Mathematics preparation for university: entry, pathways and impact on performance in first year science and mathematics subjects

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Abstract

Secondary school mathematics has always been considered central to preparation for university science degrees. Within the context of low levels of participation and attainment in both secondary school and tertiary mathematics and science, we examine the relationship between these two. Using university databases, we examine secondary school mathematics preparation in relation to university entry, pathways and performance for science students at a single, research-intensive university in Australia. We analyse the relationship between senior secondary school mathematics choice and attainment and overall attainment in Science degrees and performance in large cohort units in university mathematics, physics and chemistry. We also examine the impact of mathematics bridging courses for mathematically under-prepared students on attainment in the university mathematics unit. Our findings indicate that the higher levels of mathematics taken in senior secondary school are strong predictors of success in first year science and mathematics, but that our students who achieve in the top bands of each level of mathematics taken in senior secondary school can and often do outperform their peers who study a higher level of mathematics at school but achieve a lower band result. The impact of mathematics bridging courses on attainment in university mathematics is also discussed.

Introduction

In opening the Bridging Mathematics Conference in 1992, the Minister for Science and Technology, The Honourable Ross Free MP (1992, p. 5) said:

> *... mathematics is the basis of all modern science and technology. If you accept the proposition that science and technology are crucial to Australia's future, then it follows that mathematics is probably the single most important area of study.*

Twenty years later, in 2012, Australia's Chief Scientist in his report to the Prime Minister argued that 'Mathematics, Engineering and Science (MES) are fundamental to shaping the future of Australia, and the future of the world' (Chubb, 2012, p. 12). Yet over that twenty-year period, the number of students in Australia who study the higher levels of mathematics in the senior years of secondary school, has fallen (Barrington, 2012) corresponding to similar declines in other Western developed countries (Hoyles, Newman and Noss, 2001; Hourigan and O'Donoghue, 2007).

In Australia, students are admitted to university primarily on the basis of their Australian Tertiary Admissions Rank (ATAR); a ranking that allows a comparison of students who have studied different combinations of subjects for their end of year 12 secondary school qualification. Students can study mathematics essentially at three levels in the senior years of secondary school; elementary (pre-calculus), intermediate or advanced, although there is some state variation. In New South Wales (NSW), students have the option of studying two advanced levels of mathematics. In this state, of the students eligible for an ATAR, the percentage of students studying either intermediate mathematics or advanced mathematics has fallen from 61% in 1992 to 35% in 2012 (NSW Vice-Chancellors' Committee, Technical Committee on Scaling, personal communication April 2013).

The reasons why students do not choose to study the higher levels of mathematics in senior secondary school are complex and include state and territory education policies, educational opportunity and personal choice (Wilson, Mack and Walsh, 2013). Studying mathematics in the senior years of secondary school is not required in some Australian states and territories. In NSW, the requirement for students to study at least one mathematics or science subject was removed in 2001. Wilson et al. (2013) contend that the change in policy in NSW and the increase in alternative subject choices are factors contributing to the alarming trends in this state.

University admissions policies may have inadvertently contributed to this situation. At many universities there are no subject prerequisites for entry into degree programs. Students are advised of the level of senior mathematics that is 'assumed knowledge' for their degree but may nevertheless be offered a place solely on the basis of their ATAR score. Wilson et al. (2013) argue that the disappearance of prerequisites has produced anomalies including students entering science degrees without the required mathematics background.

Students' perceptions about studying mathematics at the higher levels also play a part in this context. In a large national survey of Australian mathematics teachers and career professionals, McPhan, Morony, Pegg, Cooksey and Lynch (2008) found that factors that impacted on students' decision making not to study the higher levels of mathematics at senior secondary school as perceived by both the mathematics teachers and career professionals included the self-perception of ability, interest and liking for higher level mathematics, perceptions of the difficulty of the higher level subjects, previous achievement in mathematics and its perceived usefulness. A Mathematical Association of New South Wales (MANSW, 2014) survey of 1084 teachers, representing an estimated 18% of NSW secondary mathematics teachers, found that 51% of the respondents believe that a substantial number of mathematically able students in their school are selecting a senior mathematics course below their capacity with only 34% of respondents disagreeing. The most frequent reasons given were a desire by the student to optimise their ATAR and the level of difficulty and time demands of intermediate mathematics. These findings agree with those of a small study of mathematically under-prepared students entering a research-intensive university in Sydney, Australia. Gordon and Nicholas (2013) concluded that student confidence and evaluating the time demands of the higher levels of mathematics compared with other subjects were two important factors on the student's decision not to take a higher level of mathematics. The findings indicate that students focus on the end of school ranking – the ATAR – with the goal of getting into the university degree of choice rather than being adequately prepared for that degree.

Mathematics underpins the study of many disciplines at university, not only in science, technology, engineering and mathematics (STEM) but also in agriculture, pharmacy and economics. Therefore, failure to study an appropriate level of mathematics in the senior years of secondary school may have serious consequences for a student's success in STEM degrees or indeed completion at university (Trusty and Niles, 2003). Sadler and Tai (2007) analysed the association between the amounts of high-school science and mathematics preparation and performance in introductory college science across 77 colleges and universities in the US. They concluded that the 'two pillars' supporting college science were high school study in the same science subject and more advanced study of mathematics, finding that 'students who take high-school calculus average better grades in college science that those who stop at pre-calculus' (Sadler and Tai, 2007, p. 457).

