Attendance Matters: Student Performance and Attitudes

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Abstract

Most academics consider class attendance as key to performance, using various strategies to encourage students to attend classes and engage more fully with the course, often with limited if any success. In Part 1 of this paper, we investigate the relationship between student attendance and performance based on two units. In the first unit, students scanned their student-cards before entering the lecture venue; in the second unit, attendance was based on tutorial attendance records. For each unit, attendance records were merged with performance and demographic data from the university records. The data were analysed using statistical modelling to determine the effect of attendance on performance. In Part 2, we report on surveys of academic staff and students administered across Australia, New Zealand, South Africa, South America, Europe and the US. In particular, we investigate the relationship between attitude towards attendance and importance of attendance to student performance and demography. Similarly, we investigate the relationship between attitudes of staff towards attendance to staff demography. Some qualitative analyses of open-ended comments from both staff and students were also performed. Statistical analysis showed a significant relationship between attendance and performance, with an increase of 0.52% per lecture and 1.7% per tutorial attendance respectively for the two units. Further, students in Mathematics and Statistics, Arts, and Medicine and Dentistry thought lecture attendance was important, while staff overwhelmingly agreed that class attendance was important.

Introduction

Teaching and learning in higher education institutions are based largely around face-to-face instruction sessions. This is especially true of mathematics and statistics. Academics spend a lot of time preparing for such sessions in the form of lectures, tutorials and laboratory classes. The advent of lecture recordings has seen a rapid decline in lecture attendance. Early studies indicated only a slight decrease (Larkin, 2010; Groen, Quigley, & Herry, 2016), but later studies indicate a significant reduction in lecture attendance (Edwards & Clinton, 2019; Doggrell, 2019; Marsh & Gurski, 2016). Attempts to harness technology in the form of blended learning, including flipped mode delivery, offers some advantages, but does not seem to increase attendance (Khan & Watson, 2018).

Traditional wisdom dictates that class attendance is key to performance. Evidence from the literature supports this point of view. Nyamapfene (2010) found, in a second-year electronics engineering course (University of Exeter, UK) with online lecture notes and no compulsory attendance requirement, that attendance is “the key determinant for academic performance.” Their study included 43 students, and their conclusions were based on simple correlations between attendance and performance. Analysis of data for second- and third-year civil engineering students (University College Dublin) by Purcell (2007) showed that, on average, a 10% increase in lecture attendance resulted in a 3% increase in examination performance. Their conclusions were based on simple linear regression between examination mark and attendance.

Dobkin & Marion (2010) used intervention for three large economics classes, requiring students scoring below the median mark on mid-term examination to attend classes. They found that for these students, attending classes improved performance significantly. O'Dwyer (2011) found a statistically significant but weak positive correlation between exam mark and lecture attendance collected by signed attendance sheets, but the study did not include any demographic data. Similarly, Romer (1993) found a positive relationship between attendance and performance after adjusting for prior performance using grade points, but again did not include demographic information. Andrietti (2014) found that for an introductory macroeconomics course, the impact of class attendance on performance is not significant after accounting for ability, effort, motivation and other individual characteristics. However, the study used proxy variables to capture the effect of unobservable variables that were possibly correlated with attendance. Credé, Roch, and Kieszczynka (2014) conducted a meta-analysis of college grades and attendance (US data), and found that mandatory attendance had a small positive impact on performance. However, they considered only correlations and did not include demographics.

Lukkarinen, Koivukangas, and Seppälä (2016) investigated the effect of attendance on performance of students in an advanced methodological course in a Finnish university. They found that attendance was strongly positively related to performance. Their statistical analysis included Age, Gender, a measure for motivation, and whether the student had taken a pre-course. Attendance was obtained using a sign-up sheet in class. Their sample size was only 86, which limited their statistical analysis. Doggrell (2020) surveyed literature on the relationship between lecture attendance and performance for human bioscience students, and reported a positive association in 75% of the courses in her survey. Most of the studies in her survey did not adjust for student background and demographics. Another study (Doggrell, 2018) for nursing students showed that when lectures were recorded, attending students performed better than non-attending ones.

No study thus far has reported on the effect of attendance in mathematics and statistics. Further, no study uses all of exact attendance, demographic variables and previous performance as moderators in a statistical model. It is important to adjust for these moderators, as these also affect performance. In particular, a better performance may be due to higher ability and not attendance. In addition, students with a range of mathematical backgrounds may be enrolled in a course, and this will also affect performance.

Another aspect is that considering pairwise correlation between variables or considering the effect one-at-a time on performance is not statistically sound. The presence (or absence) of one variable changes the effect of other variables. Without adjusting for moderator variables, the true effect of attendance cannot be estimated by statistical models (Fox, 1997).

Purpose of Study

Our aim is to develop a statistical model that estimates the effect of attendance in mathematics and statistics after adjusting for the effect of other variables that are predictive of, or associated with, performance. Mathematics and statistics courses have several teaching and learning sessions with different modes of learning, each designed to target a different aspect and stage of learning. Together these comprise a complete learning experience. Most previous studies have self-reported or estimated attendance and do not include other variables associated with performance, such as prior performance, which are measures of ability and background, and demographics. We want to include exact attendance, demographic variables, and measures of previous performance and ability. We will estimate the effect of attendance on performance based on a linear statistical model. This is essentially a multiple regression analysis that also admits non-numerical variables (such as sex and high school mathematics unit). No previous study on attendance and performance in mathematics and statistics includes all the above aspects.

In addition, we were interested in the attitudes of students and staff towards lecture recordings. Again, previous studies on attitudes towards lecture recordings were not for mathematics and statistics. It is interesting to investigate the views of mathematics and statistics staff and students compared with those in other disciplines. Attitudes impact teaching and learning, and understanding the attitudes of these two groups is important, given the recent focus and increase in online classrooms.

Part 1 of our study is based on exact attendance records for two courses: an introductory calculus course and a first-level business statistics course. Performance of students was measured by their final mark in the unit. Other variables that may affect performance are prior student ability (as measured by Tertiary Entrance Rank (TER)) and high school mathematics background (the mathematics unit taken and mark). Student age and sex are also important predictors of performance in mathematic. Jabor, Machtmes, Kunga, and Buntat (2011) found that in graduating high school students in the US, females performed better than males, and younger students below 19 years old performed better in mathematics. Khan and Watson (2018) found that males performed worse than females in a first-level university statistics course. Other variables that may affect performance are citizenship status (domestic or international student) and repeat status (if the student is repeating the unit).

Specific Research question
How does attendance affect student performance?

Part 2 of our study is an investigation on the attitude of students and staff towards class attendance. This was based on surveys of students at the University of Western Australia, and academic staff within Australia, New Zealand and a few from South Africa, South America, Europe and US. The primary interest is in student attitude towards class attendance, and in particular, whether or not students thought that lecture attendance was important for performance. We were also interested in the responses of academic staff to these questions. Related to this is whether or not lectures should be recorded, and the percentage of lecture recordings students watched. These questions relate to the larger topic of student study habits, what resources students used and how they were used, and what resources should staff provide and invest more time in.

A binary logistic regression model (Dobson & Barnett, 2008) was fitted to the binary response variables measuring attitude towards class attendance and lecture recording. Some qualitative analysis of the survey data was also performed.

Specific Research questions
1. Do students/staff believe that class attendance is important for performance?
2. Do students/staff believe that lectures should be recorded?
3. What percentage of students watch recorded lectures?

Method

Part 1 This study is based on two units. The first is an introductory calculus unit (CALC), for which lectures were deliberately not recorded. However, full lecture notes and solutions to problem sheets were available online. Exact student attendance was obtained by students presenting their identity cards at the lecture theatre card scanners. The second is a first-level business statistics unit (STAT), for which attendance was taken as the number of tutorial-lab classes attended, recorded by tutors. Lectures were recorded in this unit. For each unit, student performance was measured by the final mark. Demographic variables (Sex, Age, Visa status) were obtained from student records and merged with the performance and attendance data.

