MINISTRY OF EDUCATION

Te Tāhuhu o te Mātauranga

Are particular school subjects associated with better performance at university?

New Zealand Government

Learners in tertiary education

This report forms part of a series called Learners in tertiary education.
Other topics covered by the series are access, pathways, support, participation, retention and qualification completions.

Author
Ralf Engler, Senior research analyst
Email: ralf.engler@minedu.govt.nz
Telephone: 04-463 7039
Fax: 04-463 8713

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SUMMARY

KEY POINTS

Higher performance at university is more closely related to how well students performed at school, rather than to the particular subjects they studied at school.

This applied to a broad range of school subjects, and to nearly every field of study at university.

There are some skills and knowledge that do appear to be important to performance at university. Mathematics at school is associated with better performance in mathematical science, chemistry with chemical science, English with studies in law. The strongest effect was for accounting students taking courses in accountancy.

But what school subjects are taken is less important than how well students perform at school, and doing well in one school subject can offset doing poorly in another.

The results of this study raises questions about the need to prescribe the subjects a student must take at school, as a general pre-condition for entry to university. A better approach is to consider how well a student achieves at school. This presumes that the school subjects a student takes include a broad range of academic skills. And if a student requires specific skills or knowledge in their university studies, or where having those skills gives the student an advantage, then taking particular subjects at school is likely to be beneficial.

Basing entry to university on school achievement will improve student outcomes, but this should not be the only guide for entry to university. Previous studies, using the same cohort of students, have shown that some students with low school achievement, when they get to university, can outperform their peers who had higher school achievement.

This analysis looks at the association of school subject and school achievement on university performance. The school subjects considered are those on the ‘approved list’ of subjects for the New Zealand university entrance requirement.

There is a popular view that mathematics is linked to higher university performance in a range of degree-level studies. But in this study, we found that university performance overall is largely independent of what subjects are studied at school. Furthermore, this applies to a wide range of fields in degrees at university.

What we did find was that how *well* a student achieves in a school subject is strongly associated with university performance. Some subjects were marginally associated with higher university performance, but not in all fields of study. The strongest effect was consistently associated with increasing levels of school achievement.

In other words, for two students with the same level of school achievement, and enrolled in the same field of study, their university performance in most cases will be statistically indistinguishable. In only a few cases, one student will have slightly better university performance, and this is associated with that student taking a particular school subject. In these instances, there is a subject-matter link between the school subject and the degree study; mathematics for mathematical science study at university, chemistry for chemical science, or school accounting for accountancy. But the difference in performance is generally small. The largest differences in university performance occur between students with different school achievement.

This finding does not mean that the skills or knowledge gained in a subject are unimportant. If there are pre-requisite skills or knowledge required for a field of study, then those students with those skills and knowledge will be expected to do well. But, a student must take the class *and* achieve well if taking the subject is going to provide any subsequent benefit in their university studies.

Our findings have implications for universities. Universities are facing high levels of demand for degree level study, but their enrolments are constrained by the number of places funded by government. In response, some universities are altering their general admissions criteria, giving preference to students with higher levels of school achievement. While these changes will *generally* identify students more likely to perform well at university, the findings of our earlier study (Engler 2010) suggest the proposed changes will disadvantage particular groups of below-average students at school who, counter-intuitively, do well at university. The present study also suggests that requirements for achievement in a *particular* school subject is not necessary, at least for students who have met the university entrance requirement, since good achievement in one subject can offset poorer achievement in another.[1]

Our findings also have implications for the setting of the university entrance requirement. Currently, in New Zealand, the university entrance requirement for those less than 20 years of age requires a student to achieve credits in literacy and numeracy across the National Certificate of Education Achievement (NCEA) levels 1 and 2, in addition to gaining credits at level 3 of the National Qualification Framework in a prescribed list of subjects.[2] Our study has shown that, at least for the subjects that are currently in the prescribed list, the actual subjects taken have little bearing on university performance. This conclusion must be tempered with our earlier caveats regarding specific skills and knowledge that may be assumed in particular university courses, and with the recognition that there may be some subjects that develop skills that have a lesser relationship with the sorts of skills needed in degree-level study.

We conclude that personal attitudes and traits such as motivation, study habits and time management skills also contribute to the basis of successful learning, whether it occurs in school or at university. These factors are clearly independent of the subject matter being studied, so it is not surprising to us that university performance is only weakly associated, if at all, with the subjects taken at school. It is the extent to which a student possesses these attitudes and traits which affect how well a student performs academically, whether at school or at university.

The study looked at intramural, first-year bachelors-degree students at a university. Each student had gained the NCEA level 3, and met the university entrance requirement. For a particular subject, students were excluded if they attained less than 14 credits in that subject. Students in the study varied between 17 and 20 years of age, and were studying at tertiary level in the years 2006 to 2008.

[1] We are not suggesting that universities *are* going to implement such a requirement.

[2] The list of 'approved subjects' is provided in Appendix A. More details can be found at http://www.nzqa.govt.nz/qualifications-standards/awards/university-entrance/.

1 INTRODUCTION

In December 2009, a report was released which reviewed the deteriorating state of mathematical sciences and related quantitative disciplines, and the teaching of mathematics in schools in Australia (Brown 2009). In that report, Brown writes

> "Moreover, mathematical skills are universally needed for the study of science. Mathematics is an important enabling science. The community perception is that this relates mostly to the physical sciences. However, it is an enabling science for a much broader range of disciplines, including environmental sciences, meteorology, psychology, health sciences, geography, economics, finance, business, and many others. For example, an article in the journal Science in 2007 [Sadler and Tai 2007] observed that taking extra mathematics at high school gave students an advantage across all science subjects, 'including college biology, a discipline not traditionally associated with strong mathematics preparation'" (Brown 2009 page 6).

This belief, that mathematics is associated with success in tertiary study, is often seen in the literature (Tho 1994, Trusty and Spencer 2003, Eilsen, Strauss and Jonck 2007, Sadler and Tai 2007, Alcock, Cockcroft and Finn 2008, Mallik and Varua 2008), although languages are also regarded as important in the study of law (Kok 2007). Most of these studies do not control for student achievement at school—in fact most are unable to control for this—and so several of these studies include statements alluding to the fact that it might be the higher achieving students who choose mathematics at school, and this higher achievement may be the reason behind the benefit that the study of mathematics provides. Studies that have controlled for student ability found an effect of mathematics over and above student ability (Alcock et al 2008), whereas others found there was only a weak positive correlation between high school mathematics results and performance at university (Rauchas et al 2006).

Our study investigates the association between the subjects studied at school and a student's performance in their first year of bachelors-level study at university. It uses essentially the same cohort of students as our recent study on university performance (Engler 2010), which considered a number of demographic factors that affect university performance. A particular advantage of the data used for these studies is that it allows us to control for student achievement at school, both at the aggregate level, over all subjects, and at the individual school subject level.

The difference between the cohort of students used in our study and the earlier one by Engler is that we exclude students for subjects in which the student gained less than 14 credits.[3] This was done so as to remove the possibility that university performance was determined by the number of credits a student achieved, rather than how well they performed. It might have been the case that, when considering a particular subject, students with less than 14 credits in that subject were the poor performers in their university studies, and that once this threshold or tipping point of credits had been reached, all students fared equally well.[4] However, this was found not to be the case. We thought it prudent to exclude these students anyway, since taking only a small number of credits may have reflected a student 'dabbling' in the subject, as opposed to gaining any mastery of the subject material. The conclusions of the study are strengthened as a consequence.

