Teaching First-Year Business Statistics Three Ways

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Teaching first-year service courses in mathematics and statistics is often a challenge. Such units are usually taught to large classes, most with poor mathematics backgrounds. Since these are often compulsory units, most students take them unwillingly. Attendance tends to drop off very fast and many students do not complete set work. This paper reports an innovative way to teach first-year Business Statistics that evolved over four semesters. Changes were made each semester to how the unit was delivered. Student performance is compared for the four methods, giving some perhaps surprising results. Some insight is discussed regarding the lessons learnt.

1. Introduction

Teaching first-year service units in mathematics and statistics is a challenging task. Most students enrol in these units not out of choice but out of compulsion and such units often have students with a wide range of mathematical preparation and backgrounds. Consequently, engaging students and maintaining their interest for long is difficult. Experience and data show that class attendance drops off very quickly as the semester progresses. For such large first-year classes attendance ranges from 70% [1, 2] to as low as 7% [2], and is typically around 30% [3]. Reasons for missing classes include lecture quality, lecturer quality, work commitments, ease of access to university and perceived difficulty of subject [4, 5, 6]. Several researchers have investigated the relationship between attending classes and student performance [1, 6, 7, 8, 9, 10]. Nyamapfene [8] reported that class attendance “is the key determinant for academic performance”. His study was for courses with online lecture notes, which is almost universal these days. Purcell [1] found that for civil engineering students a 10% increase in lecture attendance resulted in a 3% increase in examination performance. Obeidat et al. [9] found that for industrial engineering students lecture attendance was strongly related to performance. Similarly, Rico et al. [10] reported that less well attended classes had higher failure rates.

This paper presents a method for teaching business statistics that evolved over four semesters. The unit is a requirement for all majors in Business, with around 1,000 students each year over two semesters. Students who do not have the appropriate mathematics pre-requisites from high school are first required to obtain a pass in a bridging unit. Consequently, in general the first semester class has a better mathematics background.

The unit content is typical of a first course in statistics, and the topics covered are, in order, exploratory data analysis, probability, random variables, normal, binomial and Poisson distributions, sampling theory, estimation, one-sample tests for means and proportions, two-sample tests for means, ANOVA, simple and multiple regression, and chi square tests of independence for contingency tables.
I had previously taught this unit for several years in the traditional way – three lectures per week, a one hour tutorial and a one hour laboratory class. I again taught the unit in semester 2 of 2011 after a three year break. This paper is on the evolution of teaching and learning over four semesters, based on lessons learnt from my previous experience and the facilities afforded by changing technology.

The rest of this paper is organised as follows. In the next section I outline the issues associated with the traditional teaching methods in my experience. In Section 3, the details of the changes are presented. Section 4 contains data analysis of student performance and Section 5 contains discussion and conclusions.

2. Previous Teaching Methods

2.1 Teaching activities

The traditional teaching method for business statistics is based on lectures. Supplementing these may be tutorials and laboratory classes. A survey was conducted on the teaching methods for first-year business statistics in Australian universities by email and also from course websites. Table 1 summarises the findings. Of the 25 universities (not including mine) for which information was obtained, sixteen had two hours of lectures per week (most having these as a single session and others as two separate one-hour sessions), eight had three (one-hour) lectures per week and one had four (one-hour) lectures per week. Seven did not have any tutorials or laboratory classes. Eleven had a one-hour tutorial per week but no laboratory classes and one had both a one-hour tutorial and a separate one-hour laboratory class per week. Three had a two-hour tutorial per week, while another three had a one-hour combined tutorial-laboratory session. One university had a one-hour weekly problem solving session. Eleven of the universities had four or more contact hours per week. The teaching activities of the majority of universities are based on the traditional lecture-tutorial model.

Our previous teaching regime was lecture-based supplemented by a one-hour tutorial session and a separate one-hour laboratory session. These sessions were not chronological, so a student could have the tutorial before the laboratory or vice-versa. Tutorials focused on theoretical concepts and problem solving using a calculator for numerical calculations, whereas in the laboratory session data was analysed using Excel and the results were interpreted. For example, in tutorials a data-based question would be asked with summary statistics provided in order to reduce calculations. The same question would be asked in laboratory sessions where students would analyse the original data using Excel and interpret and report the results. This meant that the principles underlying the question had to be covered twice, once in the tutorial and then again in the laboratory. The laboratory session was held in a large computer laboratory with 128 computers and two staff. An attendance mark was given for each tutorial to encourage attendance but otherwise there were no other assessments in the tutorials. There were no marks for laboratory attendance but there were two Excel-based laboratory tests based on this work.

2.2 Issues with the Teaching mode

There were several issues with student participation and performance, particularly in laboratory and tutorial classes.

