

# Improving On- and Off-Campus Student Performance in Structural Mechanics

Dr Wayne Hall, Mr Clive Ferguson, Dr J. Trevor Jones and Dr Stuart Palmer\*  
School of Engineering and Technology,  
Deakin University, Victoria 3217, Australia

## Abstract

This paper investigates the performance of 329 (173 on- and 186 off-campus) students enrolled in two structural mechanics units at Deakin University, a leader in engineering distance-education in Australia. The two units experience unacceptably high rates of failure. An analysis of the assignment, laboratory and examination marks is presented. Consideration is also given to the total marks. The results show that on-campus students perform better in structural mechanics than their off-campus counterparts. Plots of the student performance distributions for the three assessment methods are provided (for each unit) and high failure rates are linked to low examination marks. Students tend to perform best in assignments and worst in examinations. Parametric statistical tests show a correlation between the continuous assessment and examination marks. To motivate students to fully participate in continuous assessment tasks the authors therefore propose several changes to the assessment criteria and marking schemes.

## 1. Introduction

In recent years, the number of students entering tertiary education has risen significantly and this has had a negative impact on the average intake standards. Thus, failure and withdrawal rates for some university courses have risen to unacceptable levels. The programmes that universities offer need to enable students to be successful [1] and there is therefore a temptation to lower expectations, but this has an impact on the technical competencies of university graduates. To maintain graduate standards it is therefore essential that teaching and learning methodologies are scrutinised before consideration is given to the revision of course content.

For engineering courses, structural mechanics units are often considered to be the most “difficult” and hence, tend to experience the highest failure rates [2]. Two structural mechanics units are offered at Deakin University and both experience unacceptable rates of failure. The authors of this paper are challenged with improving student performance (and pass rates) for these units without revising the course content downwards and therefore impacting on graduate technical competencies. To meet this challenge, consideration is being given to two key issues:

- how the course (lecture and tutorial) material is presented; and
- how the unit is assessed, i.e. the impact of assessment method on performance.

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\*Corresponding author: spalm@deakin.edu.au

This paper investigates the current methods used at Deakin University to assess a student's competence (i.e. assignments, laboratory reports and a written examination) and the on- and off-campus marks in each of these. In doing so, it highlights the underlying reasons why high failure rates occur and then discusses some initial steps the authors are taking to tackle these failure rates.

## 2. Structural Mechanics at Deakin University

The two units Deakin University's School of Engineering and Technology currently offers are: Statics and Strength of Materials (SEM224); and Stress Analysis (SEM312) [3]. These units investigate the theoretical and practical concepts of structural mechanics and are available in on- and off-campus modes. This results in a diverse student population with a significant proportion of the enrolment studying off-campus and/or part-time. SEM224 is a level two unit which comprises two modules - Statics and Mechanics of Materials. This unit addresses the concepts of statics and the fundamentals of deformable-body mechanics. It is the prerequisite for SEM312 (a third level unit) where consideration is given to more complex issues of deformable-body mechanics. The material presented in SEM224 is therefore essential to the understanding of SEM312 and the same prescribed text book is used in both units.

The assessment method for these two units is a combination of continuous assessment - three assignments plus two laboratory reports - and a written examination at the end of the semester. To pass each of these units the total of assignment, laboratory and examination marks must be at least 50% and a suitable mark (at least 40%) in the examination must be achieved. These rules, however, are not rigidly enforced – for example, a pass mark for the examination component is often given to students who attain 37% or above. In order to encourage a sustained effort and promote the development of the required skills during the taught period of the semester, the assignments and laboratory reports carry 40% of the total marks for SEM224, while for the higher level unit this is set at 30%. The contribution of the continuous assessment and examination marks to the total mark is broken down on a component basis in Table 1.

Table 1. Contributions to the total mark for SEM224 and SEM312

Assessment	SEM224 % marks	SEM312 % marks
Assignment	30	18
Laboratory	10	12
Examination	60	70

## 3. Analysis of Mean Performance

To examine the performance of on- and off-campus students, an analysis of the assignment, laboratory and examination marks for the two most recent enrolments - as of October 2004 - was carried out. In the investigation, 194 students (112 on-campus and 82 off-campus) completed SEM224 and 135 finished SEM312 (61 on-campus and 74 off-campus). The mean percentage scores calculated for each method of assessment, i.e. assignments, laboratory and examination marks, together with the mean total marks are given for SEM224 and SEM312 in Tables 2 and 3, respectively. In these tables, the on-, off-campus and combined scores are

listed. Parametric statistical tests are used to analyse the marks, assuming a significance level of one in one hundred (i.e.  $p < 0.01$ ).

