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Delivery and assessment strategies to improve on- and off-campus student performance in structural mechanics

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Abstract

This paper considers the delivery and assessment strategies used in two structural mechanics units at Deakin University, a leader in distance-education in Australia. The two units have experienced unacceptably high rates of failure. Student perceptions of the delivery method are analysed and an investigation of the performance of 329 (173 on- and 186 off-campus) students enrolled in the two units is carried out. 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, and it is therefore proposed that in order to improve performance the students must be encouraged to

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fully participate in all aspects of the course. It is shown that a relatively large proportion of
the student population are unenthusiastic about laboratory-practical sessions and do not think
their inclusion aids understanding of the theoretical material. Motivation to participate is often
dependent on the perceived relevance of a given task and its contribution to the total mark and
thus, to help motivate students to fully participate in the continuous assessment tasks the
authors propose several changes to the delivery methods, and assessment criteria and marking
schemes.

KEYWORDS: Delivery, Assessment, Structural Mechanics, On-campus, Distance-education

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. In 2004, the authors were challenged with improving student performance (and pass
rates) for these units without revising the level of difficulty of the course downwards and thus, impacting on graduate technical competencies. To meet this challenge, consideration has been 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.

This paper investigates the students’ perceptions of the delivery approach adopted in the two units and then considers the current methods used to assess a student’s competence (i.e. assignments, laboratory reports and a written examination). The on- and off-campus marks in each assessment type are analysed and in doing so the underlying reasons why high failure rates occur are identified. Based on the findings a series of recommendations are made to tackle poor performance.

2. Structural Mechanics at Deakin University

The two structural mechanics units that Deakin University have offered in recent years are: Statics and Strength of Materials (SEM224); and Stress Analysis (SEM312) [3]. These units are single semester units which investigate the theoretical and practical concepts of structural mechanics. They are available in both on- and off-campus modes, resulting 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 (offered in semester 2) 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, offered in semester 1) 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 (for the scope of this work) the same prescribed text book [4] was used in both units.

Delivery of the two structural mechanics modules is via three lectures of one hour duration and a one hour tutorial session per week. The lectures are delivered by academic staff members whilst tutorials have tended (in recent years at least) to be taught by postgraduate students. There are also two laboratory sessions for each of the units and these typically take a total of three hours per unit to complete – these are frequently delivered by postgraduate students supported by technical staff. The purpose of these practical sessions is to support or supplement the concepts and theories presented in the lecture theatres and tutorial rooms. The hypothesis being that teaching and learning of structural mechanics concepts and theories are reinforced by way of experimentation and/or demonstration. Evidently, however, if the lectures, tutorials and laboratories are taught by different people there is potentially a lack of continuity in the delivery of material.

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 is often given to students who attain 37% or above if they perform adequately in the coursework components and can achieve an overall mark of 50%. This inherent flexibility enables the lecturers to consider the complexities surrounding equity between year groups – while lecturers strive to set coursework and examinations at the same standard for each cohort
inevitably slight variations occur from one year to the next as assessment tasks must change each time the same course is offered.

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>
<thead>
<tr>
<th>Assessment</th>
<th>SEM224 % marks</th>
<th>SEM312 % marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assignment</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>Laboratory</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Examination</td>
<td>60</td>
<td>70</td>
</tr>
</tbody>
</table>

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

3. Method of Delivery

It had already recognised that there could potentially be a lack of continuity in the delivery of course material (as discussed earlier) and this raised the question, what else was there that was not immediately obvious? It was therefore deemed prudent to ask the current student intake about their experiences. Thus, all students enrolled in SEM312 (semester 1, 2005) were surveyed in order to quantify their perceptions about the methods of delivery used on the unit.
Whilst a simultaneous survey of SEM224 students was not possible since the two units are offered in alternate semesters, the similarity in delivery method of the two units meant it was reasonable to assume the generic responses for SEM312 were representative of the students’ views of SEM224. Furthermore, since SEM224 is a prerequisite for SEM312 all students (other than a small number of direct entrants) would have completed the second level unit prior to commencing on the third level one. The survey was undertaken by means of a questionnaire that sought student feedback on the following themes:

- demographic information – age, gender, course and mode of study;
- student perceptions of the lectures and tutorials (on-campus students only);
- student perceptions of the laboratory-practical sessions; and
- student views on the volume of material and relative difficulty of SEM312;

As required by the Deakin University Human Research Ethics Committee, the questionnaire was anonymous and voluntary. A significance level of one in one hundred (i.e. p<0.01) is used here for parametric statistical tests.