Success in university mathematics courses similarly depends on the level of mathematics studied in secondary school. In a Canadian study, Kajander and Lovric (2005) found that the amount of time students spent learning mathematics in the final years of secondary school was strongly correlated to their performance in a first year calculus course. In Australia, Rylands and Coady (2009) concluded that students' secondary school mathematics background, and not their ATAR, has a dramatic effect on pass rates with 77% of students with only elementary mathematics failing a basic first year mathematics course. Poladian and Nicholas (2013) found that students, who studied intermediate mathematics in senior secondary school and hence were mathematically under-prepared for their university mathematics courses, were more likely to withdraw from or fail their first year mathematics courses. They further showed that although 77% of the intermediate mathematics students who enrolled in a pre-university mathematics bridging course were able to pass their first semester calculus course, they did not achieve at the level of their well-prepared peers who had studied advanced mathematics. These latter findings agreed with those of Varsavsky (2010) who found that the biggest contrast in performance and engagement is between those students who studied mathematics to an advanced level in senior secondary school and those who did not.

In this paper, we investigate the impact of students' choice and level of attainment in secondary school mathematics upon their entry, pathways and performance in university mathematics and science at the University of Sydney. The study has been designed in response to concerns regarding mathematics participation and attainment levels in both secondary and tertiary levels, and to answer the following research questions.

1. What secondary school mathematics preparation, in terms of mathematics subject choice and attainment, do students bring on *entry* to the University?
2. a) What mathematics study *pathways* are available to students at the University?
   b) How do these relate to both secondary school preparation and attainment at the University?
3. a) How is secondary school mathematics subject choice and level of attainment related to overall, first year *performance* in Science degrees?
   b) How is secondary school mathematics subject choice and level of attainment related to *performance* in individual units for first year mathematics, physics and chemistry?

Methodology

This is a secondary data analysis of the total population of first year science and mathematics students at the University of Sydney. As a total population study we rely on descriptive statistics to report trend in this population, and inferential analyses are not necessary.

The context

The Higher School Certificate in NSW

The end of year 12 qualification for senior secondary students in NSW is the Higher School Certificate (HSC).

The HSC students receive their results in all courses studied for their HSC in terms of a performance band and a mark within that band. For most courses, there are six bands with Band 1 the lowest and Band 6 the highest. The mark ranges assigned to these bands are fixed for all such courses. Band 1 will give a mark in the range 0 – 49 and each subsequent band covers a 10 mark range up to 90 – 100 for Band 6. In each course, a set of course-specific band descriptors — a description of what a typical student in that band knows, understands and can do — is used by judges to determine how the raw mark distribution for that course will be mapped onto the bands and so produce an HSC mark distribution, which provides the student's HSC mark on that course. A consequence of this process is that the percentage of the course candidature in each band varies from year to year. The process, with performance band descriptors for each course, may be found online (Board of Studies, Teaching and Educational Standards [BOSTES], 2014).

The ATAR, for those students eligible to receive it, is the result of a scaling process applied to the full set of *raw* marks obtained by these students and so does not use either bands or HSC marks in its calculation.

Mathematics levels in NSW

In NSW, students can choose to study mathematics in the senior years of secondary school at four levels for the HSC. These are General Mathematics (pre-calculus), HSC Mathematics, HSC

Mathematics Extension 1 and HSC Mathematics Extension 2. Following the terminology used in the well-known national studies of Barrington and Brown, HSC Extension 1 and 2 courses are classified as *Advanced*, HSC Mathematics is classified as *Intermediate* and the General Mathematics course is classified as *Elementary* (Barrington, 2006). Students can also choose not to study mathematics for their HSC.

Students' results in General Mathematics and HSC Mathematics are reported as marks out of 100 in the six bands as described above. For HSC Extension 1, there are four bands; E1 has marks ranging from 0 to 24, E2 from 25 to 34, E3 from 35 to 44 and E4 has marks ranging from 45 to 50. The students in HSC Extension 2 also have their achievement reported in bands E1 to E4 but the mark range in each band is essentially double that of Extension 1 to make it out of 100.

The university context

The University of Sydney is a large research-intensive university in NSW with over 50,000 students. Our university has no subject prerequisites for entry into its degree programs but students are advised of the 'assumed knowledge' appropriate for each degree in the University Admission Centre (UAC) guide to the application process. Students who do not have the 'assumed knowledge' for their degree can choose to enrol in one of two mathematics bridging courses – short courses organised by the University – prior to commencing their university studies. Further details of the bridging courses are given below.

All students entering science degrees are required to study 12 credit points of first year mathematics or statistics. This constitutes one quarter of a full-time load for one year. Engineering and IT students are also required to meet this requirement. The focus of our research is on Science students; however when we examine performance in the largest first year mathematics service unit, Differential Calculus (MATH1001), this cohort includes many Engineering and IT students and students from other faculties.

Data collection and analysis

Data were collected from the University's databases to examine students with a 2011/2012 HSC or a 2011/2012 NSW University Admission Centre (UAC) application and enrolled in the 2013 first year cohort at the University of Sydney. This was done by tracking enrolled students across the school-university transition using a linkage between HSC data provided by the BOSTES and offers data provided by UAC, which includes ATAR information. Data are analysed and presented according to the research questions exploring entry, pathways and performance.

Data were collected on students who were enrolled in the units Differential Calculus MATH1001, Physics 1 (Regular) PHYS1001 and Chemistry 1 CHEM1101 in Semester 1 2013. Students were only included in the study if:

- They had a 2011 or 2012 HSC or, in the case of MATH1001, applied to the Universities Admission Centre (UAC) for the first time in either 2011 or 2012;
- The subjects they studied for the HSC and their marks in those subjects were recorded, and
- They were allocated a grade in the unit.