1. Lecture attendance declined after a few weeks to about a third of the class by mid-semester.
2. Laboratory sessions were poorly attended. Student feedback indicated that this was mainly due to inadequate staffing.

3. Students attended the tutorials classes simply to get the marks. There were reports from tutors that participation in the tutorials was low and students did not attempt the questions beforehand.

4. Student engagement was low and many students did not attempt semester assessments. Several students who failed by only a few marks would have passed if they had attempted a few more of the semester assessments, and in particular if they had attended a few more tutorials.

5. A lot of synergy existed between tutorial and laboratory questions, but this was lost since these teaching activities were separated.

3. Changes to the Teaching Activities

The changes in teaching regime were motivated in order to address the issues raised in the last section and to improve student engagement and participation as well as enhance understanding of course material. More specifically, the following were the aims of the changes.

1. To improve student participation in teaching and learning activities.
2. To improve student engagement and improve participation in assessment tasks.
3. To increase student attendance in tutorial and laboratory classes.
4. To provide more learning opportunities in laboratory classes.

The changes were undertaken over four semesters as ideas evolved. Student feedback was also used in formulating the teaching and learning activities. The details of the changes are given in the following subsections.

Table 1. A summary of teaching activities for business statistics units in surveyed Australian universities. Table entries are the number of institutions with the corresponding teaching regime of lectures, tutorials and laboratories (hours per week).

<table>
<thead>
<tr>
<th>Lectures</th>
<th>Tutorials</th>
<th>Laboratory 2</th>
<th>3</th>
<th>4</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>6</td>
<td>1</td>
<td>0</td>
<td>7</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>6</td>
<td>5</td>
<td>0</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Tut/Lab</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>16</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>25</td>
</tr>
</tbody>
</table>

3.1 Semester 2, 2011

The first change was to merge the tutorial and laboratory classes into a combined two-hour session with one tutor. The class sizes were capped at a maximum of 22, requiring around 35 sessions for a total of 745 students. This session included tutorial type problems as well as Excel-based data analysis. The first issue was a logistic one. These sessions now had to run in smaller computer laboratories with facilities to run a tutorial type class as well. Finding a sufficient number of such venues that were available posed a significant challenge, but this was resolved with help from support staff. The second issue was merging the existing tutorial and laboratory material in a seamless manner so that the combined session could flow smoothly, and tutors could switch from a tutorial type activity to a laboratory activity without disruption. For example, questions in tutorials and laboratories based on the same data had to be re-written to remove
duplication while at the same time including aspects of both questions. This required around a month of work with the help of an assistant. A final challenge was finding sufficient staff of appropriate quality. We opted to complement our tutors with senior undergraduate students for two reasons — they were younger and would be able to relate to the class more easily in such a setting, and they were more cost-effective. The second reason was important since the administration had to be convinced that the changes would not cost more.

Another change introduced was that in each tutorial-laboratory class, students were required to submit the solution to one question to their tutor for assessment, worth 1% each. Some of the submitted work involved laboratory work, where the student would show a computer output to the tutor on the screen. Often the tutor could mark assessed work in the session itself, so the marking task was not onerous.

An addition to the teaching activities was a one-hour problem solving session per week, where the facilitator would solve interactively with the class some extra examination style problems. The rationale for this was that more time was spent in lectures re-enforcing concepts, but this left less time for examples. Thus in total there were now six contact hours per week compared to five previously, the extra hour being the problem solving session.

All unit material—lecture notes, tutorial problems and solutions, problem solving questions and solutions—were placed online. However, it was a conscious decision that lectures were not recorded.

A few differences were immediately observed during the semester.

1. Records showed an immediate increase in attendance at tutorial-laboratory classes compared with the previous semesters. High attendance levels were maintained throughout the semester.
2. Tutors with previous experience reported that students seemed more engaged and focused. This may be because there was an assessment at the end of the class.
3. The level of assistance with laboratory type work was markedly increased as there was now one tutor per a maximum of twenty two students in a dedicated facility, as compared with two staff for 128 students. This may also be a reason for the higher attendance.
4. Tutors with previous experience reported that exploiting the synergies between laboratory and tutorial type activities allowed the connections between the theory and data analysis to be made more easily. They also reported that the classes were easier to conduct.

A final change related to assessments. There were two short tests (worth 5% each) and a mid-semester examination (worth 15%) during the semester. The material tested in these was then not re-tested directly in the final examination, but knowledge of this was still required since the later material depended on this earlier work. This meant that the final examination was only on the inference and modelling sections of the course, from one-sample tests onwards.

### 3.2 Semester 1, 2012

Following the changes made in the previous semester, an online survey of the class was conducted at the end of the semester to determine the student perception of the changes. In particular, students were asked to indicate if they had taken this unit previously—their feedback and comments received special attention as they had experienced both forms of delivery. A total of 400 responses were received, of which thirty were from...
repeat students (from a total of sixty repeat students). Besides the online survey, informal feedback was obtained in conversations with fifty students selected at random from the class. Overall the response was very positive and encouraged us to take the changes further, relying on student and tutor feedback for ideas. Based on this feedback two changes were made.