To ensure the student responses were representative of the whole enrolment consideration was given to the demographic information available to the authors. The gender, course and mode of study characteristics of the student enrolment were known and this allowed a comparison of the population and respondent groups. The respondent and population groups were relatively large, independent and random, permitting a chi-square test of homogeneity. The statistical analysis found that for these three characteristics there was not a significant difference between the respondent and population groups, i.e. $\chi^2_1 = 0.035$ (p>0.85), $\chi^2_1 = 0.2$.
(p>0.65) and $\chi^2_1 = 0.95$ (p>0.33) respectively). Based on this data the authors argue that the results supplied by the respondents are representative of the whole student enrolment.

A summary of the survey group response rate by mode of study is given in Table 2. The table highlights the relatively high total response rate (about 44%) and indicates that 22 out of the possible 44 on-campus students responded (50%) as well as 8 of the 24 off-campus students (33.3%).

<table>
<thead>
<tr>
<th>SEM312</th>
<th>Student Responses</th>
<th>Student Enrolment</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-campus</td>
<td>22</td>
<td>44</td>
<td>50.0</td>
</tr>
<tr>
<td>Off-campus</td>
<td>8</td>
<td>24</td>
<td>33.3</td>
</tr>
<tr>
<td>All (On- and Off-)</td>
<td>30</td>
<td>68</td>
<td>44.1</td>
</tr>
</tbody>
</table>

Table 2. Survey group response rate by mode of study for SEM312 (semester 1, 2005)

**Course Content**

The survey results indicate that students perceive SEM312 to contain a greater volume of material when compared to other third level units at Deakin University. They also showed that students thought the content was more difficult, confirming the thoughts of Mills *et al.* [2]. A significant positive correlation (r=0.78) was noted between the students’ perceptions of the volume of material and the level of difficulty (p>0, p<3x10^{-5}). It is realistic to recognise
that too much content will have a negative impact on student performance since, clearly, there will be less teaching time for students to master a topic before the course has moved onto the next. This must therefore raise the question, ‘is it better to teach less content at a slower pace, or the entire content quickly?’ Discussion of this issue is beyond the intended scope of this article as the focus of the research is primarily on teaching and learning methodologies and not on revision of course content. The question is raised here in the hope that it will stimulate further discussion.

**Lectures and Tutorials**

As mentioned (see Section 2), it had been recognised that there was a potential lack of continuity in the method of delivery. This perceived lack of continuity was linked to the number (and differing levels of experience) of the teaching team. This issue had not escaped the attention of the student enrolment with more than 83% of the respondents making the comment that they would prefer the lecturers to deliver the lectures, tutorials and laboratories. Less than 17% saw a benefit of tutors (e.g. postgraduate students) participating. Moreover, when asked to “list any other comments about the delivery of [the unit]” the on-campus respondents typically reflected on the different teaching styles of the teaching team.

Evidence from the survey also showed that on-campus students were overwhelmingly against the traditional delivery model of “three lectures for theory and one dedicated tutorial.” Instead they reported a preference (76% to 24%) for “four sessions incorporating theory and tutorial problems.” They also identified (93.1% to 6.9%) that a series of ‘workshop’ sessions with a focus of providing an overview of the topics presented in the classroom would be a welcome addition.
Laboratory-Practicals

Most of the respondents agreed that the laboratory-practical sessions had helped to reinforce the theoretical concepts presented in the classroom (64.3% agreed). Worryingly, however, more than 35% disagreed. Those students who recognise the ‘value’ of their studies tend to be more motivated and hence perform much better. Conversely those who do not recognise the value, frequently underachieve. It is therefore clear that the fact that so many disagreed is a cause for concern – this issue is discussed further in Section 5 in relation to student participation.

4. 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 3 and 4, respectively. In these tables, the on-, off-campus and combined scores are listed. A significance level of one in one hundred was again used for all parametric statistical tests.
### Table 3. Mean percentage scores (assignment, laboratory, examination and total) for SEM224

<table>
<thead>
<tr>
<th></th>
<th>Assignment</th>
<th>Laboratory</th>
<th>Examination</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-campus</td>
<td>75.4</td>
<td>61.7</td>
<td>45.1</td>
<td>55.9</td>
</tr>
<tr>
<td>Off-campus</td>
<td>74.9</td>
<td>56.0</td>
<td>45.1</td>
<td>54.9</td>
</tr>
<tr>
<td>All (On- and Off-)</td>
<td>75.2</td>
<td>59.3</td>
<td>45.1</td>
<td>55.5</td>
</tr>
</tbody>
</table>

### Table 4. Mean percentage scores (assignment, laboratory, examination and total) for SEM312

<table>
<thead>
<tr>
<th></th>
<th>Assignment</th>
<th>Laboratory</th>
<th>Examination</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-campus</td>
<td>78.2</td>
<td>59.6</td>
<td>52.8</td>
<td>58.3</td>
</tr>
<tr>
<td>Off-campus</td>
<td>68.0</td>
<td>49.9</td>
<td>40.5</td>
<td>46.5</td>
</tr>
<tr>
<td>All (On- and Off-)</td>
<td>72.6</td>
<td>54.3</td>
<td>46.0</td>
<td>51.8</td>
</tr>
</tbody>
</table>

### 4.1 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 for the laboratory marks (an issue that is probably related to the cohorts view on the value of laboratory-practicals). 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.