These criteria resulted in data on 285 Science students enrolled in PHYS1001, 651 Science students enrolled in CHEM1101, and 892 Science, Engineering and IT students, enrolled in MATH1001.

Limitations

This study focuses on only one cohort of students at the University of Sydney; the 2013 cohort. Our analysis shows that these entering HSC students, although typical for this university, generally possess high ATAR ranks by comparison with the full spectrum of HSC students entering NSW universities. Furthermore, our mathematics bridging courses were taken only by those students who were prepared and able to commit the time and money to attend them in order to increase their competence in the 'assumed knowledge' in mathematics specified for their intended courses. Many other variables including motivation levels and the amount of mathematics support students received during their studies are unknown and cannot be controlled.

Findings and Discussion

University Preparation

First we examine the secondary mathematics courses chosen by the University science cohort. Table 1 gives the numbers of students eligible for an ATAR in each level of mathematics for the HSC in NSW in 2012 together with corresponding data for the University of Sydney science cohort in 2013.

Table 1: 2013 University of Sydney science cohort and 2012 total NSW HSC cohort participation in HSC mathematics courses

		No maths	Elementary	Intermediate	Advanced		
			General Maths	2 Unit Maths	Extension 1	Extension 2	Total
Total HSC cohort	Number	8665	26999	10357	5390	3436	54847
	%	16	49	19	10	6	100
University Science cohort	Number	108	209	399	275	215	1206
	%	9	17	33	23	18	100

The elite level of students at the University is evident as the University of Sydney science cohort shows a high proportion (41%) of students studying advanced mathematics when compared to the state-wide HSC cohort (16%). The University cohort also show substantially lower proportions of students who did not study mathematics, or who studied elementary General Mathematics (26%) than the total HSC cohort (65%). However both these statistics are cause for concern. Across the state two thirds of students study no mathematics or mathematics at elementary level and, even at an institution with high ATAR entry requirements, 9% of students in Science degrees have no mathematics study in senior secondary years and 17% have only elementary mathematics preparation, with no calculus study. These students are likely to have extreme difficulty if enrolled in mathematics units with an assumed knowledge of calculus. For this reason, very few students with elementary mathematics or no mathematics enrol in the unit Differential Calculus that has 'assumed knowledge' of HSC Mathematics Extension 1. Only 41% of Science enrolments meet this assumption. We will examine how these science students together with engineering and IT students, without a background of Extension 1, fair in this unit with and without support through bridging courses.

University pathways in mathematics

Figure 1 illustrates the pathways into the four mathematics levels offered to students at the University of Sydney ranging from an introductory calculus course, for those students without a prior knowledge of calculus, to advanced mathematics for those students who studied Mathematics Extension 2 in senior secondary school. Students are advised of the mathematics units appropriate for their background but some degrees such as engineering and IT and majors such as physics have requirements or recommendations that can lead students to enrol in a unit for which they are mathematically under-prepared.

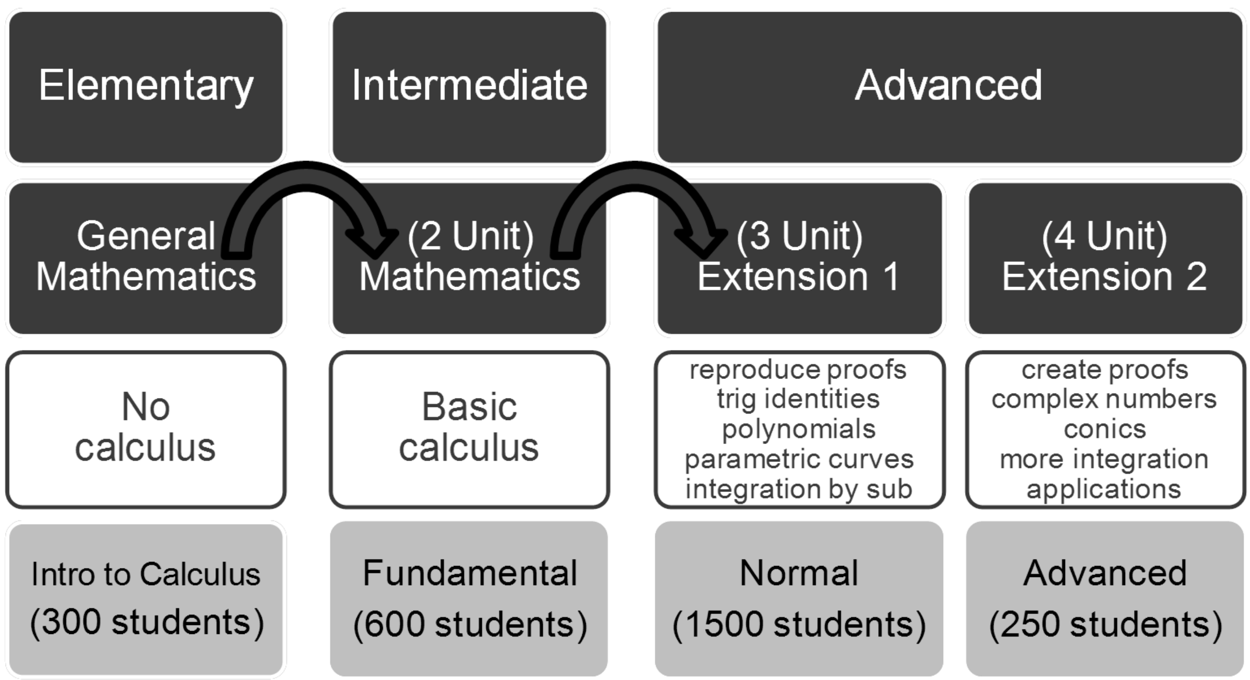

Figure 1: Pathways into different mathematics levels offered at the University of Sydney

