Classes to passes: Is class attendance a determinant of grades in undergraduate engineering subjects?

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CONTEXT
The rapid advancement in information technologies in recent times has opened a number of opportunities to the higher education sector. This has led to a revision of the traditional educational paradigm through the advent of "online/flexible content delivery" and "massive open online courses (MOOCs)". However, despite these advances, there is an underlying question as to the role of face-to-face teaching in the modern era. In this respect a number of studies have demonstrated that attendance at lectures and tutorials could be strongly correlated to students' success in their studies.

PURPOSE
This work aims to determine if the observations relating to student attendance apply to students studying engineering at undergraduate level and to determine the implications of this for teaching practice in engineering.

APPROACH
For this study an attendance register was kept for several courses across a semester for students enrolled in papers spanning a range of years and disciplines. Subsequently, the relationship between each student's attendance and his/her final grade was examined.

RESULTS
The results showed that for two of the three courses examined in this study there was a strong relationship between attendance and final grade. However, in the third course, this relationship was less clear and rather there was a stronger correlation with students' performance in a pre-requisite course.

CONCLUSIONS
In summary, it can be said that attendance can serve as an indicator for a student's grade, however, other factors can also impact this. In this respect the work illustrates not only the benefits of student attendance but also the flow through impact of knowledge gained in pre-requisite courses.

KEYWORDS
Attendance, grades, pre-requisites.

Introduction

In a historical sense, engineering draws its origins from the artisans where the principal mechanism of instruction was through younger generations serving an apprenticeship. This approach led to technological developments coming through incremental progressions and refinement of ideas passed from generation to generation. In the late 18th century, however, the French revised this model through the development of the Ecole Polytechnique where students were equipped with a mathematical background, before moving into a specific field of engineering (Ferguson, 1992), thus representing the first step towards "modern" university based engineering education.

In charting this history one can see that there has been a gradual shift from one-to-one training, to small group instruction, and with the advent of economic rationalism, a one-to-many approach. This drive for economic efficiencies, combined with the ready availability of information and communication technology, has led to much discussion in the popular press of new educational paradigms. Such paradigms include the advent of flexible delivery modes and massive open online courses (MOOCs), where a course is aimed at delivering unlimited participation and open access via the Internet. By taking the idea of MOOC's to their absolute limits, Russel et al (2013) paints a rather nihilistic picture in questioning: "Will Stanford still be Stanford when the majority of people with Stanford degrees have never visited California?"

Now in considering this, one of the principal criticisms of such an approach to education is that students are generally not satisfied with the level of interaction of MOOCs. Based on this observation, Khalil and Ebner (2014) noted that, in reality, there is a need for more student-instructor interaction if student satisfaction is to be improved. In this vein, Clow (2013) observed that there tends to be much higher drop-out rates with MOOC's than from 'formal' education. Because of this, it was argued, MOOCs alone cannot replace degrees or most other formal qualifications. Similarly, Siemens (2011) notes that the long term value for universities is likely to lie in exactly those things that cannot be cheaply duplicated through a MOOC.

Considering Siemens point leads to questions regarding where this value may lie, and has led to a growing interest in the field of 'Learning Analytics'. Broadly put, this involves:

> *The measurement, collection, analysis and reporting of data about learners and their contexts, for the purposes of understanding and optimising learning and the environments in which it occurs.* (Conole et al, 2011)

Hence, learning analytics should allow learning difficulties to be identified earlier such that corrective actions can be taken to improve student learning outcomes. In effect a well-designed analytics system can provide an early warning procedure and identify 'at risk of failure' students before they seriously struggle.

In developing such an approach, there are many factors that may contribute to good learning outcomes, such as attendance at lectures/tutorials, prior experience/qualifications, social background, learning environment and individual learning styles. Work by Power et al (1987) has shown the importance of previous academic performance and university performance, while Pantages and Creedon (1978) found that students with poor study habits are more than likely to withdraw from university or struggle with their studies.