Table 2. Mean percentage scores (assignment, laboratory, examination and total) for SEM224

SEM224	Assignment %	Laboratory %	Examination %	Total %
On-campus	75.4	61.7	45.1	55.9
Off-campus	74.9	56.0	45.1	54.9
All (On- and Off-)	75.2	59.3	45.1	55.5

Table 3. Mean percentage scores (assignment, laboratory, examination and total) for SEM312

SEM312	Assignment %	Laboratory %	Examination %	Total %
On-campus	78.2	59.6	52.8	58.3
Off-campus	68.0	49.9	40.5	46.5
All (On- and Off-)	72.6	54.3	46.0	51.8

**ASSESSMENT METHODS:** The highest mean scores in the two units (for both on- and off-campus students) are achieved in the assignment component and the lowest in the examination which has the greatest contribution to the total mark (see Table 1). The mean on- and off-campus assignment scores are 25-30% higher than the corresponding examinations and 15-20% higher than the laboratory marks. Students do tend to perform much better in continuous assessment exercises where there is freedom to iterate through possible solutions without the constraint of a fixed time period. However, a mean examination mark that is so low in comparison (in this case, 30% lower) suggests a failure to relate the theoretical concepts and/or practical knowledge gained in the laboratory to new unfamiliar problems.

**MODE OF STUDY:** For the second level unit (SEM224), on- and off-campus students achieve similar mean scores in the assignment and examination components and hence, similar mean total marks due to the dominant contributions of these two components. The mean on-campus laboratory mark is about 5% higher. While the distributions of assessment marks for on- and off-campus students in SEM224 are not Gaussian, they were similar to each other (see Section 4), permitting a Kruskal Wallis test of population medians. Under this test no significant difference is found in the mean on- and off-campus marks for assignments ( $H = 0.76$ ,  $p > 0.38$ ), laboratory work ( $H = 0.76$ ,  $p > 0.38$ ), examination ( $H = 0.005$ ,  $p > 0.94$ ) and total marks ( $H = 0.06$ ,  $p > 0.81$ ). On-campus examination and total marks in the third level unit (SEM312), however, are significantly better than those for off-campus students; examination ( $H = 8.40$ ,  $p < 0.004$ ) and total marks ( $F_1 = 8.95$ ,  $p < 0.004$ ). An approximately Gaussian distribution for the total marks permitted an analysis of variance comparison of mean marks.

Across the two units, on-campus students tend to perform much better than their distance-education counterparts with higher total marks and lower on-campus failure rates in both units. When considering failure rates, it is important to realise that the authors have taken account of the two criteria (a total mark of at least 50% and at least 40% on the examination)

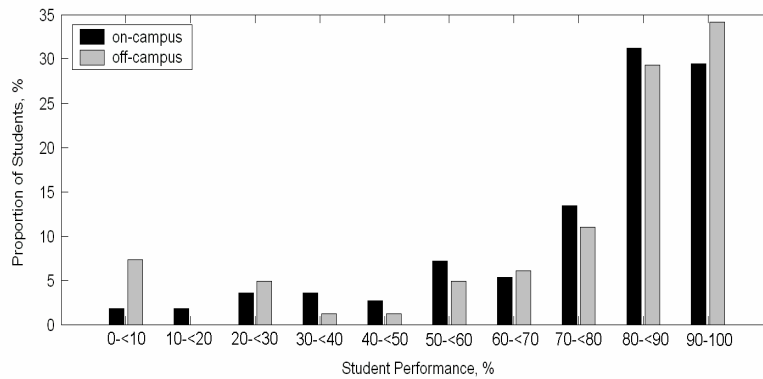
and the aforementioned ‘flexibility’ of the rules as applied to each intake. For SEM224, the on-campus failure rate is about 28% while for off-campus students it is 37%. Failure rates of students in SEM312 are about 30% for on- and 53% for off-campus students. Sample groups are large and random, permitting a Chi-square test of homogeneity. For SEM312, the on- and off-campus failures are found to be significantly different ( $\chi^2_1 = 7.37$ ,  $p < 0.007$ ). If the total marks for the two structural mechanics units are pooled to examine overall performance of on- and off-campus students, the proportion of fails is also significantly different. The on-campus failure rate is about 28% and the off-campus rate about 44% ( $\chi^2_1 = 9.73$ ,  $p < 0.002$ ).