School achievement is known to be strongly associated with performance in tertiary studies, especially for the first year of study (Scott 2008, Engler 2010). Any study considering factors affecting university performance must control for student achievement at school. Furthermore, if

[3] To meet the university entrance requirement, a student requires at least 14 credits each in two subjects from the 'approved subjects' list, at least 14 credits from no more than two domains on the National Qualifications Framework, at least 14 credits in mathematics or statistics and modelling at NCEA level 1 or higher, and 8 credits at NCEA level 2 or higher—4 in reading and 4 in writing. See http://www.nzqa.govt.nz/qualifications-standards/awards/university-entrance/ for further details.

[4] I am indebted to Dugald Scott of Victoria University of Wellington for making this suggestion.

we intend to consider the effect of school subject on university performance, we must first ascertain the relationship between school achievement and subject selection. If there is an association, then school achievement *must* be controlled for, given the strong link between school achievement and university performance. Not controlling for school achievement will confound the effects of subject choices, and achievement in those subjects. If we were to find that some subjects are associated with better university performance, we would be unable to conclude if it is the school subject that is associated with the improvement; it may actually be that the students are higher achievers, who happened to have done that subject. This report will show that higher school achievement *is* associated with particular subject choices at school, and then, when school achievement is controlled for, the advantage observed in university performance for most school subjects largely disappears.

A limitation of our study is that we can only investigate students who proceed to university, and therefore are limited to the subjects *these* students studied at school. These subjects, by definition, are those prescribed in the 'approved subjects' list (see appendix 1). We can't determine how a student fared at university if they took alternative subjects, since these students in the main do not go on to bachelors-level study. The conclusions of our study are therefore restricted to that set of 40 subjects in the 'approved subjects' list. However, we believe this is not a severe limitation, since we are focussing our attention on bachelors-level students at university, which necessarily limits our focus to academic, rather than vocational, study. We also present results for students who took visual arts subjects—also in the 'approved subjects' list—which suggest our conclusions may have wider applicability.

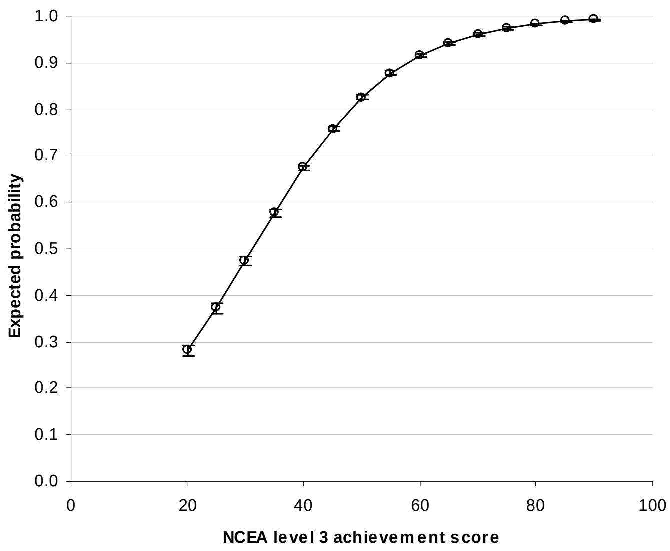
We also can not say that taking a subject at school *results* in a particular level of university performance. We can only say that taking a subject is *associated* with university performance. That is, we are not able to determine the cause of the relationship, simply that there is one.

2 SCHOOL ACHIEVEMENT AND UNIVERSITY PERFORMANCE

Achievement at school[5] and subsequent university academic performance are highly correlated. Figure 1 (taken from Engler 2010, figure 4, page 20) shows the relationship. The students whose results are shown in the figure all achieved the NCEA level 3 qualification, and met the university entrance requirement.

Figure 1

Expected probability (and 90 per cent confidence limits) of passing most (more than 75 per cent) first-year bachelors courses at university by school achievement



Results are calculated using all ethnic groups, all study types, all degrees studied at university, all school decile categories, gap and no gap year students, and both genders. They exclude extramural students. The achievement score is explained in footnote 5.

The mean school achievement score for this population of students is about 50. It can be seen that for students with below-average school achievement, the relationship between school achievement and university performance is quite strong, and essentially linear. For every 5 point improvement in school achievement, there is a corresponding increase of about 10 percentage points in the likelihood of passing most first-year courses. For above-average school students, the relationship is less strong: improving school achievement results in small and decreasing improvements in university performance. This is to be expected, as the likelihood of passing most first-year courses nears certainty.

[5] Achievement at school is measured using a statistic named the NCEA level 3 achievement score. This score is based on students' grades in their level 3 standards against other students in the same year, producing a score between 0 and 100. Students who gained level 3 credits with excellence and merit grades will score higher than students who gained their credits with relatively fewer merits or excellences, or with relatively more achieved grades. The score also adjusts for the level of difficulty within a standard. A student, who achieved an excellence in a standard where many people gained a merit or excellence, will receive a lower score for that standard, while a higher score is given to a similar student in a standard where most people received an achieved grade, for example. Details about the National Certificate of Education Achievement can be found at http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/. Further details about the calculation of the school achievement score can be found in Ussher (2008).

3 SCHOOL ACHIEVEMENT AND SCHOOL SUBJECT CHOICE

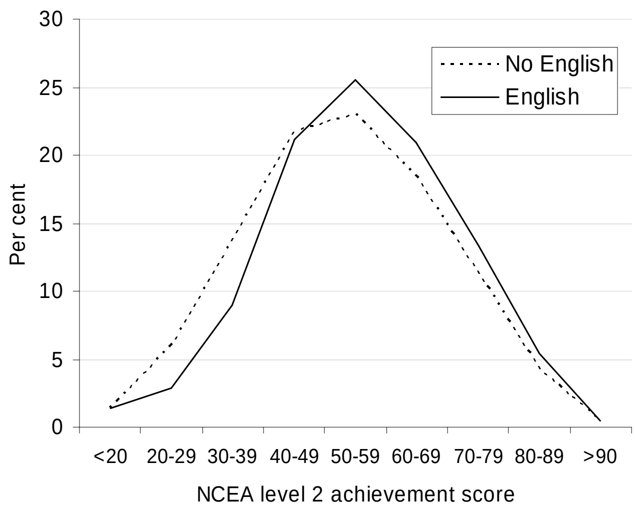
There is an association between achievement at school and students' choice of subjects.

The data available in this study allows us to compare, on average, student achievement in one year with the selection of subjects in the following year. Accordingly, we have used school achievement at NCEA level 2 and compared it to the choice of subject at NCEA level 3.

Figure 2 shows the frequency distribution of students across the range of NCEA level 2 achievement, calculated across all level 2 subjects, for students who did or did not take NCEA level 3 English.

Figure 2

Frequency distribution of students who did, or did not take NCEA level 3 English, against overall school achievement in NCEA level 2



It can be seen that students with achievement scores less than 50 were slightly less likely to take English, while students with achievement scores of 50 or higher were slightly more likely to take English. Although largely overlapping, the two distributions have different average level 2 achievement scores (table 1).

This situation can be contrasted with figure 3, which shows the distribution for students who did or did not take the subject mathematics with calculus[6] as a level 3 subject. Students with above-average school achievement at NCEA level 2 are far more likely to take mathematics. In other words, the level of achievement of students taking mathematics is, on average, higher than students who did not take this subject.