Of the factors that may influence students' learning outcomes, perhaps the easiest one to quantify is attendance at lectures and tutorials. Understanding the relationship between student success and attendance would provide insights into the value of traditional face-to-face interaction that alternative pedagogical approaches, such as MOOCs, are unable to provide. In this respect, a number of studies have found a positive correlation between attendance and overall grades in a range of engineering disciplines. Nyamapfene (2010)

observed a strong positive correlation between attendance and grades in a second year electronics engineering course, though was limited by a relatively small sample size. Similarly, McCarthy (2011) also observed a positive correlation for first year electrical engineering students, however, it was noted that this was a weak positive correlation. Most recently, Moldabayev et al (2013) reported positive correlations across a range of first year engineering papers from various disciplines, but also found in one instance of a negative correlation between attendance and overall grade. As such, there appears to be evidence to suggest that attendance at class may serve as an indicator for engineering student success, particularly in the early stages of their studies.

On this basis it was decided to explore if these observations applied not only to early years but also to later years, across multiple branches of engineering and cohorts of students studying at Auckland University of Technology (AUT), New Zealand.

Method

AUT offers a number of accredited degree options including 4-year Bachelor of Engineering (BE) degrees (aligned the Washington Accord) and 3-year Bachelor of Engineering Technology (BEngTech) degrees (in line with the Sydney Accord), across a range of disciplines, including mechanical, electrical and built environment engineering. In offering these programmes, AUT has framed itself as a contemporary university with a distinctive approach to teaching and learning. It has a vision of providing student-centred, innovative and responsive learning experiences.

In line with this vision, this study set out to understand some of the factors that influenced student success in AUT engineering programmes, as a subset of a larger university effort in the field of Learning Analytics. In doing this, the work posed the question: *Is class attendance a determinant of grades in undergraduate engineering subjects?*

In order to address this question, three undergraduate engineering courses were selected from AUT offerings, to form the basis of this analysis. The first paper, Statics 1 (80 students), is a first year course for BEngTech students studying mechanical engineering. The aim of this is to introduce the principles of static mechanics, including simple selection applications based on accepted design standards.

The second paper, Embedded Digital Systems (47 students), is a third year course for BE students in electrical and electronic engineering that discusses the design and development of the hardware and software of an embedded system and communication interfaces it may use. It also provides an introduction to the use of object oriented programming languages (such as C++ or C#) to develop engineering application programs in a graphical environment.

The final paper, Thermodynamics and Heat Transfer (106 students), is a second year course for mechanical engineering BEngTech students. This course examines basic thermodynamic principles, such as the ideal gas law, property tables, mass and energy conservation, mechanisms of heat transfer and heat exchangers. Each of these courses has a mixture of assessable coursework items (such as laboratories, assignments and tests) accounting for 30% of the final grade and a final examination representing the remaining 70%.

For each course, a register of attendance was circulated during lecture and tutorial times with students requested to sign as acknowledgement of their attendance. In this respect, the attendance record relied on self-reporting by students, and that students would not sign on behalf of colleagues. Inspection of the signatures suggested that there was minimal occurrence of manipulation and the numbers self-reporting aligned broadly with the observations of the teaching staff. Subsequently, for the three cohorts, students' attendance was compared with their overall mark in the course.

Furthermore, in the first two courses (Statics 1 and Embedded Digital Systems), in addition to recording attendance, teaching staff took intervention measures when they observed that

students were repeatedly absent during the early portion of the semester. Such interventions included telephoning and e-mailing students to determine if they wanted to continue in the course. In the third (Thermodynamics and Heat Transfer), staff maintained a register of attendance but did not attempt to intervene. This approach allowed a picture of how attendance and performance were linked, as well as how some of the principles embodied in a Learning Analytics programme could be applied (i.e. intervening in an attempt to improve outcomes for students identified as being 'at-risk'), and the efficacy of such measures.