The first aspect related to lecture recordings. Lectures were not recorded by choice the previous semester. This semester lectures were recorded and made available to the class. There are many arguments for and against recording lectures [11, 12, 13]. Bell et al. [13] consider various advantages of lecture recording, including flexibility for students that results in a broader student base, timetabling clashes, venue capacity, availability of multiple viewing by students, and freedom of place and time for viewing the lecture. A further advantage not mentioned in literature is that the lecturer can also view the recording with the aim of evaluating and improving his/her performance. A major (perceived) disadvantage is that lecture attendance is much lower when lectures are recorded. While several reasons have been forwarded for this decline [3, 4, 5], a major reason is the availability of recorded lectures [3]. (There is evidence based on my as yet unpublished research that recorded lectures are only of benefit to students who attend lectures.) I also experienced a reduction in lecture attendance compared with the previous semester.

A second aspect was that most business units provided a unit reader containing all the unit material. In the previous semester lectures were based on partially blank slides that were made available online prior to the lecture, and the lecturer would fill these in during the lecture. Later, the full slides were made available online. So it was a simple matter to organise the blank slides into a unit reader that was made available for purchase in the bookshop.

3.3 Semester 2, 2012
The changes in the previous semesters had improved student participation, but reduced lecture attendance. My focus for this semester was to increase lecture attendance. I decided to trial some ideas by Professor Eric Mazur on peer instruction [14, 15, 16]. As such, I adopted the following.

1. I provided full lecture notes as a unit reader. Students were required to read the lecture notes for each lecture before the lecture.
2. I required the class to complete a concept-based quiz before the lecture based on their readings. The quizzes over each week were awarded a mark of 1% as an incentive.
3. Lecture material could now be covered faster as there was very little writing. The lecturer would cover the more tricky aspects of the material and concentrate on stressing important points. In addition, based on the online quiz results, student misconceptions could be identified and addressed.
4. A mobile-phone based in-class response system (provided by a publisher) was used to test and reinforce student understanding of concepts. Students responded to quiz questions during the lecture at appropriate times. They were then allowed time to discuss their response in groups (peer-instruction) before re-submitting their answer.
5. All assessments were made open book, and students could take with them hard copies of any material, including past assessments and solutions.

As a result of these changes, lecture attendances were higher than the previous semester, with a decline only in the last three weeks. Student participation in increased and there
was clearly an interest and eagerness in attending lectures. The class was now an active participant rather than a mostly passive audience. Further, despite my early doubts, students quickly returned their attention to the lecture once they had responded to the mobile phone-based quiz questions.

3.4 Semester 1, 2013
At the end of semester 2 2012 another web-based survey of the class was taken. A total of 300 responses were received. There were three main findings from the survey. Firstly, students overwhelmingly (82%) preferred the open book assessments. This is similar to findings by other researchers [17, 18, 19 20]. Gharib et al. [19] report that students had less anxiety during open book examinations.

Secondly, mobile phone based in-class quizzes received a very favourable rating by students. Similar to findings by Dunn et al. [21], the students preferred the anonymous response afforded by such a system. They also appreciated the chance to discuss problems and concepts with fellow students and to consolidate the lecture material immediately.

Finally, daily online quizzes were not very popular and were considered too onerous. Consequently, for this semester the only change was having weekly quizzes based on the previous week’s lectures.

4. Statistical Analyses of Student Performance
All data analysis was performed using the R statistical software [22]. Data over the four semesters were analysed to determine any differences in student performance. The final marks and the examination marks were used as responses. A summary of the marks is presented in Table 2. Boxplots of the marks are presented in Figure 1. Semester 1 2012 has the highest median final mark, while semester 2 2012 has the lowest median final mark. The highest mean exam mark was obtained in semester 2 2013, while the lowest mean examination mark was in semester 2 2011. It is interesting to note that the standard deviations of the marks were lowest for semester 1 2013.