The type of pattern depicted in figure 2 for English is also seen for the level 3 subjects statistics and modelling, economics, and accounting. The type of pattern seen in figure 3 for mathematics is also seen for the subjects physics, chemistry, and other languages.[7] The frequency distribution for biology falls somewhere between that of English and mathematics, with a clear 'shift to the right', but is not as pronounced as that seen for mathematics. For humanities,[8] there is a 'shift to

[6] In this report, the shorthand term 'mathematics' will sometimes be used to refer to the subject 'mathematics with calculus'.

[7] Other Languages include French, German, Spanish and Latin.

[8] Humanities, as defined in this study, include geography, history, art history and classical studies.

the left'. That is, students who chose to study humanities subjects were slightly more likely to have below-average achievement in their level 2 studies. For visual arts subjects,[9] this 'shift to the left' is more pronounced. Table 1 shows the average level 2 achievement score for the various level 3 subjects.

Figure 3

Frequency distribution of students who did, or did not take NCEA level 3 mathematics with calculus, against overall school achievement in NCEA level 2

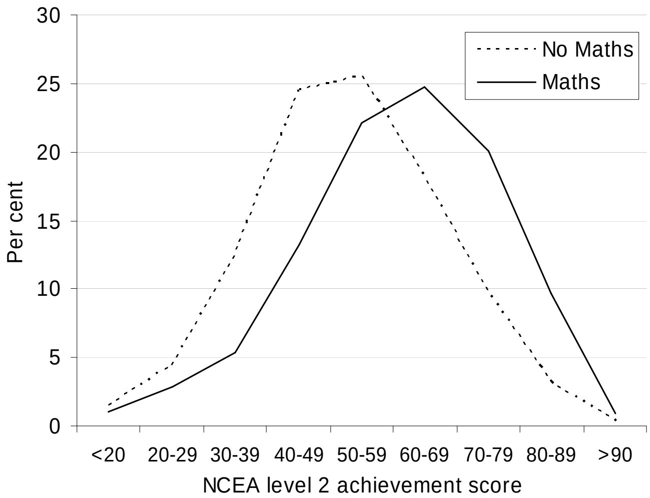


Table 1

Mean and inter-quartile ranges for NCEA level 2 achievement scores for level 3 subject choices

	Did take the subject		Did not take the subject		
Level 3 subject	*Mean*	*Inter-quartile range*†	*Mean*	*Inter-quartile range*†	*Difference between means*
Chemistry	58.0	47–71	47.6	36–59	10.4
Other languages*	59.5	48–73	50.0	38–62	9.5
Physics	56.5	44–70	48.5	37–60	8.0
Mathematics with calculus	56.1	44–69	48.6	37–60	7.5
Biology	54.1	43–66	48.7	36–61	5.4
Accounting	53.3	42–65	50.3	38–62	3.0
English	53.1	42–65	47.0	33–60	6.1
Statistics and modelling	52.6	41–64	48.6	36–61	4.0
Economics	52.1	41–64	50.3	38–63	1.8
Humanities*	50.8	39–62	50.5	37–63	0.3
Visual arts*	48.5	37–60	51.3	39–63	-2.8

† The inter-quartile range is the range of values between the 25th and 75th percentiles. That is, a quarter of the students in the particular subject have scores below the lower value of the range, and a quarter have scores above the higher value of the range.
*Other languages include French, German, Spanish and Latin. Humanities include geography, history, art history and classical studies. Visual arts include photography, printmaking, design, sculpture and painting.

[9] Visual arts subjects include photography, printmaking, design, sculpture and painting.

What these results show is that students with higher levels of school achievement are more likely to take particular subjects. These subjects are chemistry, other languages, physics, and mathematics with calculus. We would expect, given the relationship between school achievement and university performance, that students taking these particular school subjects would, on average, show higher levels of university performance across a range of bachelors-level study courses. For the average student taking these subjects, this difference in school achievement translates into a 7 or 8 percentage point increase in the likelihood of passing most first-year courses at university (extrapolated from figure 1).

It is not coincidental that higher school achievement is seen for particular groups of subjects. Table 2 shows the correlations between pairs of subjects taken by students. It can be seen that taking mathematics with calculus is positively associated with also taking physics, chemistry, economics and accounting, but negatively associated with taking statistics and modelling, English, humanities and visual arts. There is no statistical association between mathematics and other languages. It is likely to be much the same group of higher-achieving students taking a particular group of subjects.

It can also be seen that the correlations between subjects are generally small. The largest correlation, between physics and chemistry, is +0.46. Clearly, while there are ‘natural’ groupings of subject choices, in reality, there is a very large variety of subject combinations taken by students. This makes it somewhat problematic to determine the impact a single school subject has, in isolation, on university performance.

Table 2
Pearson correlation coefficients of the selection of NCEA level 3 school subjects

	Physics	*Chemistry*	*Biology*	*Statistics*	*Accounting*	*Economics*	*Languages*	*English*	*Humanities*	*Visual Arts*
Mathematics	+0.45	+0.30	+0.01	-0.06	+0.10	+0.07	**-0.00**	-0.17	-0.22	-0.09
Physics		+0.46	+0.17	+0.10	-0.07	-0.09	-0.04	-0.14	-0.27	-0.12
Chemistry			+0.43	+0.17	-0.09	-0.14	**-0.00**	-0.10	-0.23	-0.20
Biology				+0.15	-0.16	-0.18	-0.03	**-0.01**	-0.11	-0.16
Statistics					+0.17	+0.16	-0.05	-0.09	-0.16	-0.19
Accounting						+0.39	-0.05	-0.08	-0.11	-0.13
Economics							-0.02	-0.03	-0.04	-0.15
Languages								+0.08	+0.04	-0.05
English									+0.04	-0.02
Humanities										+0.01

Correlations shown in bold type are not significantly different from zero at the 95 per cent level of confidence.

4 EFFECT OF SCHOOL SUBJECT ON UNIVERSITY PERFORMANCE

The previous two sections of this report showed that school achievement is associated with university performance, and that school achievement is also associated with the level 3 subjects studied at school. The fact that school achievement links the two factors of interest, school subject choice and university performance, makes it important that we control for school achievement when considering university performance.

School achievement can be controlled for in a variety of ways. In this report we consider four methods.

- First, we look at the university performance of students who did or did not take a particular subject at school. While this is not strictly controlling for school achievement, we are interested in contrasting the effect of taking a school subject on university performance against not taking that subject.

- Second, we model university performance using logistic regression, with school achievement in one subject used as a continuous variable (0–100), and a second subject regarded as a categorical variable (did or did not take the subject).

- We model university performance controlling for school achievement in two subjects, used as continuous variables, for students who took both subjects.

- Lastly, we model university performance for students who did or did not do a subject, controlling for school achievement in the subjects the two groups of students have in common.

The methods above are applied to university study considered in broad fields—physical and natural science, for example. We also consider study in narrow fields—mathematical sciences, and chemical sciences, for example, to test the hypothesis that the more similar the subject topic between a school subject and the university study, the more likely there is to be an association.

We could theoretically control for more than two subjects, but sample sizes become small and undermine the robustness of the models. Even with two subjects, not all subject combinations can be analysed because there are too few students.

4.1 Effect of taking, or not taking, a school subject

This section considers whether taking a particular subject is associated with higher university performance, and, conversely, whether *not* taking a subject is associated with lower performance. We consider a range of tertiary fields of study, staring with degrees in engineering.