#### 4. Student Performance Analysis

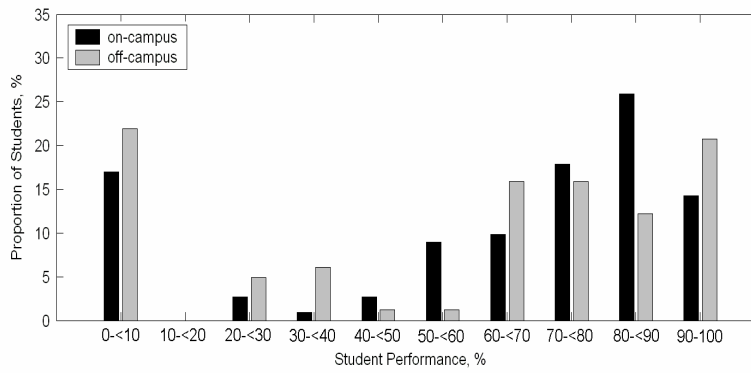
The statistics in Section 3 highlight the trends in mean performance of on- and off-campus students in structural mechanics for each assessment method and, in doing so, raise concerns about off-campus performance in SEM312 and the general examination marks of both groups of students. Whilst useful as a performance benchmark, an analysis of mean marks fails to take into account the spread of on- and off-campus scores and hence, can hide important information. This is emphasised by the comparable mean total on- and off-campus scores for SEM224 but noticeably higher proportion of off-campus students who fail. For this reason, the student performance distributions for each of the three assessment methods are shown in Figures 1 and 2.

These performance distributions highlight the reason why the mean examination marks are low (45.1% and 52.8% for on- and 45.1% and 40.5% for off-campus students) and failure rates are high. Considering SEM224, approximately 34% of on-campus and 40% of distance-education students do not get 40% in the examination (note, these values are higher than the failure rate statistics due to the ‘flexibility’ of the pass criteria). The statistics are even worse for the off-campus cohort in SEM312 where about 50% do not attain the examination hurdle of 40%, and 70% of the cohort score less than 50% on the examination. So, why do students perform so poorly in structural mechanics examinations and why do off-campus students do the worst?

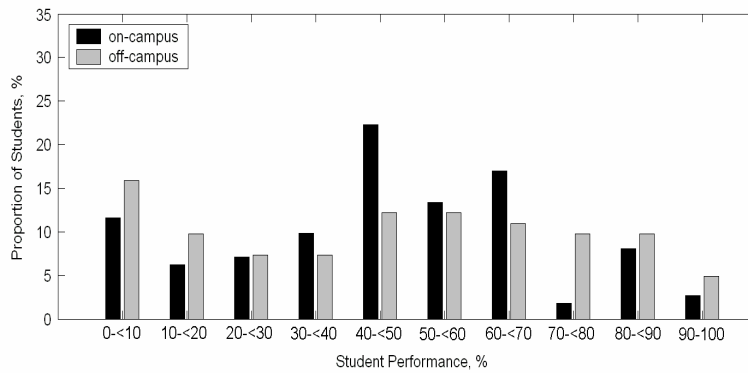
The authors propose that an answer to these questions can be found in the on- and off-campus student attitudes towards the continuous assessment components, and often in their marks. A significant proportion of students gain assignment and/or laboratory marks of less than 10% and a substantial number do not attain 50%. Off-campus students are the biggest offenders, particularly in SEM312 where 20% of off-campus students score less than 50% in the assignment component. For the laboratory component this figure is 42%. A low score in continuous assessment tasks tends to be indicative of an unwillingness of the student to fully participate in all aspects of the unit and a score of less than 10% often implies assignment or laboratory reports are not submitted. These students limit the development of their numerical and analytical skills – such development is the purpose of assignments and the tutorial questions on which they are based – and/or fail to realise the educational value that is gained by periodic reinforcement of theory through experimentation. As a result, these students are more reliant on their examination scores to attain the requisite total pass mark but tend to struggle due to their lack of enabling skills.