The STAT tutorial-lab sessions were by their nature interactive and student centred. The CALC lectures were also very active sessions, run almost as a workshop. Students solved problems in groups and peer-learning was encouraged and promoted.

The data were analysed to determine the effect of attendance on performance after adjusting for the effect of the other variables. More specifically, a linear model (Fox, 1997) was fitted to the data for each unit with final mark (Final) as response. Further, a k-means cluster analysis (Peng, 2016) and a principal components analysis (Kassambara, 2017) were performed to reveal any other insights into how both attendance and demographic variables affected performance.

Part 2 For investigating attitudes towards attendance, surveys were conducted online, and students at the University of Western Australia and academic staff from Australia, New Zealand, South Africa, South America, Europe and the US were sent the survey link by email. In addition to some demographic, attendance and performance information (see *Results I: Student Performance* section), students were asked three more specific questions.

Q1 Do you think attending classes is important for performance (Y or N)?
Q2 Should lectures be recorded (Y or N)?
Q3 What percentage of recorded lectures did you watch?

The academic staff survey obtained information on sex, age, discipline, level of teaching, if lectures were recorded and class attendance. Staff were asked questions 1 and 2 as above, as well as the following question.

Q4 What percentage of your class watched lecture recordings?

In addition, an open question on attitude to lecture attendance and recordings was asked of each group.

Binary logistic regression models (Dobson & Barnett, 2008) were fitted to the data as follows:

1. Responses to Q1, Q2 and Q3 separately against the student demographic information.
2. Responses to Q1, Q2 and Q4 separately against the staff demographic information.
3. Combined responses to Q1 and Q2 against the student and staff demographics information.

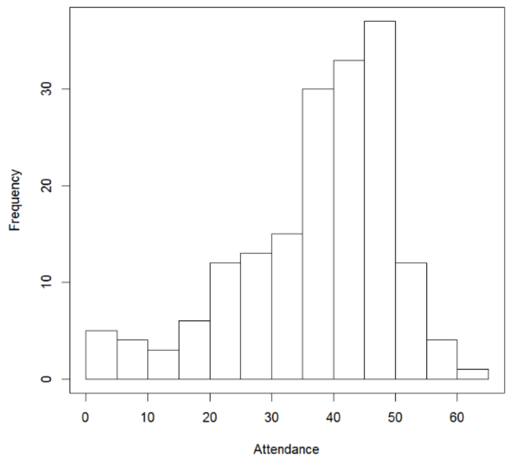
The responses to the open question were analysed qualitatively.

Results I: Student Performance

Data description

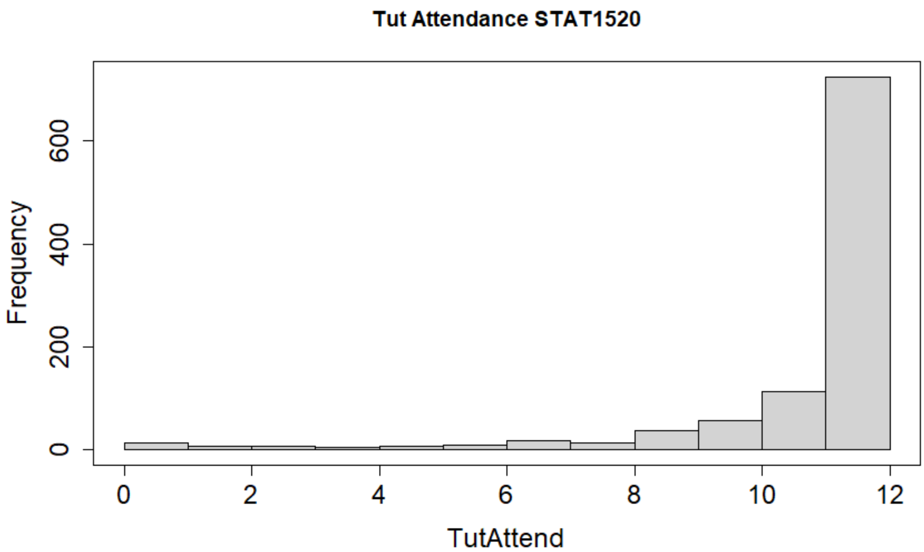
The variables in the data sets are described in Tables 1 and 2, which also contain summaries.

Table 1. Description of variables in CALC.

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>Final</td><td>Final mark in the unit (mean=56, median=66, sd=16)</td></tr>
<tr><td>Test1—Test5</td><td>Five short tests, each worth 5% of the final mark</td></tr>
<tr><td>Mid-semester exam</td><td>Mid semester exam worth 20% of the final mark</td></tr>
<tr><td>Final exam</td><td>Final exam worth 55% of the final mark</td></tr>
<tr><td>Attendance</td><td>Number of lectures attended (1 to 64)

</td></tr>
<tr><td>Age</td><td>Age of student, categorised as (frequency in second row):<table><tr><td>17-18</td><td>19</td><td>20</td><td>21-25</td><td>26-30</td><td>31-35</td></tr><tr><td>91</td><td>163</td><td>76</td><td>67</td><td>3</td><td>3</td></tr></table></td></tr>
<tr><td>Sex</td><td>Sex of student (M=158, F=245)</td></tr>
<tr><td>Repeat</td><td>Indicates if student is repeating this unit (Y=53, N=350)</td></tr>
<tr><td>Citizenship</td><td>The citizenship status: Australian=369, International student=24, Permanent resident=10</td></tr>
<tr><td>TER</td><td>Tertiary Entrance Rank (%) (min=72, mean=median=88, max=99)</td></tr>
<tr><td>HSMaths</td><td>High School mathematics unit (Mathematics Applications=15, Discrete=345, NA=43)</td></tr>
<tr><td>HSMMark</td><td>High school mathematics mark (%) (mean=median=65, sd=10)</td></tr>
</table>

For CALC, a total of 64 class sessions (Attendance) were held. Of these 52 were lecture sessions and 12 were revision sessions intended to provide assistance to struggling students, but several very good students also attended these revision sessions. The histogram of attendance is left skewed with a broad distribution, indicating that most students attended most of the sessions. However, 96 students (33%) attended less than 30 sessions.

Table 2. Description of variables in STAT.

<table>
<tr><th>Variable</th><th>Description</th></tr>
<tr><td>Final</td><td>Final mark in the unit (mean=63, median=67, sd=19)</td></tr>
<tr><td>Test1, Test2</td><td>Two short tests, each worth 5% of the final mark.</td></tr>
<tr><td>Mid-semester exam</td><td>Mid semester exam worth 15% of the final mark</td></tr>
<tr><td>Quizzes</td><td>Weekly online quizzes worth 13% of the final mark</td></tr>
<tr><td>TutParticipation</td><td>Mark for participation in tutorials, worth 5%</td></tr>
<tr><td>TutSubmission</td><td>Mark for weekly tutorial question, worth 12%</td></tr>
<tr><td>Final Exam</td><td>Final exam worth 45% of the final mark</td></tr>
<tr><td>Attendance</td><td>Number of tutorials attended (1 to 12)

</td></tr>
<tr><td>Semester</td><td>The semester: 1 or 2 (507 in each)</td></tr>
<tr><td>Age</td><td>Age of student, categorised as (frequency in second row)
<table>
<tr><td>15-18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27-30</td><td>31-52</td></tr>
<tr><td>86</td><td>335</td><td>178</td><td>165</td><td>84</td><td>61</td><td>31</td><td>26</td><td>8</td><td>9</td><td>11</td></tr>
</table></td></tr>
<tr><td>Sex</td><td>Sex of student (M= 624, F=390)</td></tr>
<tr><td>Repeat</td><td>Indicates if student is repeating this unit (Y=119, N=895)</td></tr>
<tr><td>Citizenship</td><td>The citizenship status: Australian=726, International student=233, Permanent resident=55</td></tr>
<tr><td>TER</td><td>Tertiary Entrance Rank (%) (min=69, mean=median=90, sd=6)</td></tr>
<tr><td>HSMaths</td><td>High School mathematics unit (7 units)</td></tr>
<tr><td>HSMMark</td><td>High school mathematics mark (%) (mean=median=66, sd=9)</td></tr>
</table>

For STAT the classes comprised 52 lectures and 12 two-hour tutorial-laboratory sessions. Lecture attendance was not recorded, so here Attendance is taken as the number of tutorial-laboratory classes attended. The histogram for attendance (Attendance) is very heavily left skewed, indicating that almost all students attended most of the sessions. Indeed, only 30 students (4.3%) attended less than half (6) the sessions.