Engineering

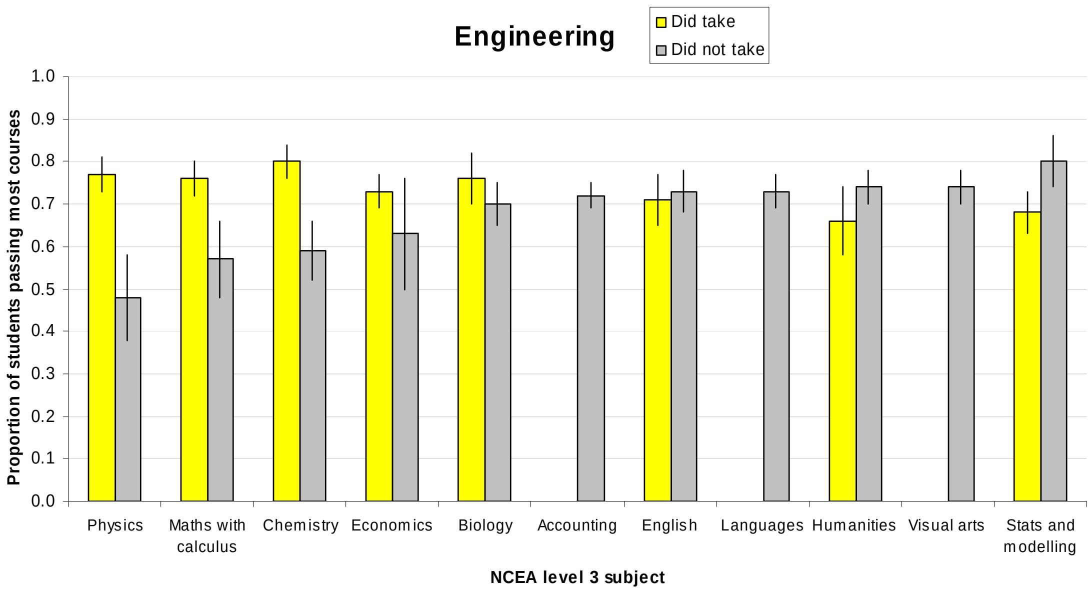
Figure 4 shows the proportion of students passing most of their first-year engineering courses, by whether or not a student took a particular level 3 school subject.

The figure shows two aspects. Firstly, it can be seen that *not* taking physics, mathematics with calculus, or chemistry (but having taken any other subject) is associated with a significantly lower likelihood of passing most first-year courses in engineering. However, not taking any of the other school subjects is not associated with lower chances of passing engineering courses. Students who did not take statistics and modelling at school show a relatively higher likelihood of passing most courses, indicating that this group of students probably took mathematics with calculus, or physics or chemistry, given the height of the bar in the graph.[10]

Secondly, taking chemistry, physics, or mathematics with calculus is associated with higher likelihoods of passing most courses than for the other school subjects. This also applies to level 3 biology, but the difference is not significantly higher than not taking biology. Students taking statistics and modelling were significantly less likely to pass most of their engineering courses. Again, this is likely to be because they did *not* take those subjects that appear to be necessary for successfully studying engineering.

Figure 4

Effect of school subject on course pass rates for students studying **engineering** at bachelors-level at university



School subjects are sorted in order of increasing course pass rate for when the subject was not taken.
Error bars are 90 per cent confidence limits.
Results for where there were fewer than 50 students are not shown.

The difficulty with this analysis is that we are not actually controlling for school achievement. The higher pass rates are seen for subjects that have, on average, higher school achievement. Based just on this data, it is difficult not to come to the conclusion that physics, mathematics with calculus, and chemistry, overall, provide some benefit in studying engineering.

Later in this report we show results when controlling for school achievement. We find, in most cases, that when controlling for school achievement, most associations diminish or disappear entirely. Unfortunately, few students take engineering, and students who do not take mathematics, chemistry or physics at school, rarely go on to study engineering, so modelling performance in engineering to control for school achievement is problematic. However, our exploratory analysis suggests that once school achievement is controlled for, performance in engineering is independent of whether or not a student took physics, mathematics or chemistry at school.

Physical and natural sciences

Figure 5 shows course pass rates for students who studied physical and natural sciences[11] at university.

[10] Refer to table 2 for subject choice correlations.

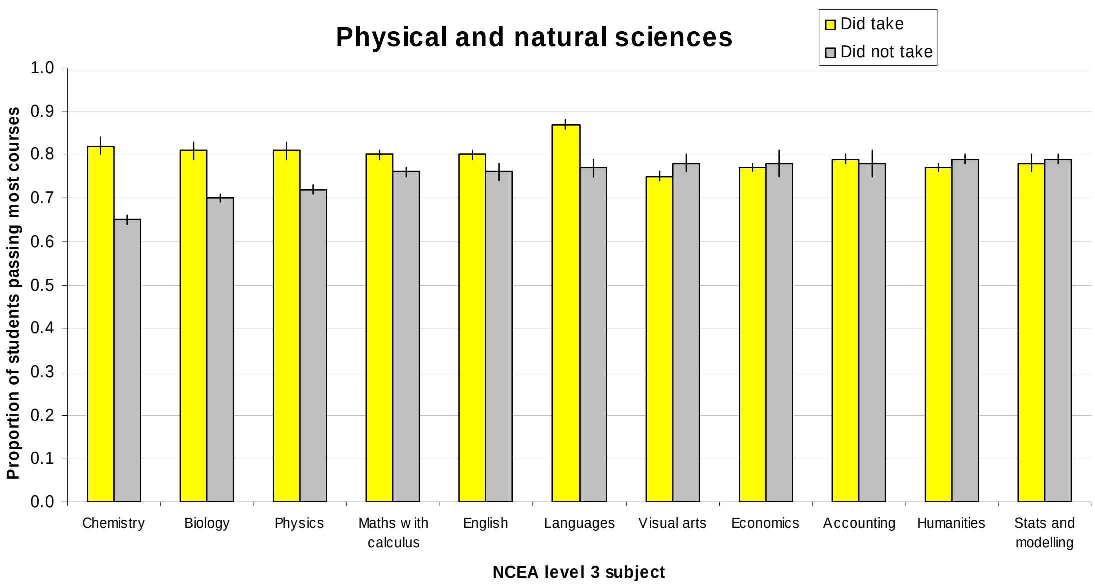
[11] Physical and natural sciences includes studies in biological, earth and chemical sciences; physics and astronomy; and mathematical sciences.

The first impression is that the results are not as striking as for engineering. The other difference is that the confidence bars are much shorter, reflecting the fact that the number of students studying engineering is relatively small, while science is one of the larger fields of study at university.

In spite of the smaller differences, it is clear that *not* studying chemistry, biology, physics, mathematics with calculus, and other languages, is associated with significantly lower likelihoods of passing most courses, compared to students who did take those subjects. The difference is pronounced for chemistry, biology and physics, which happen to be science subjects. Of course, these subjects are again those selected by students with higher school achievement, although the effect for biology in figure 5 is higher than we might have expected given the difference in the average level 2 achievement score (table 1).

Unlike engineering, the probability of passing most courses for students not doing any of the school subjects ever falls below 0.5 for the study of science at university. Not doing chemistry alone results in a probability below 0.7, but students who do not take chemistry at school have a quite low average level 2 achievement score (table 1).

Figure 5
Effect of school subject on course pass rates for students studying **physical and natural sciences** at bachelors-level at university



School subjects are sorted in order of increasing course pass rate for when the subject was not taken.
Error bars are 90 per cent confidence limits.