(a)

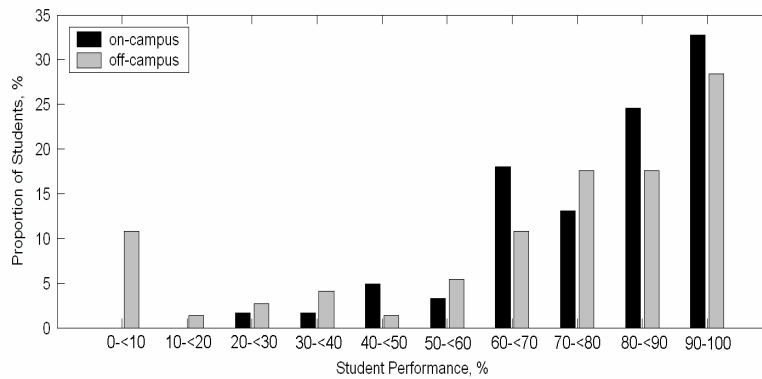


(b)

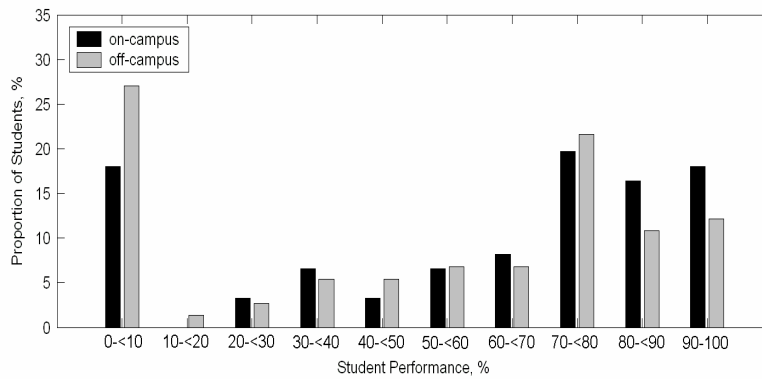


(c)

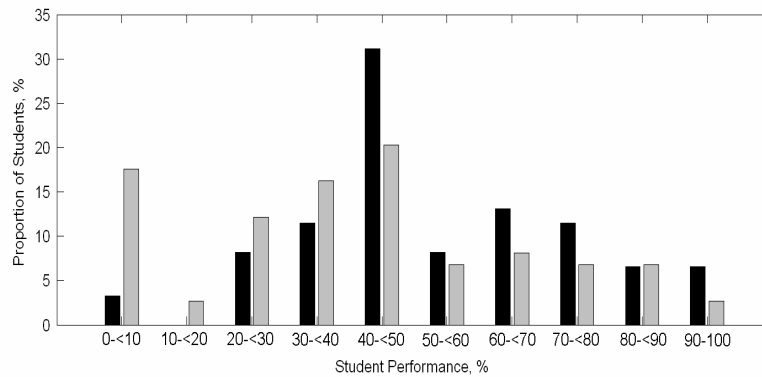
Figure 1. Distribution of on- and off-campus percentage scores for the three methods of assessment in SEM224: (a) assignment; (b) laboratory; and (c) examination



(a)



(b)



(c)

Figure 2. Distribution of on- and off-campus percentage scores for the three methods of assessment in SEM312: (a) assignment; (b) laboratory; and (c) examination

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While some students do perform well in the continuous assessment exercises and poorly in examinations, this is not the general trend. Based on a parametric test of linear correlation coefficient equal to zero, there is a significant correlation between assignment and total marks (for SEM224,  $r = 0.48$ ,  $p < 1.2 \times 10^{-12}$  while for SEM312,  $r = 0.63$ ,  $p < 1.2 \times 10^{-16}$ ) and, laboratory and total marks ( $r = 0.41$ ,  $p < 1.7 \times 10^{-9}$  for SEM224 and  $r = 0.42$ ,  $p < 1.6 \times 10^{-7}$  for SEM312).