Below we first present the results of the statistical analysis of student performance for the two units.

Performance

Effect of other variables

For CALC, a scatterplot of the final mark against attendance is given in Figure 1, and shows that broadly the final mark increases as attendance increases. The data contains large variability, but this is not unexpected for such data, as students with similar attendance can have very different performances. In particular, other variables (ability, background, level of participation) also affect performance but are not represented in this plot.

For STAT, Figure 2 shows a boxplot of final marks against the number of tutorials attended. Again, the data shows large variability, but the overall trend is that final marks are increasing with increasing attendance.

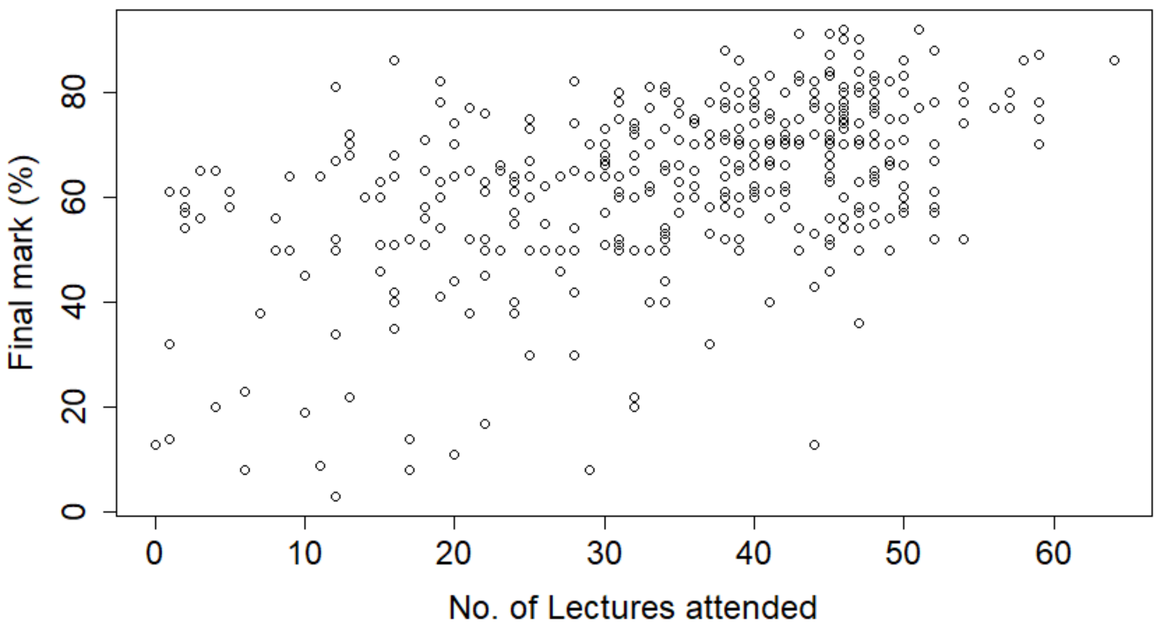


Figure 1. Plot of final marks against lecture attendance for CALC.

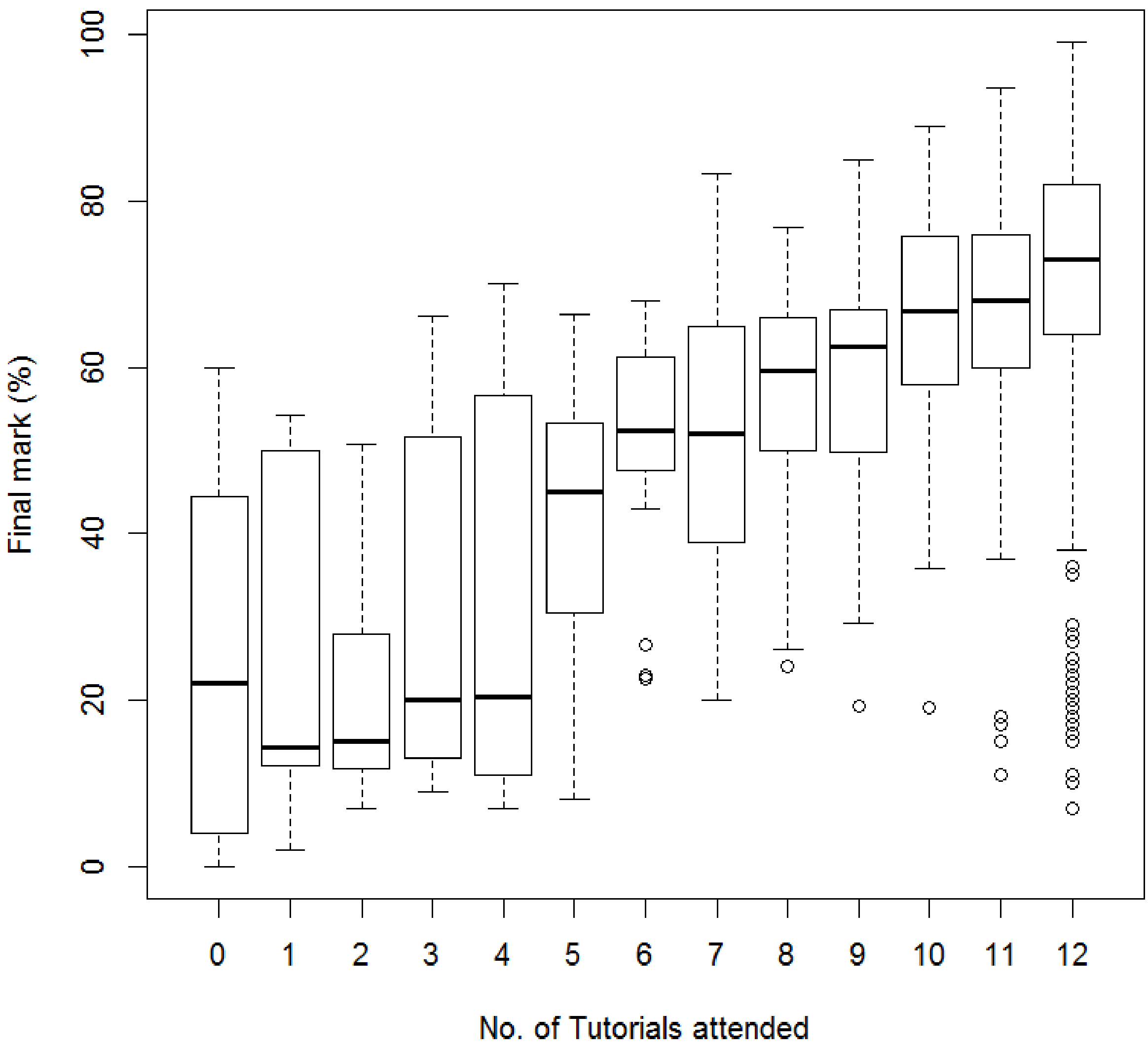


Figure 2. Boxplot of final marks against tutorial attendance for STAT.