Results and Discussion

In considering the answer to the question that the work posed, it can be suggested there does appear to be a relationship between a student's attendance and his/her overall mark in a course, as illustrated by Figures 1-3. In each figure it can be seen that there is a positive correlation between attendance and grade, inferring that there is a degree of benefit to be derived from regular attendance at class. This is most clearly illustrated for students in Statics 1, as shown in Figure 1, where there is a relatively strong positive correlation between attendance and mark.

In this instance the results show a Pearson product-moment correlation coefficient (R) of 0.56. Of course in considering this, the value of R indicates that there is a relationship between attendance and achievement, but does not imply causality. Hence, given that R is not equal to 1, it is apparent that attendance is not a sole indicator for success, and that there are other factors that may influence a student's overall mark.

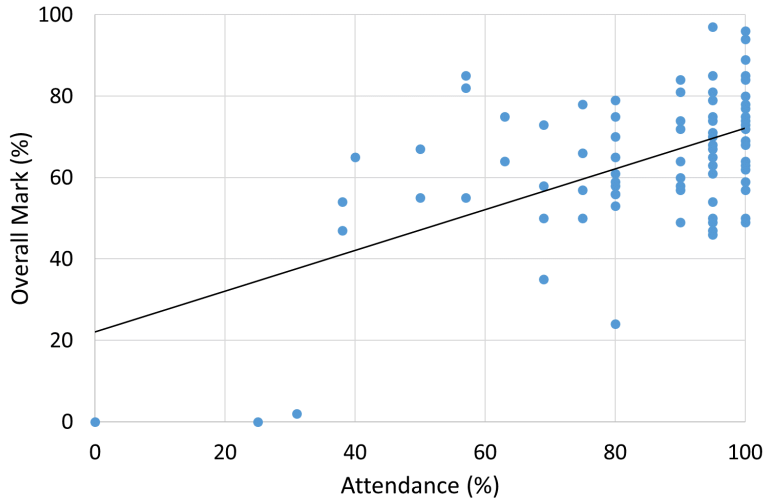

Figure 1: Overall mark vs attendance for Statics 1

Similarly, Figure 2 shows a reasonably strong positive correlation (R=0.46) between attendance and grades for students studying Embedded Digital Systems. From this, it would serve to illustrate that class attendance as an indicator of likely success irrespective of subject discipline or year of study. This is further supported by the results for students attempting Thermodynamics and Heat Transfer, shown in Figure 3, where again a positive correlation is observed. However, it is interesting to note that for Thermodynamics and Heat Transfer the strength of this correlation is somewhat weaker (R=0.4).