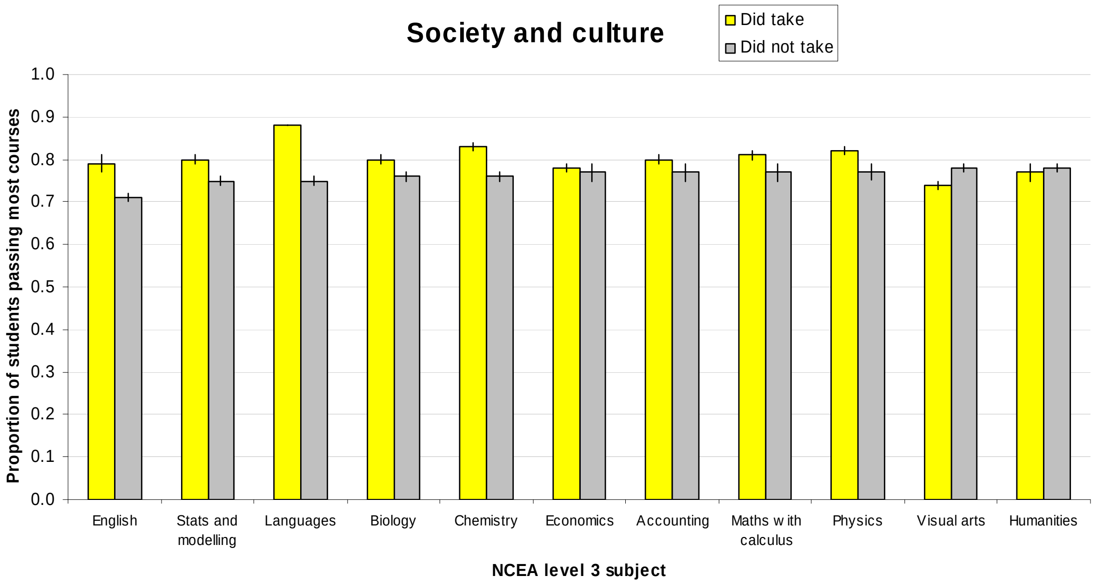
Society and culture

Figure 6 shows the results for students studying society and culture.[12] Here, not studying any of the subjects is not associated with lower university performance, with all probabilities of passing most courses above 0.7. Certainly, taking English, statistics and modelling, other languages, chemistry, biology, mathematics with calculus, physics or accounting is associated with significantly higher course pass rates than not taking these subjects. But it would be wrong to conclude these subjects provide an advantage. Students who took these subjects have on average higher school achievement. On the other hand, these results suggest that not taking English may be associated with lower university performance, at least relative to not taking other subjects.

[12] Degrees in society and culture include studies in humanities and social sciences; law; political science; language and literature; philosophy; economics and econometrics; and sport and recreation.

Figure 6

Effect of school subject on course pass rates for students studying **society and culture** at bachelors-level at university



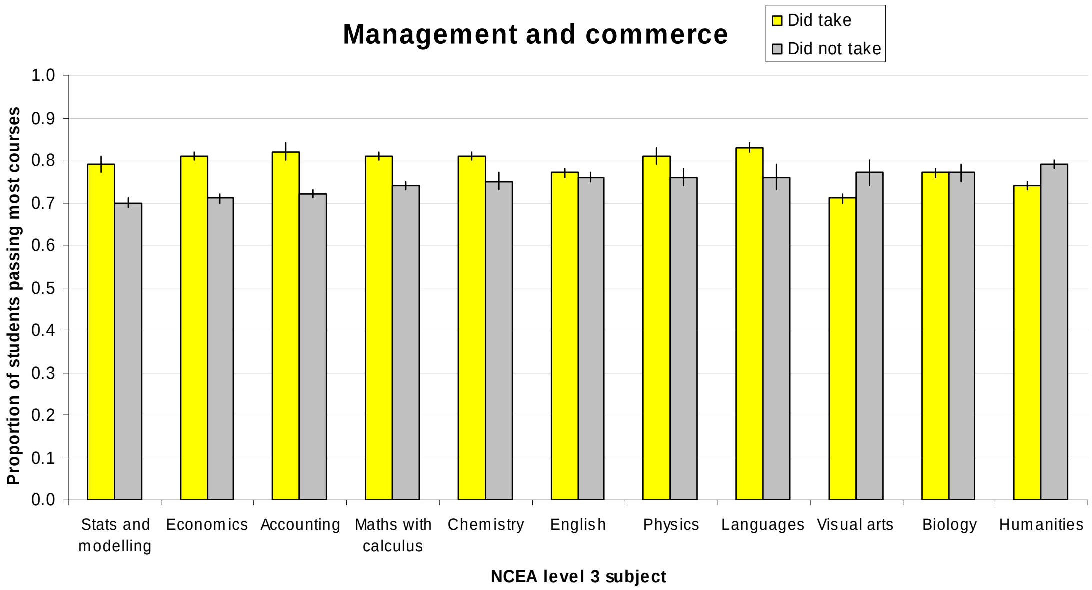
School subjects are sorted in order of increasing course pass rate for when the subject was not taken.
Error bars are 90 per cent confidence limits.

Management and commerce

Figure 7 shows the results for students studying management and commerce[13] at university.

Figure 7

Effect of school subject on course pass rates for students studying **management and commerce** at bachelors-level at university



School subjects are sorted in order of increasing course pass rate for when the subject was not taken.
Error bars are 90 per cent confidence limits.

[13] Degrees in management and commerce include studies in accountancy; business and management; sales and marketing; tourism; and banking, finance and related fields

The results are similar to that seen for society and culture (figure 6), with no likelihood of passing most courses below 0.7. However, the order of the subjects has changed. Performance in a management and commerce degree at university is lower for those students who didn't take statistics and modelling, economics and accounting, which we find intuitively correct given the skills likely to be needed in this field of study. Yet we again see significant differences between students who did and did not take mathematics with calculus, chemistry and physics. And once more, taking other languages at school is also associated with better performance at tertiary level.

Summary

Had mathematics been the only school subject considered in this part of the study, it would be reasonable to conclude, like Sadler and Tai (2007) that mathematics is 'an enabling science for a broad range of disciplines'. Interestingly, when we looked at the degrees in health, education or creative arts,[14] mathematics did not show this association, although student numbers are low for these disciplines.

When a broad range of school subjects is considered, it is often mathematics, chemistry, physics, and other languages which are associated with higher levels of university performance, the same subjects which are associated with higher levels of school achievement. But for most fields of study, not taking these school subjects is not associated with 'low' levels of university performance, even though the difference between taking and not taking the subject may be statistically significant.

The exception appears to be engineering. It seems that *not* taking a science subject (mathematics, physics or chemistry) is a disadvantage when studying engineering at university. But this should not be surprising. In any discipline, if there are pre-requisite skills or knowledge required of a student, especially if these are fundamental to the particular area of study, then students with those skills and knowledge will have an advantage, and would be expected to do better. But there is a caveat; simply taking a mathematics class, and not gaining mastery of the skills taught, ought not to provide this advantage. As we will show in the next sections, a student must take the class *and* achieve a level of understanding that leads to proficiency in the use of those skills and knowledge, for there to be an association with higher levels of university performance.

A possible reason that engineering showed such strong results is that engineering, even when using the broad definition of university degrees as we have in our study, is quite a narrow discipline. Whereas physical and natural science encompasses studies in botany, zoology, chemistry, physics and genetics, for example, engineering is quite narrowly defined. It is possible that the closer the link between specific course requirements, and the particular skills and knowledge gained in studying a subject at school, the more likely we are to find an association between that school subject and performance in those university studies. We consider this question in more detail in section 4.5.