For each unit, a linear statistical model (Fox, 1997) was fitted to the final marks (Final) against all the other variables listed in Tables 1 or 2 as appropriate, but excluding the semester assessments (Short Tests, Mid Semester Examination, tutorial assessments and Final examination) as clearly the final marks depend directly on these assessments. The results, after model reduction (using a significance level of 0.05), are given in Tables 3 and 4.

Table 3. Results of linear statistical model fitted to Final for CALC.

Variable	Coefficient	p-value
Attendance	0.52	<2e-16
TER	0.56	9.73e-13
HSMMark	0.47	6.67e-07
HSMaths=Discrete	-14.40	0.0001

Table 4. Results of linear statistical model fitted to Final for STAT.

Variable	Coefficient	p-value
Attendance	1.69	4.89e-12
TutParticipation	7.64	< 2e-16
Repeat Yes	-4.47	0.0015
Citizenship=PR	5.04	0.0154
HSMMark	0.56	< 2e-16

For both units there is no difference in performance between males and females, and age groups.

In addition:

- the visa status of the student has no effect for CALC, but STAT students with PR perform about 5% better on average compared with other students;
- repeat students perform no worse than first time students for CALC, but for STAT they perform worse by 4.5% on average;
- on average a 10% higher mark in high school mathematics translates to a 4.7% increase in the final mark for CALC and 5.6% increase for STAT;
- a 10% higher TER gives 5.6% increase in the final mark on average for CALC, but TER has no significant effect for STAT; and
- compared with students who took Mathematics Applications, those who took Discrete Mathematics in high school have a lower final mark by 14.4% on average for CALC, but there is no effect of high school mathematics unit for STAT. Prior to 2010, Discrete Mathematics was the lowest High School mathematics unit, containing basic algebra and some probability. From 2010, the revised mathematics curriculum replaced this by Mathematics Applications, which contained financial mathematics, geometry and trigonometry, graphs and networks. It appears that the new curriculum better prepared students to continue with higher mathematics.

Effect of Attendance

Everything else being equal, after adjusting for the effect of other variables, the effect of attendance is as follows. Every extra class attended gives 0.52% increase in the final mark for CALC. That is, for two students with similar backgrounds, the one who attends all 64 classes will on average obtain a 33% higher mark compared to one who attends no classes. For STAT, every extra tutorial attended translates to an average increase of 1.7% and every mark for tutorial participation (Tutparticipation) gives an average increase of 7.6% in the final marks. The models indicate that, after adjusting for demographic, background and ability differences, attendance has a large significant positive effect on performance.

Cluster analysis

The data for each unit was clustered using k-means clustering (Peng, 2016), based on the continuous variables in each data. Tables 5 and 6 show, for CALC and STAT respectively, the grades for students corresponding to each cluster. In each case the data is well represented by three clusters. The first cluster corresponds to students mainly with a fail grade (N: final mark < 40), the second cluster corresponds to students mainly in the middle grades (N+: final mark

$40 \leq$ final mark < 50, P: $50 \leq$ final mark < 60, and CR: $60 \leq$ final mark < 70), while the last cluster corresponds to students mainly in the D ($70 \leq$ final mark < 80) and HD (final mark ≥ 80) range.

Table 5. Cluster of Final marks for CALC.

Cluster	Grade*					
	N	N+	P	CR	D	HD
1	26	0	0	0	0	0
2	12	5	81	79	2	0
3	0	0	0	25	106	62

* N = Fail (0-44%), N+ = Fail (45-49%), P = Pass, CR = Credit Pass, D = Distinction, HD = Higher Distinction

Table 6. Cluster of Final marks for STAT.

Cluster	Grade*					
	N	N+	P	CR	D	HD
1	88	5	1	0	0	0
2	11	19	84	156	64	0
3	0	0	0	17	110	136

* N = Fail (0-44%), N+ = Fail (45-49%), P = Pass, CR = Credit Pass, D = Distinction, HD = Higher Distinction

Figures 3 and 4 are scatterplots of final marks against attendance for CALC and STAT respectively. The plotting symbol is grade of student, with the colour corresponding to the cluster. For CALC the clusters are fairly well separated, with the higher grades generally corresponding to higher attendance. The separation is also fairly clear for STAT; however, while the higher grades clearly correspond to higher attendance, as noted earlier this data exhibits large variation.

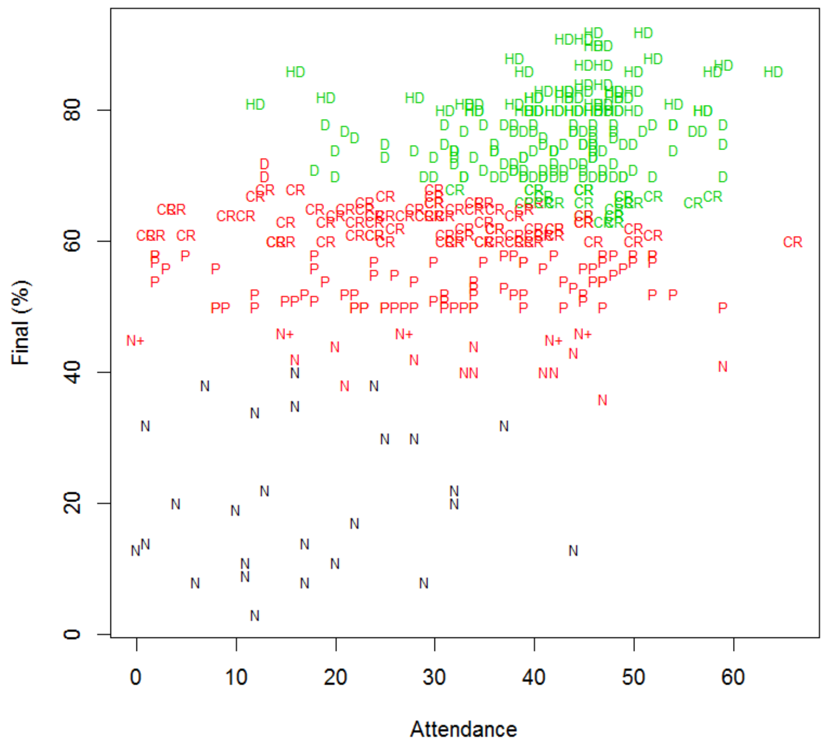


Figure 3. Plot of clusters for CALC. Each colour corresponds to a different cluster, and the plotting symbol is the grade for the student.

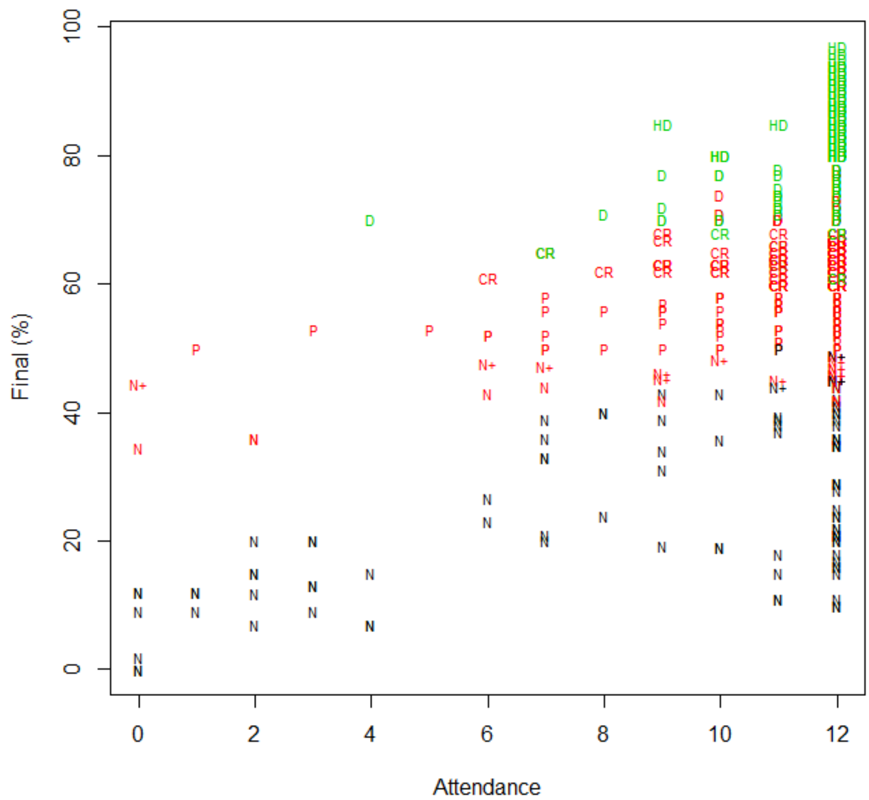


Figure 4. Plot of clusters for STAT. Each colour corresponds to a different cluster, and the plotting symbol is the grade for the student.