## 5. Discussion of Results

The authors postulate that examination marks (and pass rates) will improve if students fully embrace the continuous assessment components and the tutorials on which the assignments are based. Students who choose not to submit assignments and/or laboratory reports or make only a token attempt at them tend to struggle in the examination. These students need further encouragement. Motivation can often depend on the assessment's contribution to the total mark and hence, the authors propose to increase the proportion of the total marks which come from continuous assessment tasks. This increase in the assignment and laboratory marks will be linked to an increase in the amount of work needed for their satisfactory completion. Increasing the workload should enable the assignment and laboratory components to engage a broader range of problems from the curriculum. The intention is to initial trial this hypothesis in SEM312 (semester 1, 2006) where the contribution of the continuous assessment will rise from 30% to 40% (24 marks for assignments and 16 for laboratory reports) of the total marks.

**ASSIGNMENTS:** To minimise plagiarism and further encourage students to fully participate in assignments, the authors intend (over the next two years) to develop on-line assignments consisting of problems that have several possible variations. An excellent example of this concept is given in the work of Deeks [4]. Furthermore, for SEM312, the authors suggest an assignment which reviews the fundamental concepts of SEM224. This proposal is currently being implemented and is needed because the SEM312 in-take standard is often much lower than at the completion time of the prerequisite unit. The flexibility of the modern engineering degree means students often do not transfer directly to the higher unit from the prerequisite. For distance-education students, it can be a number of years before this transfer occurs and even the most fundamental concepts can be forgotten

**LABORATORIES:** Practical sessions need to be delivered at a time which supports the topics presented in the lecture theatres and tutorial rooms. At present, large class sizes often mean that the same practical sessions are delivered to on-campus students through most of the semester with off-campus students enrolling for 'on-campus laboratories' once or twice a year. The delay in the delivery of practical sessions means some students struggle to realise the link between theory and practice, and as a result, laboratories often tend to be viewed unenthusiastically [5]. The added problem of travel for off-campus students dissuades their involvement. To address this, the authors suggest a shift in focus towards home experiments. The home experimentation concept has been used in some units in Deakin University's mechatronics/robotics and electronic engineering programmes [6, 7]. It offers the potential to provide on- and off-campus students with relevant laboratory-practical experience without the problems intensive on-campus practical sessions introduce. The educational benefits include the freedom for students to work at their own pace and the option to iterate through possible solutions free of the constraints of fixed length time-table slots.

## 6. Conclusions

An analysis of the on- and off-campus student marks in two structural mechanics units has been carried out. Consideration was given to the continuous assessment, examination and total marks for 329 (173 on-campus and 186 distance-education) students. Across the two units, it was found that:

- The mean on-campus total marks were higher than the off-campus ones;
- The on-campus failure rates were significantly lower;
- Students perform best in assignments and worst in examinations;
- Students who perform well in the assignments do the best in examinations; and
- Unacceptably high failure rates were due to poor examination performance.

Parametric statistical tests have found a correlation between the continuous assessment and examination marks for both units. Hence, in order to motivate students to fully participate in assignments and laboratory-practical exercises (and in the tutorial questions on which the assignments are based), several changes to the assessment criteria and marking schemes have been proposed.

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## **Biographical Information**

Dr Wayne Hall is a Chartered Engineer and a Member of the Institution of Mechanical Engineers (UK). He has been employed as a Stress Engineer for Rolls-Royce plc, and has worked as a Research Academic at the University of Warwick and Nottingham (UK). He is currently a Lecturer in the School of Engineering and Technology at Deakin University. His research interests include numerical modelling and engineering education.

Clive Ferguson joined the Ballarat College of Advanced Education in 1984 before moving (in 1991) to the newly formed School of Engineering and Technology at Deakin University. He is Senior Lecturer and Director of Engineering Projects. His research interests are in engineering education and distance education technologies. He is a Fellow of both the Institution of Engineers, Australia and the Institution of Mechanical Engineers (UK).

Dr J. Trevor Jones is a Chartered Engineer and Member of the Institute of Electrical Engineers (UK). He is a Senior Lecturer in the School of Engineering and Technology at Deakin University in Australia. He has more than 20 years experience in teaching and research. His main academic interests lie in the areas of mechanism design, microcontroller applications, automated manufacturing processes and engineering education.

Dr Stuart Palmer is a Chartered Engineer and a Member of the Institution of Engineers, Australia, and the Australasian Association for Engineering Education. He is a Senior Lecturer in the School of Engineering and Technology at Deakin University, lecturing in Technology Management at undergraduate and postgraduate levels. His research interests include frequency domain analysis and engineering education.