Students enrolling in mathematics units without the assumed knowledge for those units have the option of taking a mathematics bridging course in February prior to the beginning of Semester 1. There are two levels of bridging course offered; 2 unit and Extension 1 illustrated by the bridges in Figure 1. The 2 unit course is designed for those students who have not studied calculus before and introduces students to the ideas of differential calculus, the trigonometric, exponential and logarithmic functions and revises algebra and co-ordinate geometry. The Extension 1 bridging course is designed for students who have studied HSC Mathematics (intermediate) and covers a selection of topics in HSC Mathematics Extension 1. Each bridging course is fee-paying, includes 24 hours of class time held over 12 days and is open to all including students enrolling at other universities. In 2013, a total of 365 students enrolled in the mathematics bridging courses; 42% (n=155) in the Extension 1 course.

University Performance

First we examine how secondary school mathematics subject choice and level of attainment are related to overall first year performance in Science degrees. The numbers of students within the University science cohort in each performance band for HSC mathematics courses are shown in the lower graph of Figure 2. The numbers show that the University science students are spread across a wide range of attainment bands (although there are no students with Band 1 in General Mathematics or in Extension 2) but that the majority attain in the top three bands of General and (2 Unit) Mathematics and in the top two bands of the Extension courses.

First year attainment is shown in the upper graph of Figure 2, where the Annual Average Mark (AAM) is used as a summary indicator of attainment. The AAM is a student's average mark in a single calendar year and is calculated using a weighting for the number of credit points for each unit; thus units with a lower credit points and workload contribute proportionate to their credit point value.

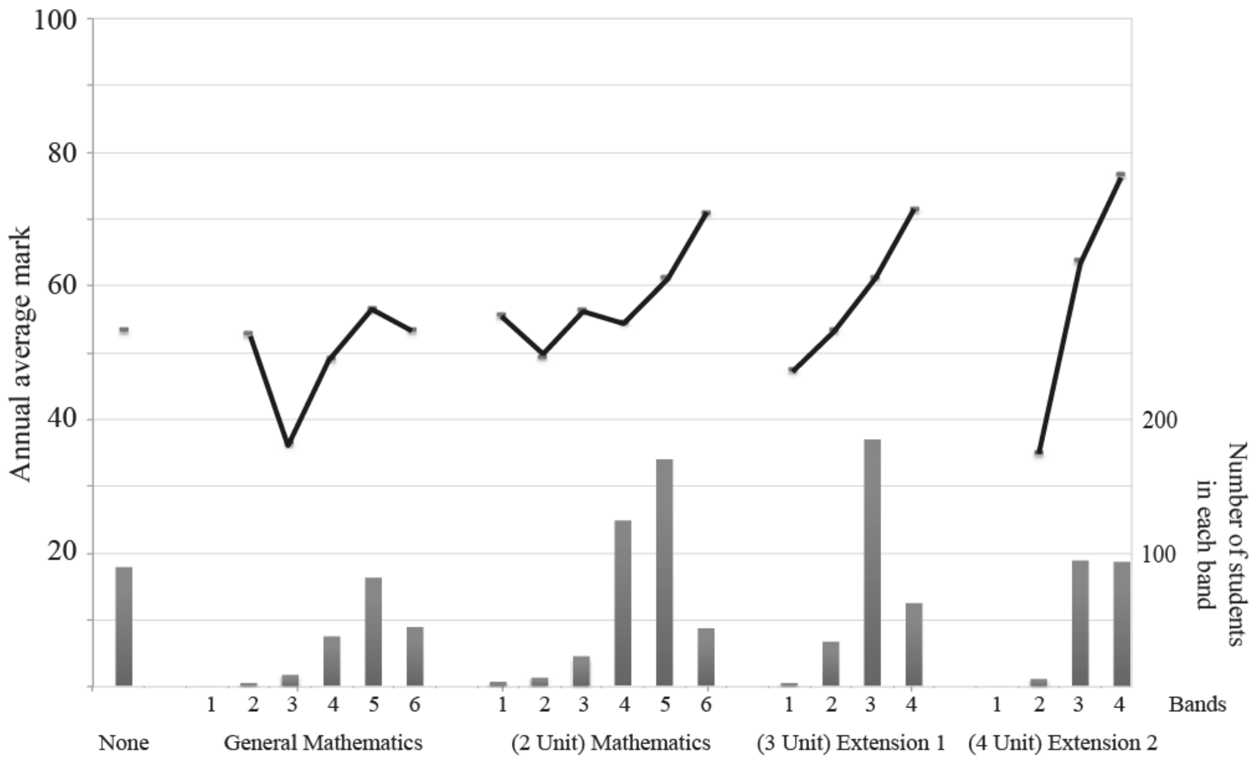

Figure 2: Annual Average Mark (AAM) in first year Science by HSC mathematics course and attainment band

Figure 2 shows a progressive, saw-toothed trend, with students' performance increasing with both the level of secondary mathematics course undertaken and the bands attained within each course. There are some anomalies with students who entered with low bands in General

Mathematics and HSC (2 Unit) Mathematics performing surprisingly well, but these data points relate to very small numbers of students. It can be observed that although AAM increases with more advanced courses in mathematics the attainment band achieved by students in each course shows a stronger association with university performance. This is such that on average a student with a Band 5 or 6 in HSC (2 Unit) Mathematics is at a level equivalent to Band 3 or 4 in Extension one or Band 3 in Extension 2 when it comes to first year performance.