Principal Component Analysis

A principal components analysis (Kassambara, 2017) of the data was conducted for each unit, based on the continuous variables in the data. Principal component analysis (PCA) essentially transforms the variables using orthonormal eigenvectors (called *loadings*) of the correlation matrix of the variables in the data.

For CALC the continuous variables are the five short tests, mid semester examination, final examination marks and final marks, along with HSMark (High School Mathematics mark) and TER. The first three principal components (PCs) explained 65% of the variation in the data. The loadings corresponding to each component are shown in Table 7.

Table 7. Loadings for the first three principal components for CALC.

	PC1	PC2	PC3
Test 1	0.238	0.265	0.587
Test 2	0.290	0.105	0.568
Mid Sem	0.344		0.126
Test 3	0.302	-0.221	-0.222
Test 4	0.360	-0.194	
Test 5	0.346	-0.287	
Final Exam	0.383	-0.148	-0.233
Final	0.429	-0.120	
HSMark	0.193	0.607	-0.202
TER	0.181	0.582	-0.394

The first PC is a weighted average of the variables (note that the loadings all have the same sign). Consequently, PC1 is large positive if all the variable values are large. This corresponds to students with high TER and high school mathematics marks, and who have done well in every assessment in the unit, on average. PC2 is a contrast between TER, HSMark and performance in early assessments in the unit (Test 1), and assessments in the second half of the unit. This is seen by the signs of the loadings (and the direction of the arrows in Figure 5). Consequently, large values of PC2 correspond to students with high TER, HSMark and Test 1, and low performance in the second half assessments. This identifies underperforming students with a good background who tended to drop off along the semester. Values of PC2 close to zero correspond to high entry students who performed well overall. Finally, negative values of PC3 identify low entry level students who performed well in the later assessments.

Figure 5 shows a plot of the second PC against the first, with the number of lectures attended as the plotting symbol colour-coded by Grade. The arrows indicate the direction and relative contribution of each variable to each of the PCs. Examining Figure 5 shows that Higher Distinction (HD) grade corresponds to large values of PC1 (students with good backgrounds who did well throughout on average) and medium values of PC2. These students generally have high attendance. At the other extreme, the Fail (N) grade corresponds to low values of PC1 (students with low backgrounds who did badly in all assessments) and high values of PC2 (students with good backgrounds who did particularly badly in the later assessments). This group generally has low attendance. Also visible is a group with low values of PC2 (below -1), corresponding to students with low backgrounds but good performance particularly in the later assessments. These students mostly have grades around a Credit (CR), with several Distinction (D) and HD grades, and all have high attendances. The few students with only a Pass (P) grade in this group have low attendances.

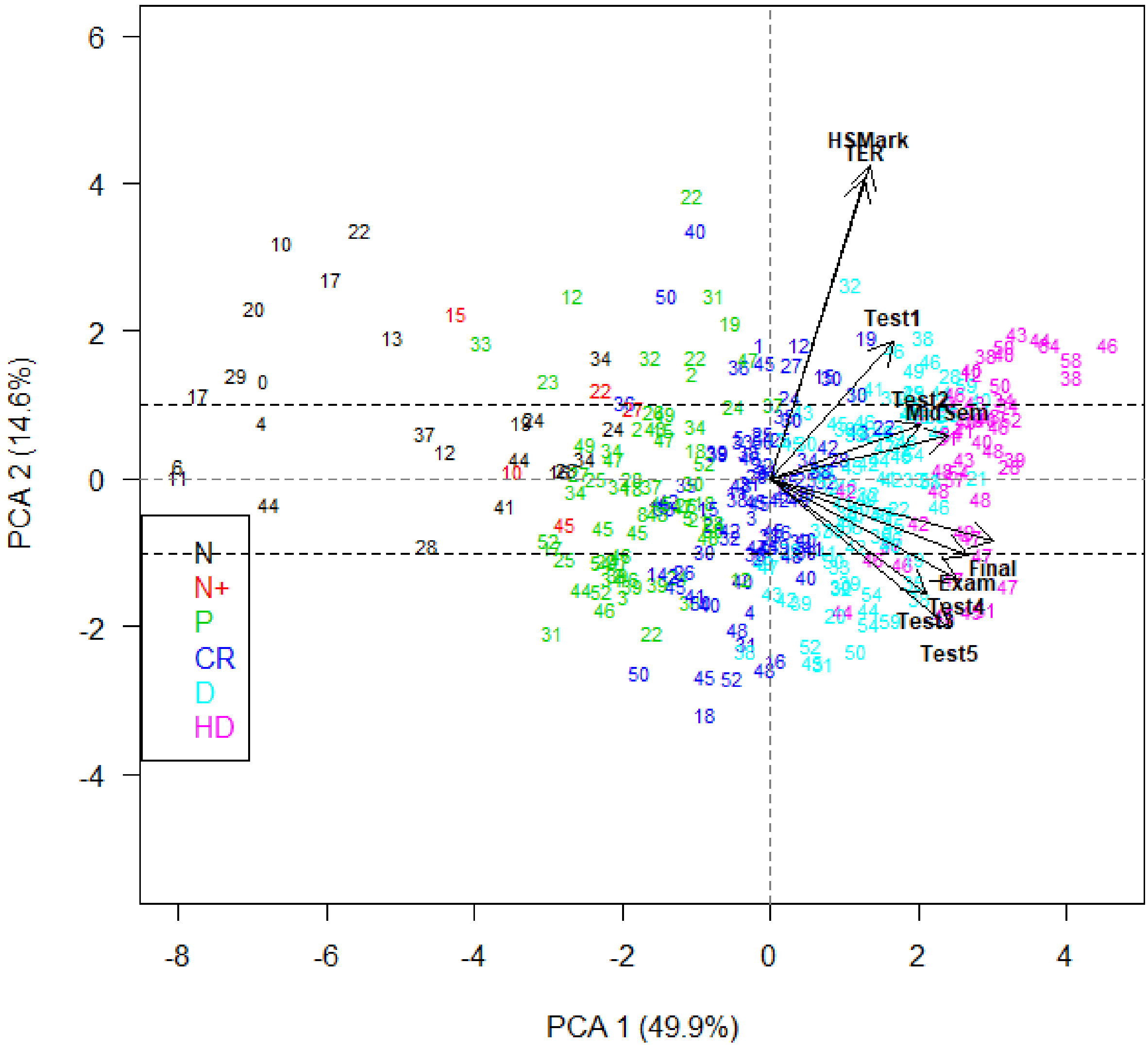


Figure 5. Plot of first two principal components for CALC. The plotting symbol is the number of lectures attended, colour-coded by grade.

A plot of the second and third PCs (not shown here) identified a group of students with good backgrounds but low attendance who failed the unit.

