysis of a truss (individual task)

You are to analyse the truss shown below. Assume that the connections can be represented by pins. Complete the following tasks using the *method of joints* and *method of sections*:

(i) List the forces in each member

(ii) Identify any zero force members

(iii) Draw the force diagram showing Compressive and Tensile members



Part 2: Explore two applications of trusses (group task)

This part of the project enables you to learn about applications of trusses. For it you will be assigned to a group.

In your group, find two suitable trusses, take photographs of them and discuss the following:

a. What does each truss do?
b. What are the loads on each truss?
c. What types of supports are provided for each truss?
d. What types of joints are used in each truss (eg. welded, riveted, pins)
e. Which members in each truss are likely to be in compression and which in tension?