To examine the relationship between mathematics preparation and science in more detail we now consider student performance in the largest cohort first year mathematics, physics and chemistry units at the University. We analysed the performance of the total cohorts in these units meeting our criteria. For chemistry and physics, unsurprisingly, the large majority of these students are enrolled in Science degrees; while in the mathematics unit the cohort is more diverse and students from Engineering, IT and other degrees are included.

Performance in mathematics

The mathematics unit that is the focus of our study is Differential Calculus (MATH1001). This unit has an 'assumed knowledge' of HSC Mathematics Extension 1 and relies on that knowledge. About 1500 students typically enrol in this unit together with its companion unit Linear Algebra in Semester 1 and two further mathematics or statistics units in Semester 2. These four units, designated as the Normal level in Figure 1, make up the required 12 credit points of first year mathematics.

We will examine the performance of those students in Differential Calculus who meet our criteria including those students who enrolled in the Extension 1 bridging course. The cohort examined includes engineering and IT students as this provides a typical population representing a good spread of HSC results from HSC Mathematics, Extensions 1 and 2.

There were 892 students who studied some level of mathematics for their HSC and completed the unit Differential Calculus. Figure 3 shows the percentages of the students' marks in each grade in the unit grouped by the highest level of mathematics studied for the HSC and broken down into performance band. The results for students who studied General Mathematics (elementary) or no mathematics for their HSC are not shown due to the very small number of students (n=10). Note that students' results in Extension 1 Band 3 have been divided according to their mark in Extension 1. Students with a mark between 35 and 39 are in Ext 1 Band 3A while those students with a mark between 40 and 44 are in Ext 1 Band 3B. This decision was made due to the relatively large range of marks falling into this band (35-44 out of 50) and the large number of students in Extension 1 Band 3 (n=353).

As expected, those students who achieved results in the higher bands for their HSC course performed better in this university mathematics unit than those students in the lower bands in the same HSC course. The high achieving students with distinction and high distinction grades were those students in Band 4 in Extension 1 and Bands 3 and 4 in Extension 2 with the majority in Extension 2 Band 4. Interestingly, although more students failed in the Extension 1 Band 4 group (6%) compared to the Extension 2 Band 3 group (2%), there was little difference between these groups with 68% of students in each group achieving a credit or above.

There were a significant number of students (n=145) who enrolled in this university mathematics unit with a HSC Mathematics background. As the 'assumed knowledge' was Extension 1, they were, therefore, mathematically under-prepared for the unit. Nevertheless, overall 70% of these students passed the course — 31% in Band 4, 70% in Band 5 and 97% in Band 6. There is a striking and surprising similarity between the results of students who achieved Band 5 in HSC Mathematics (n=96) and the results of students in Extension 1 Band 3A, i.e. with marks 35-39 (n=116). These groups have a 30% failure rate and similar percentages of Pass and Credit grades. This again seems to suggest that position in a high performance band in an HSC course is crucial for success in university mathematics units even in a unit with an assumed knowledge of HSC Extension 1.