For STAT the continuous variables are the TutPart, Test1, MidSem, Test2, Quizzes, TutSubmission, Exam, Overall mark, TER and HSMark (High School Mathematics mark). The first three principal components explained 74% of the variation in the data. The loadings corresponding to each component (for the best fit, which does not include TutSubmission) are shown in Table 8. PC1 again corresponds to a weighted average of the variables. PC2 is a contrast between HSMark, TER, Test 1 and Mid Sem, and Tutorial participation, Test 2, Quizzes and Exam. The latter four are measures of sustained performance in the unit. Large values of PC2 therefore identifies students with good backgrounds and good performances in the early assessments, but who then tend to drop off in performance. Similarly, large value of PC3 identifies students with a high TER, Exam, Final and Tutorial participation marks, but with low HSMarks, who underperformed in the semester assessments. These students may have taken time to settle into the unit due to their poor mathematics preparation.

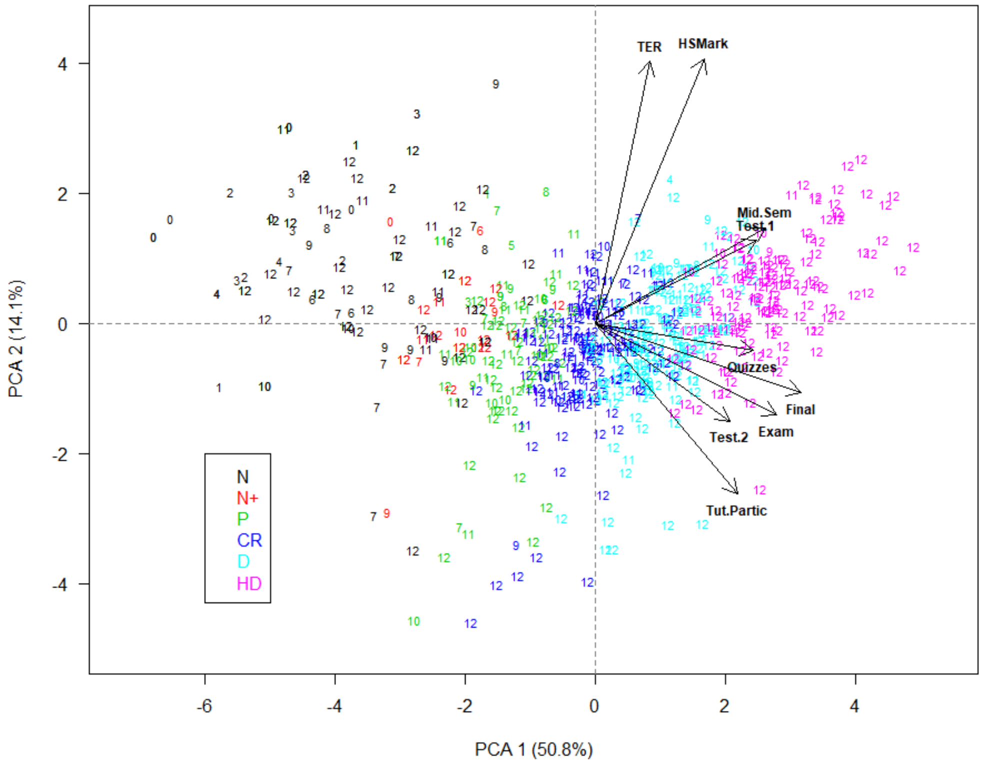
Table 8. Loadings for the first three principal components for STAT.

	PC1	PC2	PC3
TutPart	0.311	-0.375	0.342
Test 1	0.353	0.182	-0.215
MidSem	0.373	0.209	-0.210
Test 2	0.295	-0.215	-0.047
Quizzes	0.347	-0.060	-0.026
Final Exam	0.397	-0.201	0.096
Final	0.450	-0.152	0.069
HSMark	0.238	0.581	-0.388
TER	0.119	0.575	0.791

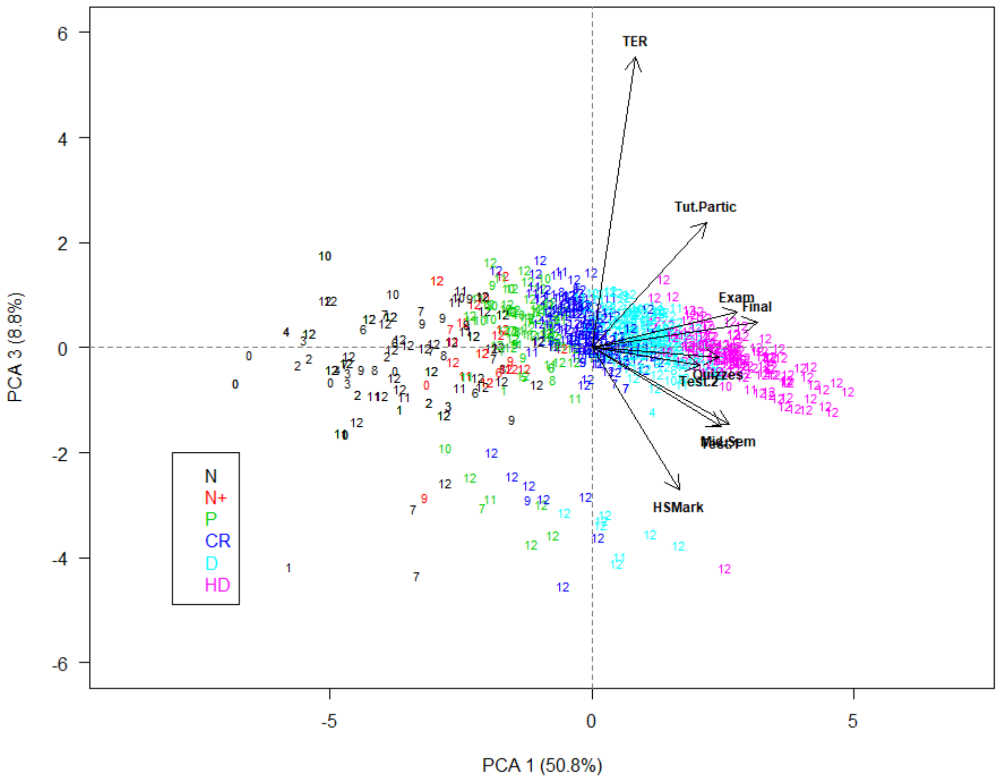
Figure 6 shows pairwise plots of the first three components, with the number of lectures attended as the plotting symbol colour-coded by Grade. Examining Figure 6(a) shows that the HD grade corresponds to large values of PC1 (students with good backgrounds who did well throughout) and medium to high values of PC2 (students with good backgrounds and good performances in early assessments). None of these students has an attendance below 10 (out of 12). At the other extreme, the N grade corresponds to low values of PC1 (students with low backgrounds and bad overall performances) and high values of PC2 (students with high TER and HSMark who did well in the early assessments but them fell off). Several of these students do have high attendances, and further investigation of this group showed that they were all Australian citizens who had either low mathematics backgrounds or they did not take the final examination.

Figure 6(b) shows the plot of PC3 against PC1. The separate group at the bottom of the plot corresponds to students who came in with low TER and high HSMark, and while they underperformed in the Exam and Tutorial participation, their performance in Test 1, Test 2, Quizzes and the Mid semester exam was sufficient to gain a pass or better. All students in this group had high attendance and passed.