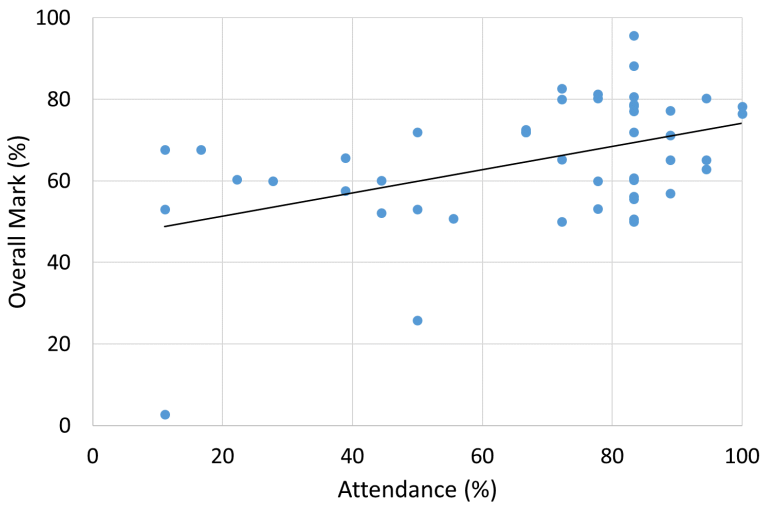

Figure 2: Overall mark vs attendance for Embedded Digital Systems

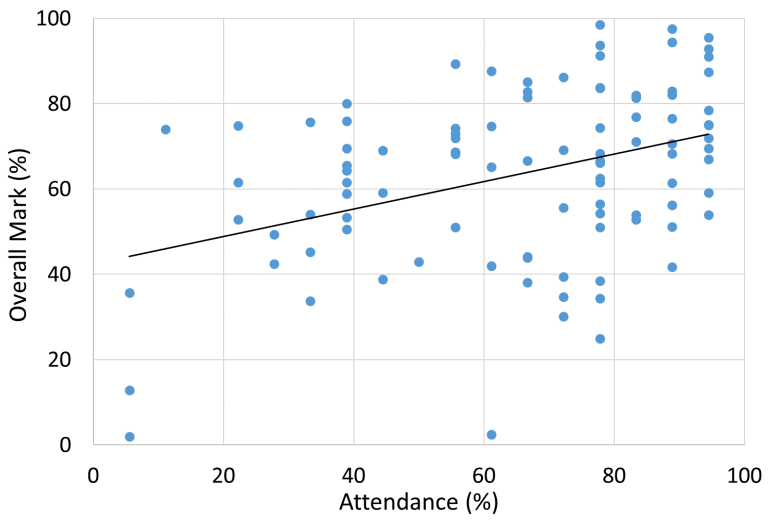

Figure 3: Overall mark vs attendance for Thermodynamics and Heat Transfer

In considering this weaker correlation, it is apparent that there must be other factors that are influencing a student's mark, such as the intervention of teaching staff in the other courses when a student's attendance was poor. That said, a student's enrolment in Thermodynamics and Heat Transfer is commensurate on them having completed three pre-requisite courses, namely: Introduction to Thermofluids and Energy, Engineering Mathematics and Dynamics 1. As such, it was decided to examine if there was any discernible relationship between students' marks in these pre-requisite papers and Thermodynamics and Heat Transfer.

In Figures 4-6 the cross-correlation of students' mark in Thermodynamics and Heat Transfer with each pre-requisite is presented. From these it can be seen that, as one would expect, there is a positive cross-correlation between students' marks in the pre-requisite papers and Thermodynamics and Heat Transfer. That said, it is interesting to note that the cross-correlation with Introduction to Thermofluids and Energy (R=0.45) and Engineering Mathematics (R=0.35) does not appear to be particularly strong. What perhaps is more revealing, is that a student's mark in Dynamics 1 appeared to be a relatively strong indicator (R=0.6) of the mark a student would receive in Thermodynamics and Heat Transfer.

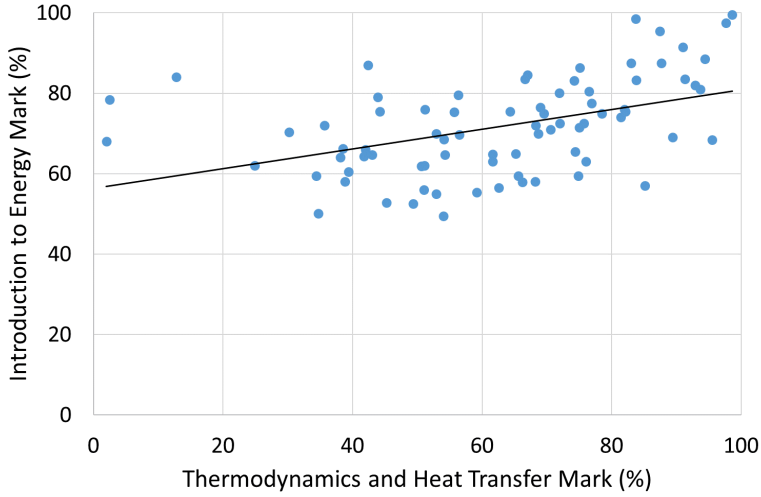

Figure 4: Cross correlation of Introduction to Thermofluids and Energy and Thermodynamics and Heat Transfer marks