The requirement for specific skills or knowledge may also be evident in some of the other tertiary fields of study: chemistry, biology and physics for the physical and natural sciences; English in society and culture; statistics, economics and accounting for management and commerce. But the same caveat will apply. Simply taking the subject ought not to provide an advantage to a student—but doing that subject *and* doing it well, may do.

4.2 Controlling for achievement in a single school subject

The results presented in the previous section considered university performance as observed in the study cohort, measured as the proportion of students passing most —more than 75 per cent—

[14] Results not shown.

of their courses in a broad field of study. An alternative method is to model the data using logistic regression. In this approach, the *likelihood* of a student passing most of their university courses in the broad field of study can be considered when controlling for other variables.

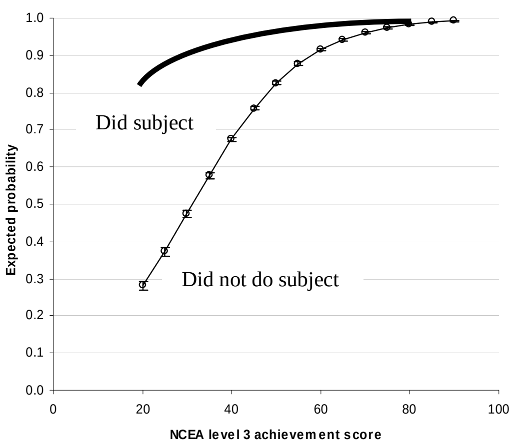
A problem that needs to be overcome in analysing school achievement is that there is no achievement information available in a subject for students who did not take that subject. While this is largely self-evident, it presents problems in an analysis controlling for school achievement. Including achievement in that subject means we have to exclude the students who did not take the subject. But if we do this, we do not have a control group of students who did not take the subject. This problem has rarely been considered in other studies.

The method we have adopted is to consider pairs of school subjects, where we control for achievement in one subject, and then contrast the results between students who did or did not take a second subject. For instance, we control for school achievement in English and see if there are differences in the university performance of those who took English and mathematics compared to the university performance of those who took English without mathematics. In this example mathematics is the control subject.

It is instructive to consider what the model results might look like if a particular subject were providing some benefit to a student in their tertiary studies. Figure 8 shows this hypothetical result.

Figure 8

Hypothetical result on the expected probability of passing most first-year bachelors courses where doing a subject provides a benefit



Our expectation is that if a particular subject is going to provide students with an advantage in their university performance, that performance ought to be more or less independent of school achievement. At the very least, it might be expected to ameliorate the effects of school achievement, such that students with below-average school achievement would perform better having taking the subject in question compared to those who did not. As school achievement increases, we would expect there might be a decreasing benefit, since there is an upper limit to university performance.

Controlling for English achievement, with and without mathematics with calculus

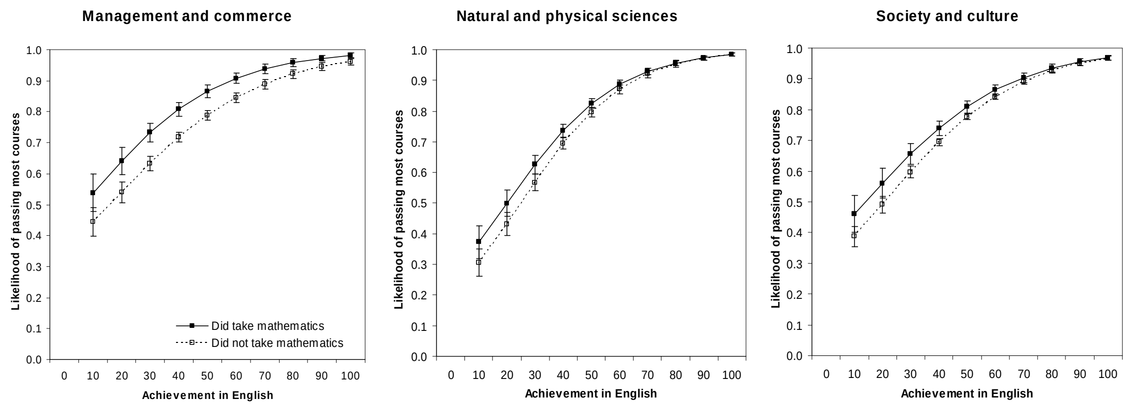
We chose English and mathematics since these are generally considered to be important subjects, and they represent subjects in the two main groups that students take. There are also sufficient numbers of students in these subjects to model reliably.

Only three tertiary fields of study are considered in this series of analyses: management and commerce, physical and natural sciences, and society and culture. These are the largest disciplines in terms of student enrolments. All of the other disciplines have too few students to model with any degree of robustness.

Figure 9 shows the results. What is immediately apparent is that the results do not resemble figure 8, our hypothetical expectation. Taking mathematics is generally not associated with better university performance for students who also took English.

Figure 9

Expected probability (and 90 per cent confidence limits) of passing most first-year courses by selected fields of study, by school achievement in **English**, with or without also taking **mathematics with calculus**



What we find instead is that taking mathematics with calculus is associated with small but significantly higher university performance in management and commerce studies, at least in the middle range of school achievement scores. This mirrors the result seen in figure 7. But we would have expected a similar result for the other two fields of study, given the results seen for mathematics in figures 5 and 6. What we find instead, is that when controlling for achievement in English, taking mathematics does not make a statistically significant difference to students' university performance in science, or society and culture degrees.

The more important finding is that the largest improvement in university performance is achieved by doing better in English, regardless of the university field of study. The improvement seen for students who took mathematics, where it does provide some advantage, is only marginal in comparison.

In other words, for students who are enrolled in management and commerce degrees, who have the same level of achievement in level 3 English, there is sometimes a small difference in university performance for students who also took level 3 mathematics. Mostly there is no difference in performance between students who did or did not take mathematics when controlling for achievement in English. The largest differences in university performance are between students of *different* levels of achievement in level 3 English.

With this technique, we are still not controlling for achievement in mathematics. Differences in university performance may still be due to differences in average achievement of students who took mathematics at school. And we are only considering students who took English at school. Table 2 shows that English students were generally less likely to also take mathematics and other science subjects. Students who took English, and also took mathematics, may not be 'typical' students, so the effect of mathematics may be different for these students, than say, a student who took chemistry and mathematics. These considerations need to be kept in mind when looking at these results. In this study, we have considered a number of combinations of school subjects, using a variety of analyses, so that overall, we can be confident of our findings.