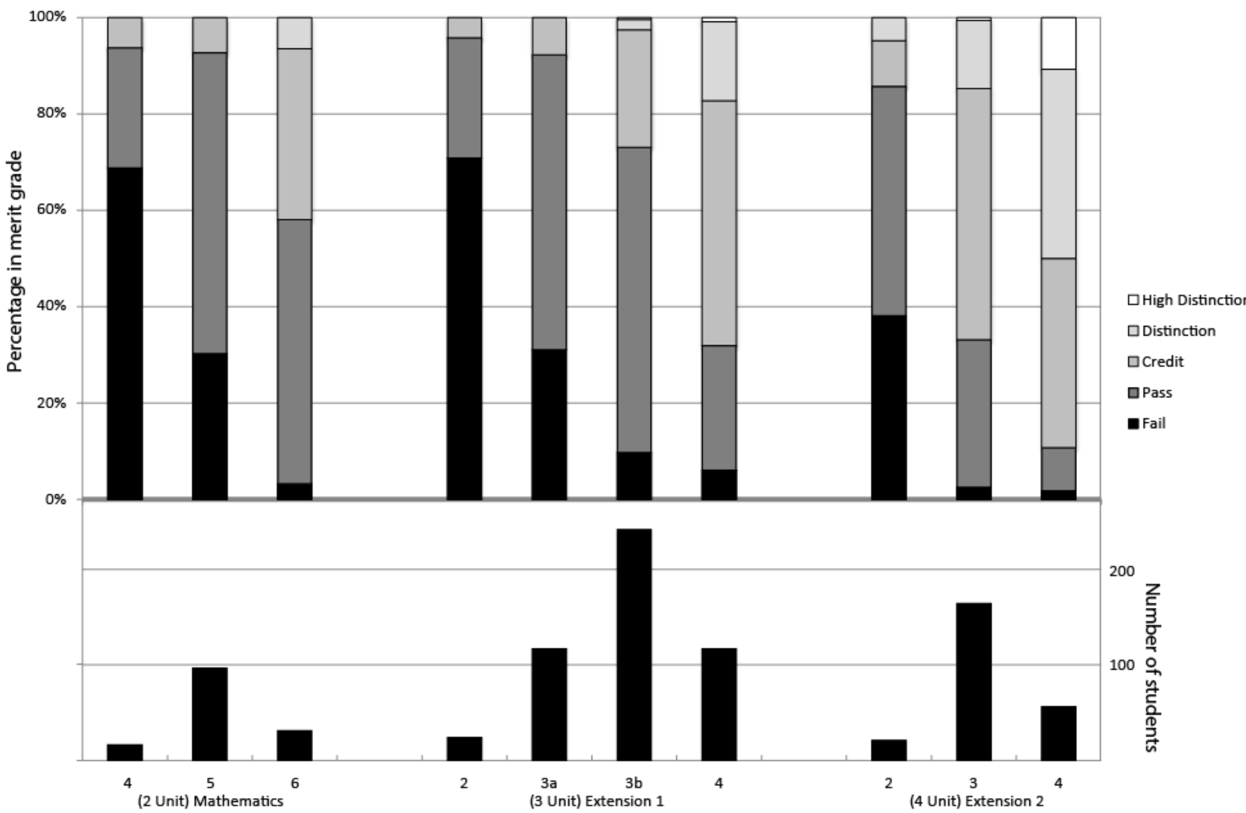

Figure 3: Performance in the unit Differential Calculus by HSC mathematics course and attainment band. Bands with fewer than 10 students are not shown.

Performance of mathematics bridging course students

In this section we divide the students who studied HSC Mathematics at secondary school and completed the unit Differential Calculus into two groups; those students who enrolled in the Extension 1 mathematics bridging course prior to Semester 1 2013 (n=71) and those who did not (n=74). We compared some pre-existing attributes of the students in these groups and found no evidence of a difference in gender, age, ATAR or mean mark achieved in HSC Mathematics. There was also no evidence of an association between HSC Mathematics band and enrolment in the Extension 1 bridging course (χ^2= 2.14, df=2, p>0.25). Figure 4 shows boxplots of the distribution of final marks in Differential Calculus grouped by highest level of mathematics studied for the HSC and broken down into subgroups; HSC Mathematics into the bridging course group and the non-bridging course group and HSC Extension 1 into the four bands.

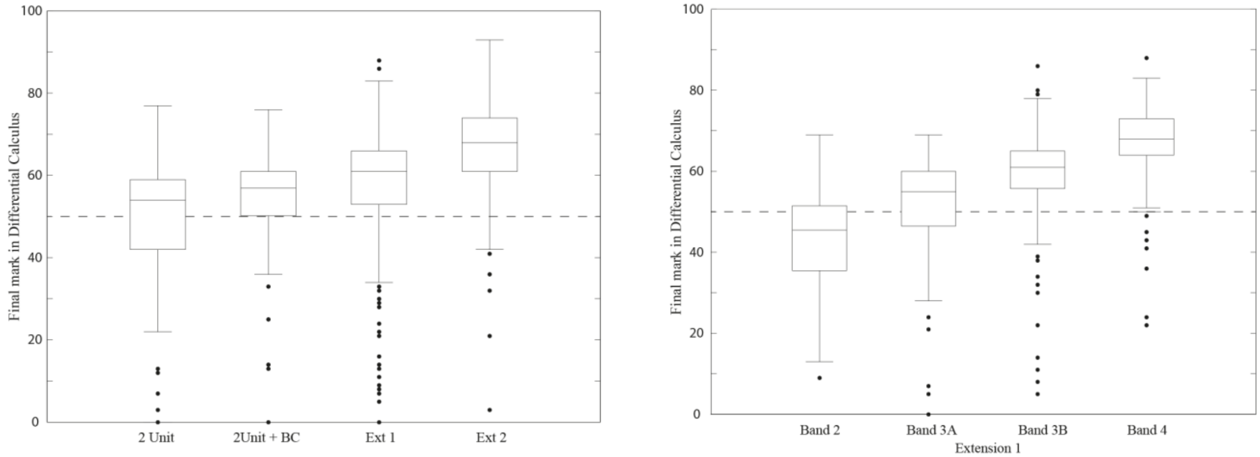

Figure 4: (L) Performance in the unit Differential Calculus by HSC mathematics course and bridging course attendance (R) Breakdown of Extension 1 group by attainment band.

A comparison between the bridging course group (2 Unit + BC) and the non-bridging course group (2 Unit) shows that the median mark of 57 for students in the bridging course group is higher than the median mark of 54 for the non-bridging course group, and there is a smaller failure rate for the bridging course students; 23% compared to 36%. In the Extension 1 groups, the poor performance of the students in Extension 1 Band 2 is again exhibited with the median mark for this group being substantially below a pass.

Comparing the results of the students in the bridging course group (2 Unit + BC) with the results of those students who studied Extension 1 and achieved a mark in the range 35-39 (the Extension 1 Band 3A), we see that the median mark of 57 for students in the bridging course group is similar to the median mark of 55 for the Extension 1 Band 3A group, but there is a smaller failure rate for the bridging course group; 23% compared to 30%.

Performance in physics

Figure 5 shows university performance in PHYS1001 – Physics 1 (Regular). Only students with Band 3 or higher performance in HSC (2 Unit) Mathematics or who had completed an extension course in mathematics at secondary school completed this first year university physics unit. The majority of students in this unit had studied the Extension mathematics courses (advanced mathematics). Those who attained the highest Bands 4 in these courses had strong performance at university, with only very small proportions failing. However, it is also apparent that although the highest proportion of university distinction students had attained Band 4 in Extension 2, distinction grades were distributed across HSC courses and bands and that even students with the lowest HSC attainment ((2U) Mathematics, Bands 3 and 4) had performed at pass and credit levels at university. Low attainment within the Extension courses (Bands 1 and 2) is associated with the highest proportions of failure in this cohort. Thus, again, we see that the attainment band, not the course level, shows the strongest association with university performance.