4.2 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 5), 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% ($\chi^2_{1} = 9.73$, $p < 0.002$).

5. Student Performance Analysis

The statistics in Section 4 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.
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
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
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. Student perceptions of the ‘usefulness’ of laboratories was raised in Section 3 (>35% of the survey respondents thought laboratory-practicals were not helpful) and this must bear some relationship to the issue of student participation. Those who do not participate in coursework clearly limit the development of their numerical and analytical (structural mechanics) 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.

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).

6. Discussion of Results

The authors postulate that a significant impact on student performance will be attained if the volume of material presented was reduced. There seems to be a lack of time to master one aspect of the course before the next is introduced. However, it is clear from this investigation that improvements in students performance can be attained without revision of the material. Examination marks (and pass rates) will improve if students were to fully embrace the continuous assessment components and the tutorials on which the assignments are based. Those 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 will improve with further encouragement. Motivation to participate is dependent on the perceived relevance or ‘value’ (the authors suggest that it is the responsibility of the teaching team to emphasis this) and the assessment’s contribution to the total mark.
To address the issue of student participation the authors propose two primary changes in the delivery and assessment strategies of the two units:

- **An increase in the proportion of the marks which come from continuous assessment components.** This increase in the assignment and laboratory marks, however, should be linked to an increase in the amount of work needed for their satisfactory completion. An increase to 50% coursework (and hence a reduction to 50% examination) is proposed. Increasing the workload should enable the assignment and laboratory tasks to engage a broader range of problems from the curriculum and should therefore improve examination performance. Whilst examinations are perceived as important to satisfy quality assurance issues, a greater move towards coursework will provide a more accurate representation of the ‘real’ world environment and is therefore a more authentic assessment method.

- **A change in the structure of the lectures, tutorials and laboratory-practical sessions.** To ensure continuity in the delivery of the two structural mechanics units and to facilitate an enjoyable teaching and learning environment it is recommended that the classroom activities are designed around four sessions incorporating theory and tutorial problems, and that lecturers deliver all aspects of the courses. If only one (or two) lecturer/s are involved rather than a teaching team (of varying levels of experience) then the student enrolment will have a clear focal point for all queries, and the relationship between assignments and laboratory-practicals to the fundamental theoretical components could be better emphasised. There is also an argument for the introduction of ‘workshop’ sessions to review certain parts of the course.
The authors also recommend secondary changes in relation to the assignments and laboratory-practicals:

**Assignments.** To minimise plagiarism and further encourage students to fully participate in assignments, the authors recommend the development of on-line assignments consisting of a series of problems that have several possible variations. An excellent example of this concept is given in the work of Deeks [5]. Furthermore, for SEM312, the authors suggest the first assignment should review the fundamental concepts taught in SEM224. This is necessary since the flexibility of the modern engineering degree means students often do not progress 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.

**Laboratory-Practicals.** 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 [6] or as is shown here their relevance is lost (at least to >35% of the population). There is also the added problem of travel for off-campus students which can dissuade their involvement. To address this, the authors suggest a shift in focus towards other methods. There are numerous alternatives for the delivery of practicals including: on-line movie clips; computer aided learning tools (simulations); laboratories controlled over the Internet; and home experimentation kits [7-11]. One of the most cost effective and flexible
methods would be home kits and some work is currently focusing on this area. The home experimentation concept has been used in some units in Deakin University’s mechatronics and electronic engineering programmes. 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.

7. Conclusions

A survey of student perceptions of structural mechanics at Deakin University was finalised and a comprehensive analysis of the on- and off-campus student marks was carried out. In the analysis, 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, the analysis 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. Motivation to participate in continuous assessment exercises is often influenced by the perceived relevance of a task (by the student) and the assignment’s contribution to the total mark. 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 delivery method, and assessment criteria and marking schemes have been proposed. Additional ‘secondary’ recommendations have also been proposed which aim to encourage student participation in assignments and laboratory-practicals sessions.

Acknowledgements

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References