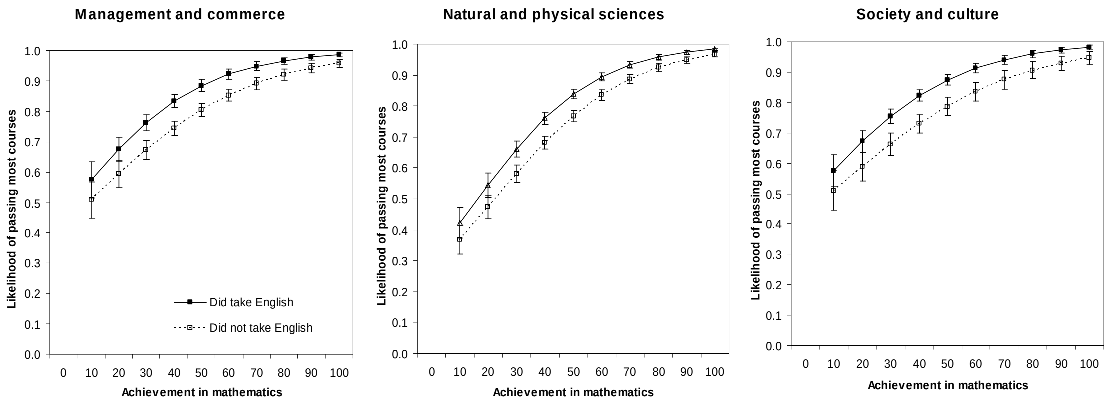
Controlling for mathematics with calculus achievement, with and without English

Figure 10 shows the results when we consider English as the categorical variable, and school achievement in mathematics with calculus as the continuous variable.

Taking English is associated with a significant improvement in university performance in all three fields of study, at least in the middle range of school achievement in mathematics. But again, while the improvement seen with taking English is statistically significant, it is marginal when compared to the improvement in performance seen with increasing achievement in mathematics.

Figure 10

Expected probability (and 90 per cent confidence limits) of passing most first-year courses by selected fields of study, by school achievement in **mathematics with calculus**, with or without also taking **English**



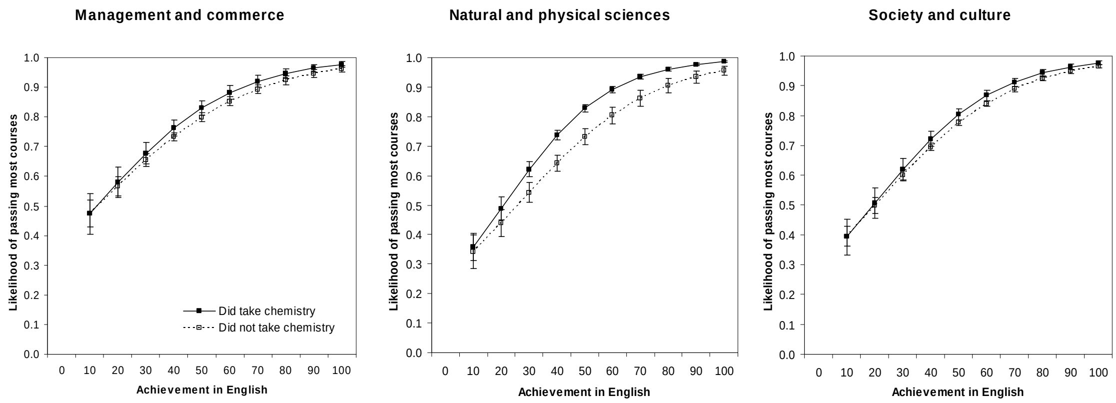
Controlling for English achievement, with and without chemistry

We now consider chemistry and English. We were curious to see if chemistry would produce an effect where mathematics did not. Chemistry appears to be important in a range of tertiary studies (figures 5, 6 and 7), and students who took chemistry showed the largest difference in level 2 achievement against those who did not take chemistry (table 1).

Figure 11 shows students who took level 3 English, and compares the university performance of students who also took chemistry to those who did not.

Figure 11

Expected probability (and 90 per cent confidence limits) of passing most first-year courses by selected fields of study, by school achievement in **chemistry**, with or without also taking **English**



The results are similar to those seen previously. Taking chemistry is associated with higher university performance for science studies, but not for management and commerce, nor for society and culture. The results seen in figures 6 and 7 suggested otherwise. And again, the largest improvement in university performance is associated with increasing achievement in English.

Controlling for chemistry achievement, with and without English

This section considers how university performance varies with achievement in chemistry, for students who did or did not also take English.

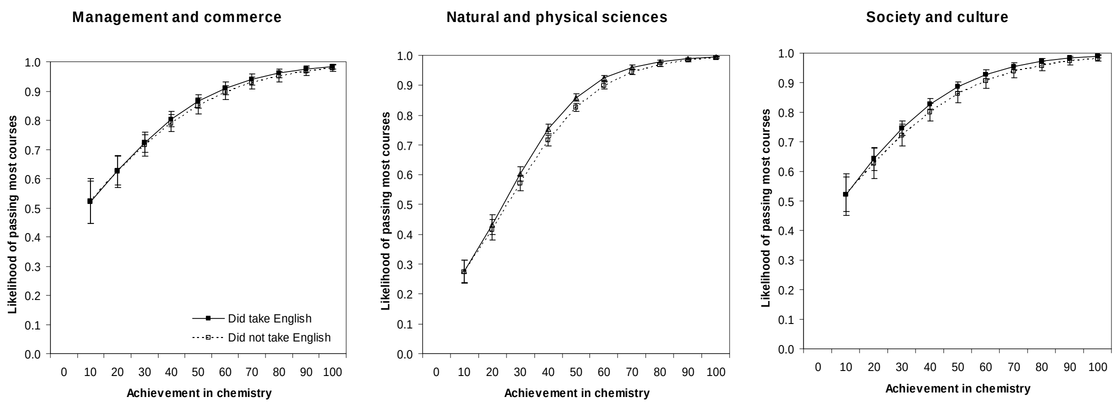
Figure 12 shows the results. We see that if a student takes chemistry, also taking English is not associated with any significant improvement in university performance.

We might have expected a difference in society and culture, given the result in figure 6.

This result reinforces our previous conclusions; once school achievement is controlled for, differences in results between students who take or do not take a subject largely disappear. When there are differences, these are marginal when compared to the improvements obtained by increases in levels of school achievement in a second subject.

Figure 12

Expected probability (and 90 per cent confidence limits) of passing most first-year courses by selected fields of study, by school achievement in **chemistry**, with or without also taking **English**



Controlling for achievement in the visual arts, with and without mathematics

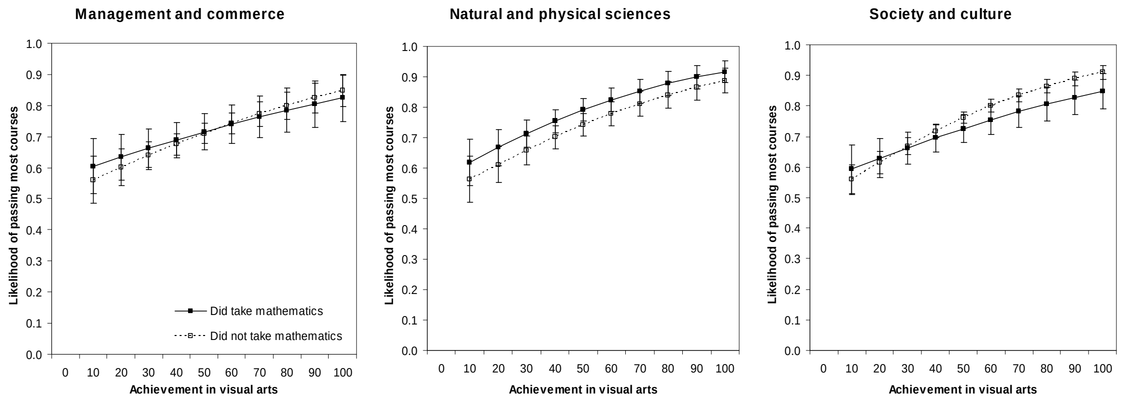
In the introduction we indicated that our study is limited to school subjects taken by students who studied at bachelors-level at university. This means we cannot apply our conclusions too widely, particularly to the non-academic and vocational subjects that are taught in schools, which are not part of the list of ‘approved subjects’ for entry to universities.