<table>
<thead>
<tr>
<th>Class Size</th>
<th>Median</th>
<th>Mean (SE)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sem 2 2011</td>
<td>745</td>
<td>63</td>
<td>62.9 (0.65)</td>
</tr>
<tr>
<td>Sem 1 2012</td>
<td>342</td>
<td>65</td>
<td>62.8 (0.98)</td>
</tr>
<tr>
<td>Sem 2 2012</td>
<td>580</td>
<td>62</td>
<td>60.7 (0.74)</td>
</tr>
<tr>
<td>Sem 1 2013</td>
<td>580</td>
<td>63</td>
<td>62.5 (0.74)</td>
</tr>
<tr>
<td>Sem 2 2011</td>
<td>745</td>
<td>45</td>
<td>45.3 (0.85)</td>
</tr>
<tr>
<td>Sem 1 2012</td>
<td>342</td>
<td>60</td>
<td>55.5 (1.26)</td>
</tr>
<tr>
<td>Sem 2 2012</td>
<td>580</td>
<td>56</td>
<td>53.6 (0.82)</td>
</tr>
<tr>
<td>Sem 1 2013</td>
<td>580</td>
<td>63</td>
<td>61.1 (0.74)</td>
</tr>
</tbody>
</table>

Table 2. A summary of student performance over the four semesters.
Statistical analyses were conducted as below.

1. A one-way Anova [23] of the final marks revealed no significant difference in the mean final marks over the four semesters (p-value = 0.109).

2. A one-way Anova of the exam marks showed that the mean exam marks for the four semesters were not all equal (p-value < 0.001). A multiple comparison using a Bonferroni correction revealed that all the means were different from each other. Thus semester 2 2011 has the lowest mean, while semester 1 2013 has the highest mean exam mark.

3. A Kruskal-Wallis test [24] revealed that there were no differences in the medians of the final marks (p-value = 0.20). For the exam marks, a similar analysis revealed that the median exams marks were significantly different. Further pairwise Kruskal-Wallis tests showed that the median exam mark was lowest for the semester 2 2011 and highest for semester 1 2013, with no significant difference between the other two.

5. Discussion and Conclusions
In this paper we described an evolution of teaching over four semesters. There is no difference in the median or mean final marks over the four semesters under consideration. However, traditional teaching methods (semester 2 2011) gave the lowest mean and median exam marks. The higher mean and median exam mark in semester 1 2012 compared to the previous semester may be the availability of a unit reader. The most plausible explanation for this is that the unit reader provided a more organised information source for the students, and this facilitated learning and revision. In the next semester open book assessments were introduced. While there was no significant change in the median exam mark, the mean exam mark was significantly lower. A reason for this may be that the open book assessment style was different to the closed book one. Indeed, the open book exam was not the traditional type, but was more concept-based and required more interpretation and synthesis of ideas than in previous exams. In the final semester the mean exam mark was significantly higher than in previous semesters. This is largely since the students had seen the open book exam from
the previous semester and were better prepared for this style of exam. Other researchers have reported higher mean marks for open book examinations [18, 19], but Loi and Teo [20] found no difference in student achievement. Interestingly, the pass rates in the four semesters were respectively 79%, 82%, 74% and 81%. The open book assessment regime seems to have advantaged only the better students, leading to a higher mean mark but not a higher pass rate. There is evidence of this from Figure 1. In semester 1 2013, the examination marks were higher on average, but the long lower tail indicates that the performance of the lower end of the class had not improved. This is also supported by the fact that the median marks were not significantly different, so the relative positions of the upper half and lower half of the classes was maintained.

My earlier trepidation that a mobile phone-based in-class response system may be distracting was unfounded. Students had no difficulty returning attention to the class after responding to the quiz questions. Similar experiences have been reported by other researchers. Dunn et al. [21] reported that students were not distracted by using mobile phones, nor were they distracted by other students using mobile phones. The interactive nature of the lecture was far more engaging for the students. In addition, students felt far more comfortable in responding in an anonymous way and the immediate feedback for the lecturer and students was very valuable for both. Peer instruction was also very useful and greatly reduced my out-of-class consultation hours. However, Mazur’s [15] idea of having students read lecture notes beforehand and attempt an online quiz per lecture was not very successful. The reason for this I believe is that my students were not as motivated as those of Professor Eric Mazur.

Recorded lectures did reduce lecture attendance. Online student surveys at the end of semester 2 2012 and semester 1 2013 revealed that a major reason for missing lectures was that it was recorded (23% and 25.8% respectively in each semester).

Changing technology in the classroom has made it imperative that teaching methods also change. It is common for universities to put all learning materials online, including recorded lectures. In such an environment missing lectures becomes more attractive. Research and experience shows however, that attending classes is important for engagement with course material and student achievement [7, 8, 9, 10].

Traditional methods of assessment have also been challenged. An open book assessment scheme for a statistics unit is not the norm and would not be considered by many. In this case having open book assessments did not seem to inflate the overall marks on average. Research shows that students overwhelmingly prefer open book assessments or cheat sheets [17, 18, 19, 20].

Students do not engage in the way that traditional teaching methods assume. Learning styles have changed in leaps and bounds over the last five years. Our teaching methods need to match student learning styles. This is especially crucial in lower level and service teaching, as it is a priori difficult to engage such classes. Our experience in this investigation is that it is possible to engage such classes by using appropriate teaching methods and appropriate use of technology.

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References