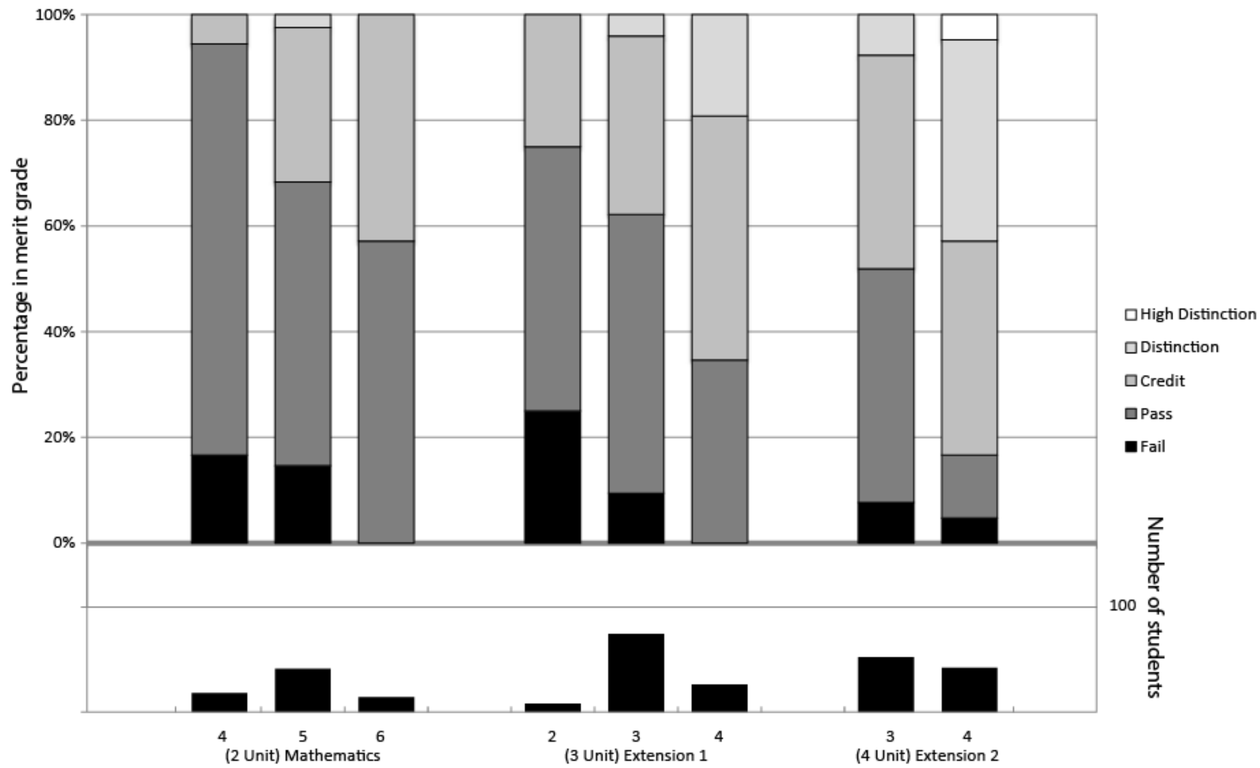

Figure 5: Performance in the unit Physics 1 (Regular) by HSC mathematics course and attainment band. Bands with fewer than 10 students are not shown.

Performance in chemistry

Figure 6 shows university performance in CHEM1101 – Chemistry 1. Unlike the physics unit, this unit attracts students with a wide range of backgrounds in secondary school mathematics. Students with no HSC mathematics and Band 3 to 6 in General mathematics completed this first year university chemistry unit. The majority of students in this unit had studied HSC (2 Unit) Mathematics or the Extension 1 course. Those who attained the highest Bands 4 in extension courses had the strongest performance at university, including high distinction grades. However, once again, it is also apparent that although the highest proportion of university distinction students had an Advanced mathematics background, distinction grades were also distributed across HSC courses and bands and that even students with Bands 5 or 6 in General Mathematics (elementary), had performed at pass, credit and even distinction levels at university chemistry. Similarly, among those students with no HSC mathematics, more than 80% had passed this course. Among those who had studied mathematics we see, again, that the attainment band, not the course level, shows the strongest association with university performance.