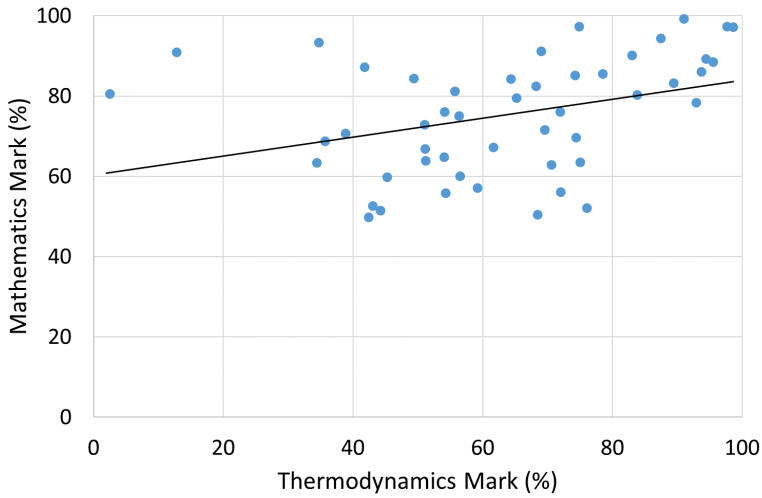

Figure 5: Cross correlation of Engineering Mathematics and Thermodynamics and Heat Transfer marks

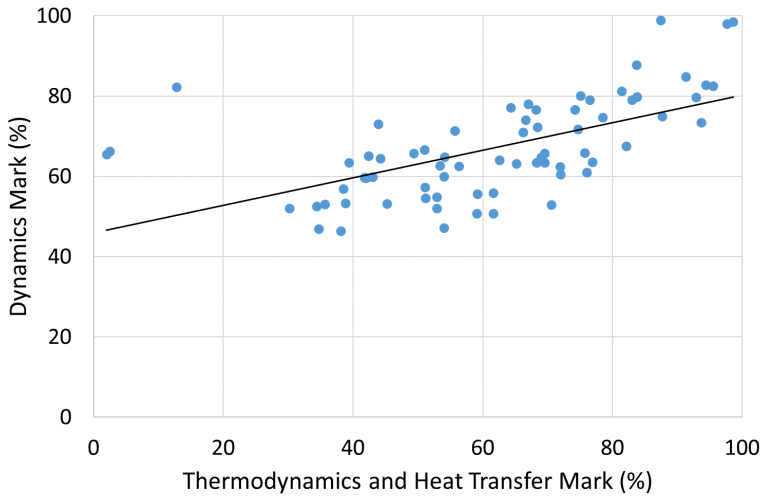

Figure 6: Cross correlation of Dynamics and Thermodynamics and Heat Transfer Marks

The reason for the relationship between a student's mark in Dynamics and Thermodynamics and Heat Transfer is not immediately apparent. Anecdotal evidence would suggest that both subject areas are ones where students struggle to master some of the concepts and are joined in this respect. Alternatively, difficulties in resolving the principles of conservation of mass and energy that feature in both papers may also be a reason, though the relationship is perhaps worthy of further investigation

Conclusion

Based on the observations made in this work, it can be concluded that attendance can serve as indicator for success. In this respect the three courses that were examined all showed a positive correlation between a student's attendance and overall mark. Given that the three papers examined came from widely varying subject areas, involved different student cohorts and students at various stages in their studies, attendance appears to be a generalizable indicator for an undergraduate student's likely success in engineering subjects.

In addition, it was noted that where lecturers had intervened after observing poor attendance, there appeared to be a stronger alignment of grades and attendance. However, in Thermodynamics and Heat Transfer, where there was no intervention, it was found that student grades were strongly aligned to a student's performance in the pre-requisite papers, and Dynamics 1 in particular.

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