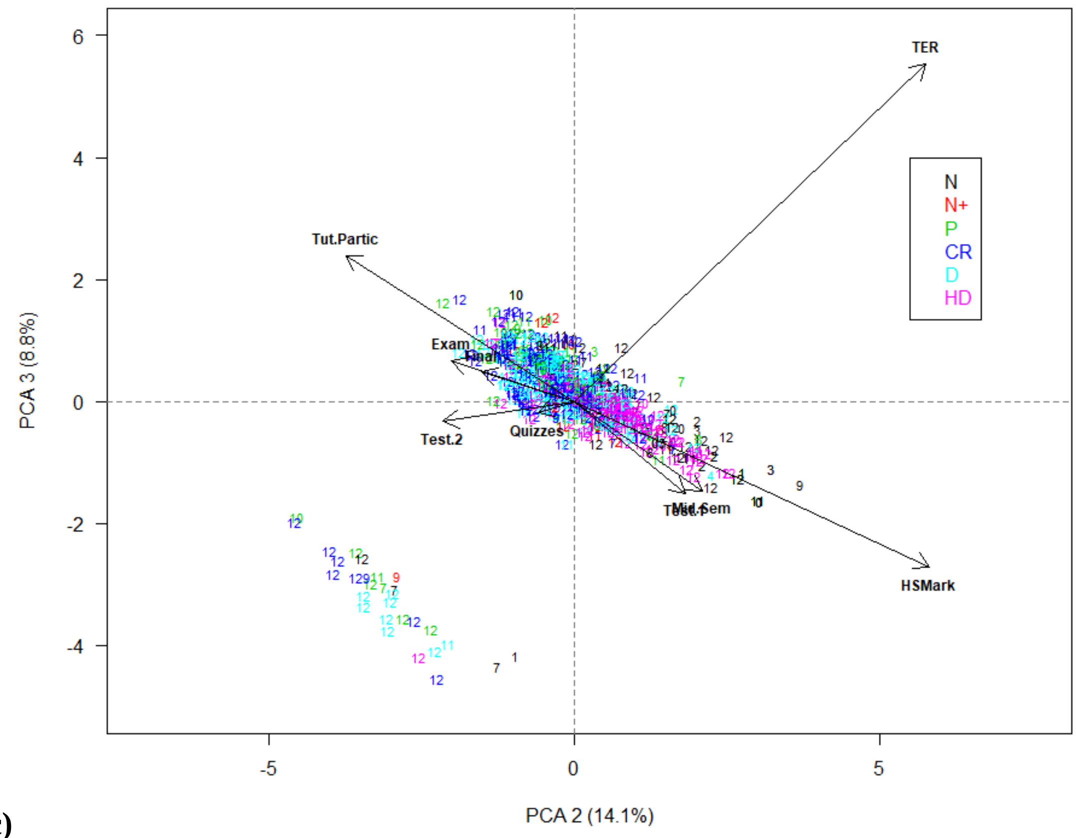
Finally, Figure 6(c) shows a plot of PC3 against PC2. Two groups are clearly visible in this plot also. In particular, the smaller group corresponds to low values of both PC2 and PC3. This represents students with a low TER but good performances in most semester assessments. All students in this group with high attendance obtained at least a P grade. The three failing students all had low attendance.



(a)



(b)



(c)

Figure 6. Pairwise plots of first three principal components for STAT. The plotting symbol is the number of tutorials attended, colour-coded by grade.

The PCA analysis shows that students with good backgrounds who do not attend classes tend to underperform and risk failure, while students with low backgrounds who attend classes obtain good passes. That is, student background seems less important, and all students who have high attendances tend to perform well.

Results II: Attitudes

Attitude to attendance

The survey of students was taken from all faculties at the University of Western Australia. A total of 992 students (539 females, 450 males) responded to the survey, but data was missing in some records. The variables collected in the survey included:

1. age (min = 15, max = 76, mean = 21.8);
2. discipline;
3. weighted mean average mark (WAM: min = 0, max = 100, mean = 68.2);
4. level of study (first, second, third);
5. whether lectures were recorded (Yes = 861, No = 36);
6. percentage of lectures attended (min = 0, max = 100, mean = 60.3);
7. whether student thought lecture attendance was important (LectImportance: Yes = 667, No = 227);
8. percentage of lecture recordings watched (min = 0, max = 100, mean = 60); and
9. whether lectures should be recorded (Yes = 851, No = 5).

A scatterplot of WAM against lecture attendance is shown in Figure 7. The plotting symbols indicate if the student believed lecture attendance was important. The plot shows that more students believe that lecture attendance is important, and these students attend more lectures and perform better.

The main interest is in determining what variables are associated with attitude towards lecture attendance. Consequently, a logistic regression model (Dobson & Barnett, 2008) was fitted to the data with LectImportance as the binary response. Table 9 shows the significant variables (at 5%), along with the odds ratios (the exponential of the coefficients).

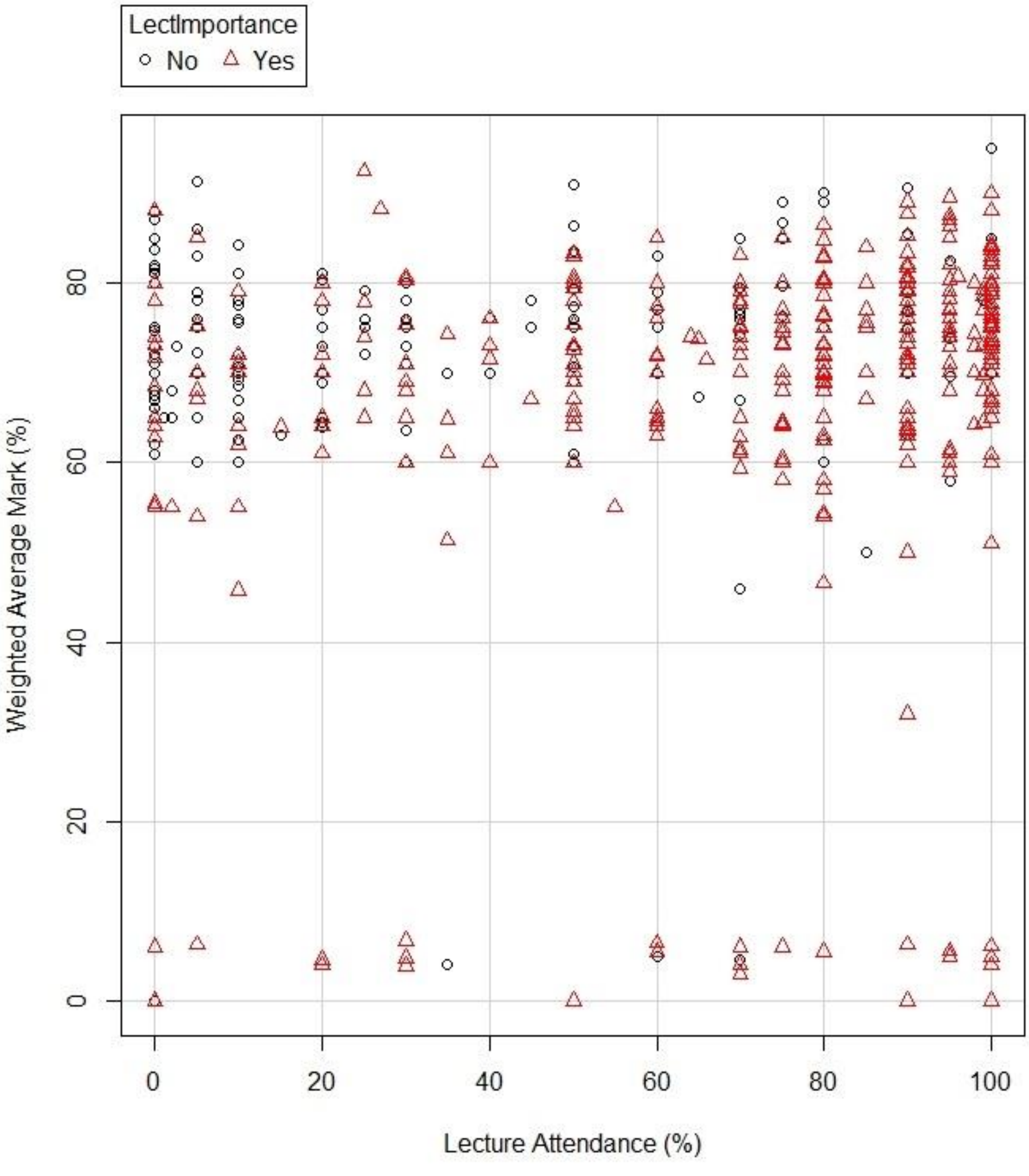


Figure 7. Scatterplot of WAM against lecture attendance. Plotting symbols represent whether the student considers lecture attendance to be important.