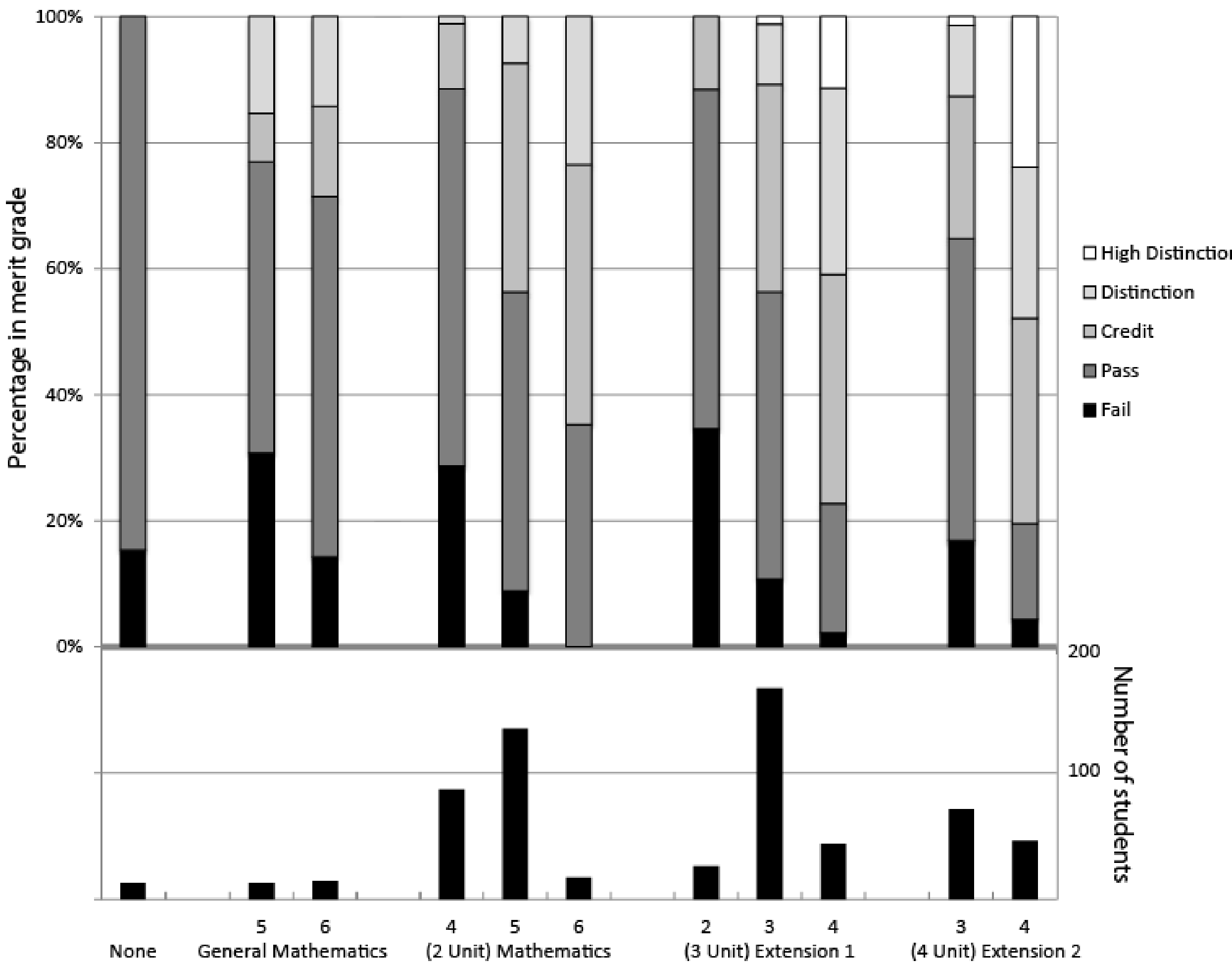

Figure 6: Performance in the unit Chemistry 1 by HSC mathematics course and attainment band. Bands with fewer than 10 students are not shown.

Concluding points

Our analysis of the performance of students in science-based degrees at the University of Sydney in 2013 indicates that the higher levels of mathematics taken for the HSC are strong predictors of success in first year science and mathematics. This, however, is not the full picture as the HSC achievement band is also critical. It is evident in the first year Annual Average Mark data for Science students and in the individual science unit results that our students who achieve in the top bands of each level of mathematics for their HSC can and do outperform their peers who study a higher level of mathematics for their HSC but achieve a lower attainment band for that level. This also appears to be the case for our students in the top bands of HSC Mathematics (intermediate) in a university mathematics unit with an assumed knowledge of Mathematics Extension 1 (advanced mathematics). If, as has been suggested by Australia's Chief Scientist, Professor Ian Chubb (King, 2014), universities move towards re-introducing prerequisites for entry into science and engineering degrees, both the level of HSC taken and the achievement band must be taken into account. Failure to do so may unfairly prevent potentially capable students from studying science or engineering at university.

Over 75% of students who studied HSC Mathematics (intermediate) in secondary school and enrolled in the Extension 1 bridging course were able to pass the first semester unit Differential Calculus. Nevertheless, they did not achieve at the same level as students who achieved a high band 3 (or better) result in Extension 1 Mathematics (advanced). Whether or not this disadvantage is mirrored in non-calculus based units or persists in future semesters is a subject of further research.

Furthermore, our analysis does not consider whether a mathematics bridging course prior to university entry is of any benefit for those students who studied elementary mathematics or no mathematics at senior secondary school. Previous research (Bahr, 2008; Wood, 2001) suggests that the gap between elementary mathematics and intermediate mathematics is too large a gap to realistically address by a short bridging course. Therefore, students should be discouraged from thinking that a bridging course is a panacea for not choosing to study a higher and more appropriate level of mathematics for their HSC.

There is no doubt that Australian universities must accept some responsibility for the decline in the number of students studying the higher levels of mathematics at senior secondary level by previously removing prerequisites on science and engineering degrees. This may have resulted in a 'perception by students that mathematics is not necessary for engineering or science' (King and Cattlin, 2014, p.6). Universities and academics have an ethical responsibility to accurately inform students of the precise 'assumed knowledge' requirements in mathematics for their degree. This recommendation emerged from the National Forum on Assumed Knowledge in Mathematics (King and Cattlin, 2014, p.7):

> *Assumed knowledge requirements need to be clear and unambiguous, allowing students to identify the essential skills needed. ... Assumed knowledge should clearly identify the actual mathematical ability and level of achievement required to succeed in the degree program.*

Once students have been accepted into their degree program, there must be mechanisms that support students to give them the best chance of succeeding in their chosen degree.

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