Table 9. Results of the logistic regression model fitted to student survey data.

Variable	Coef	Exp(Coef)	p-value
Business	-0.989	0.37	0.0011
Engineering	-0.729	0.47	0.0387
Science	-0.957	0.38	0.0159
WAM (%)	-0.024	0.975	0.0021
Attendance (%)	0.028	1.029	<0.001
Percent Recordings Watched (%)	-0.008	0.992	0.0449

The model shows the following.

1. Discipline. The odds of agreeing that lecture attendance is important for
   - Business students is 37%,
   - Engineering students is 50%, and
   - Science students is 37%
   of the odds for Arts, Medicine and Dentistry, and Mathematics and Statistics students.

2. WAM. For every 5% increase in WAM, the odds of agreeing that lecture attendance is important decreases by 12%.

3. Attendance. For every extra 5 lectures attended the odds of agreeing that lecture attendance is important increase by 15%.

Further, a survey of staff from various universities around Australia, New Zealand, South Africa, South America, Europe and the US was taken. A total of 152 responses (61 females, 91 males) were received. The variables collected were age, discipline, level of teaching, whether lectures are recorded, class attendance, whether staff considered lecture attendance is important (LectImportance, Yes = 113, No = 8, Other = 31), percentage of class who watched lecture recordings, and should lectures be recorded (Yes = 51, No = 18, Neutral = 83).

To identify variables associated with attitude towards lecture attendance, a logistic regression model (Dobson & Barnett, 2008) was fitted to the data with LectImportance as the binary response. None of the variables in the model were significant. A binomial test of proportion indicated an overwhelming support for class attendance (p-value=1.521e-09, 95% confidence interval = (0.67, 0.81)). That is, support for class attendance is at an overwhelming 74% on average, and does not depend on any staff attributes.

Finally, we merged the survey data for students and staff with a view to determining any differences between staff and student attitudes towards class attendance. The analysis revealed that the odds of staff saying lecture attendance is important is 6 times that of students.

Qualitative analysis

Several reasons were forwarded by students for non-attendance. The most common were the time and difficulty of travelling to campus (transport and parking), and work and family commitments. Some cited health issues (such as sleep disorders, hearing impairment and ADHD) that made lecture attendance problematic. Students also agreed that what happened in lectures was important—if it was simply note taking then they preferred to watch the recording, whereas if the class was more interactive and student-centred then they were more motivated and considered attending to be valuable. Staff similarly agreed that lectures needed to be value-added to make attendance worthwhile. Nonetheless, there seemed general agreement in the comments that lecture attendance was important. Both groups overwhelmingly agreed that tutorials and laboratory classes were very important to attend.

Interestingly also, of the 513 students in the survey, only 286 (56%) watched more than half and only 234 (46%) watched more than 75% of the lecture recordings.

Of the 856 students who answered the question on whether lectures should be recorded, 80 were neutral and only 5 said that lectures should not be recorded. Students emphatically support lecture recordings. A total of 126 staff answered this same question, with 47 neutral, 61 supportive and the remaining 18 against. However, staff also agree that lecture recording should only be an extra resource and not the primary source of information for students. Both students and staff agreed that non-attendance had several disadvantages, including not knowing class fellows, reduced student experience, lack of motivation to catch up on missed lectures, missing out on interaction with staff, no opportunity to ask questions or participate in class discussions, and reduced performance. A few students mentioned non-tangible aspects, such as not being able to observe the body language and facial expression of staff.

Significantly, several students from the CALC class mentioned that if lectures had been recorded then they would not have been motivated to attend as many lectures, and their performance would have suffered. These students clearly stated that lectures should not be recorded.

Conclusion

This study highlights the importance of attendance for improving student performance. This is the first study on the effect of attendance with a focus on mathematics and statistics classes. The first part analysed student performance based on demographic variables and exact attendance for a first-level introductory calculus and a first-level statistics unit. Regression analysis showed that attendance was significantly positively associated with performance in both units. Cluster analysis showed that overall higher grades corresponded to higher attendance. Finally, a principal components analysis revealed a clear relationship between attendance and performance. A key observation was that students with low backgrounds were able to gain a pass if their attendance was high. That is, once at university, the background and ability as measured by prior performance is less important than engagement and attendance. Attendance and engagement level the playing field.

It is important to note that it may not be simply class attendance that improves performance. It is possible that attendance is a proxy for other factors, such as motivation and engagement. That is, more engaged and motivated students attend more classes, leading to improved performance. However, it is also possible that attendance creates or at least increases motivation and engagement. In addition, for STAT several students had high attendance and yet performed poorly. Further investigation showed that these students had low participation marks. Thus, it is not sufficient to simply attend classes—one must actively engage in the classes.

The second part studied the attitudes of students and staff towards class attendance. Compared with students in Arts, Medicine and Dentistry, and Mathematics and Statistics, those in Business, Engineering and Science were more likely to consider lecture attendance to be important. Academic staff overwhelmingly agree that lecture attendance is important. Qualitative analysis of written responses showed that students and staff both agreed that class attendance was valuable and improved grades. However, the quality of class sessions was an important motivating factor for students. Gysbers et al. (2011) report, based on student surveys, that positive reasons for attending lectures were: students enjoy lectures; lectures provide a discipline and environment for learning; lectures enrich the university experience; and the live experience has more dimensions than the recording, including the lecturer’s body language and better concentration. Interestingly, a study by Khan and Watson (2018) showed that flipped classrooms in a Statistics unit did not increase attendance. However, this study may be inconclusive since the comparison was across cohorts in different years. Evidence from the same classes now indicates that the flipped mode maintains attendance levels, compared to classes with traditional lectures.

Class attendance repeatedly exposes students to content in various forums (lecture, workshop, tutorials, laboratory classes, class discussions), each designed to scaffold on previous exposures and increase understanding. Importantly also, students are exposed to different staff in the tutorial and laboratory classes. Students not attending classes do not partake in class discussions that allow a distilling of ideas and concepts which form the basis of firm, higher understanding, and cognitive permanency. Further, evidence, both anecdotal and supported by surveys of students, indicates that students who do not attend classes do not keep abreast of course material, but tend to look at it only before assessments. Zimmerman, Jokiaho, and Birgit (2013) found from a survey that 73% of students view only selected sections of lecture recordings and only 20% viewed the entire video. Our survey indicated that most students do not view the full lecture recordings. Evidence from our student examination scripts also indicates that students “spot-learn”; they skip through the lecture recording seeking what they deem to be important information, usually examples and solutions to problems. Trenholm et al. (2019) report that “*a reduction in live lecture attendance coupled with a dependence on RLVs* [recorded lecture videos] *was associated with an increase in surface approaches to learning*.” (page 3). Surface learning is based on partial information and leads to superficial understanding, as the journey of learning has been missed. Understanding complex ideas takes time and struggle.

One important aspect is whether attendance and performance are causally related, and if so, what is the direction of causality? Do students who attend more classes perform better, or do better, higher performing students attend more classes? Our results show that students with inferior backgrounds but with high attendance perform much better than those with superior backgrounds but low attendance. We therefore claim that higher attendance results in higher performance.

It is hoped that the results of this study will motivate students to attend more classes, and academics to improve the in-class experience so students are motivated to attend. We also hope this will stimulate further research in this important area of class attendance. In the recent COVID-19 affected environment, all classes had to be delivered online. Once restrictions were eased a clear demand by students for face-to-face sessions was voiced. Nonetheless, class attendance has not improved. Student engagement seems to be declining over time.

In conclusion, this study shows that class attendance is a key factor in student performance. And so, we end with the same words that we began with. Attendance *matters!*

Ethics Approval

The appropriate ethics approval for this study was obtained from the University of Western Australia (RA/4/1/7978).

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