Visual arts subjects is one group of subjects that are on the ‘approved subject’ list which may be regarded as requiring skills that are somewhat different to those in other subjects. In our study, we grouped together students who gained standards in photography, painting, design, sculpture and print making.

Figure 13 shows the effect of taking mathematics or not, on students who also took visual arts subjects. Confidence limits are wider than in previous results because of the small number of students who do visual arts with or without mathematics and calculus.

Figure 13

Expected probability (and 90 per cent confidence limits) of passing most first-year courses by selected fields of study, by school achievement in **visual arts** subjects, with or without also taking **mathematics with calculus**



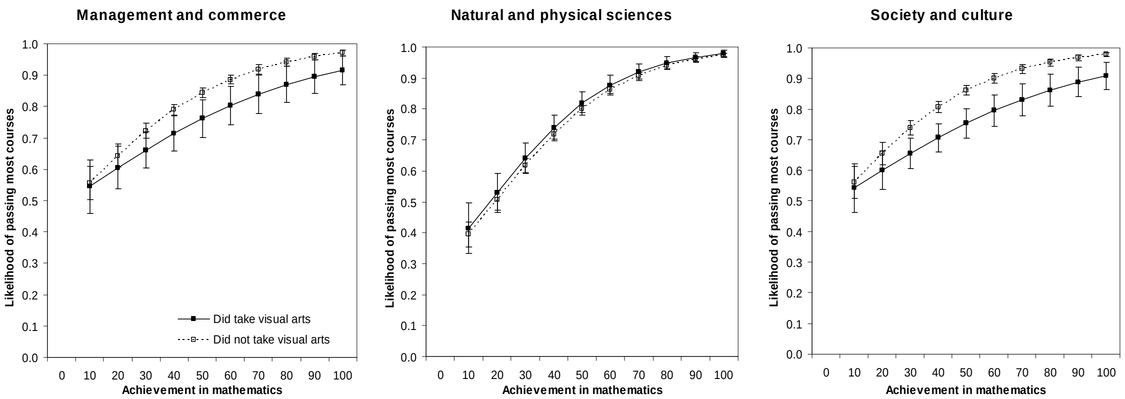
It can be seen there is no significant difference in university performance between students who did or did not take mathematics in any of the tertiary fields of study. We see the now familiar relationship with increasing school achievement and university performance, although the highest level of university performance is lower here than we have seen for other subjects. In spite of this, the results clearly show that increasing achievement in the visual arts is associated with increasing levels of university performance, in fields of study that we would presume would not benefit from having studied visual arts, and this occurs for students even if they did not also take mathematics. This occurs in spite of the results observed for mathematics in figures 5–7, and table 1.

Controlling for achievement in mathematics, with and without visual arts

Figure 14 shows the results when we consider achievement in mathematics with calculus, for students who also did or did not take a visual arts subject.

Figure 14

Expected probability (and 90 per cent confidence limits) of passing most first-year courses by selected fields of study, by school achievement in **mathematics with calculus**, with or without also taking **visual arts** subjects



Here, we see that there is no difference in university performance in science. There is a suggestion that there may be a difference in management and commerce, and there is a clear difference, at least in the middle to higher levels of mathematics achievement, in society and culture. In contrast to the previous sections' results, it is the students who did *not* take a visual arts subject who have the higher university performance, but this is to be expected, given that visual arts students have, on average, lower levels of school achievement (table 1). What we do find surprising is that there is no difference in science (compare with figure 5), and that there is only a marginal difference for management and commerce (compare with figure 7). Again, we are led to the conclusion that, when controlling for achievement in a subject, differences in university performance between taking another subject or not largely disappear. Moreover, it makes almost no difference which two subjects we care to consider.

Summary

In this section we looked at the relationship between pairs of level 3 subjects on university performance, considering one subject as a categorical variable (did or did not take the subject), and achievement in the other subject, treated as a continuous variable. The results show us that in some cases, taking a subject is associated with a statistically significant difference in the likelihood of passing most first-year courses at university. We saw this for students who took English, where also taking mathematics is associated with a difference in management and commerce degrees, but not for science, or society and culture degrees. We also saw that chemistry is associated with a difference in science degrees for students who also took English, but not for management and commerce, or society and culture degrees. English is associated with a difference for students who also took mathematics in all three degree categories we considered, but in none of the degree categories for students who also took chemistry. These rather inconsistent results provide no clear picture of a subject being associated with higher likelihoods of passing most first-year courses. What is consistent is that the likelihood of passing most first-year bachelors courses at university is associated with increasing achievement in a subject, and from the results presented, and others we reviewed but did not present, it appears this applies to any subject in the 'approved list'.

4.3 Controlling for achievement in two school subjects

If increasing levels of school achievement in a subject—rather than simply taking that subject—is associated with university performance, then the next step is to consider what happens when we control for school achievement in two subjects.

Mathematics with calculus, and English

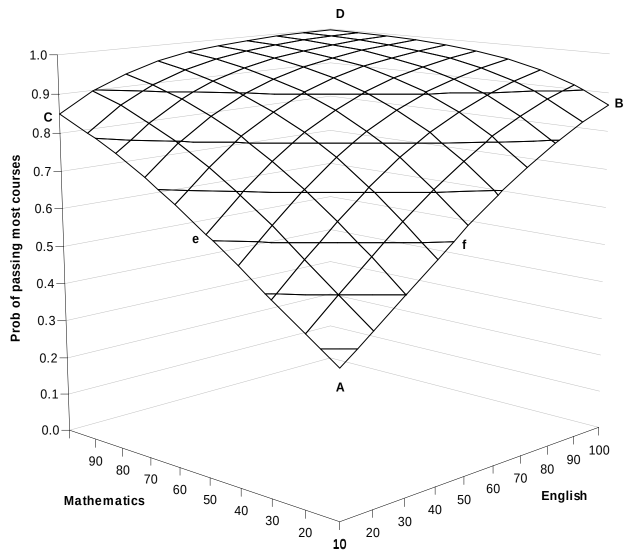
This section considers students who did both mathematics with calculus *and* English. Figure 15 shows the results, averaged over all university fields of study. The vertical axis is the same as in the previous sets of graphs, and shows the expected probability of passing most first-year bachelors courses. The two horizontal axes represent school achievement in mathematics with calculus (on the left) and English (on the right), ranging from 10 to 100.[15] The vector $\overline{AB}$ represents the relationship between the probability of passing most courses with increasing levels of achievement in English, when the level of mathematics achievement is 10. The vectors parallel to $\overline{AB}$ (visualised in the three dimensional space) up to and including vector $\overline{CD}$ show this relationship for each step increase in mathematics achievement.

The vector $\overline{AC}$, on the other hand, represents the relationship between the probability of passing most courses with increasing school achievement in mathematics, when the level of English achievement is 10. Again, the vectors parallel to this, up to and including $\overline{BD}$, show the results for each step increase in English achievement. The curvilinear surface *ABDC*, formed by these intersecting vectors, represents the probability of passing most courses with varying levels of achievement in both subjects.

[15] Due to limitations in the graphing software, it is not possible to represent the origin as 0,0. This limitation does not affect the results or the interpretations of the graphs.

Figure 15

Expected probability of passing most first-year bachelors courses against school achievement in **mathematics with calculus**, and **English**



For students in their first year of bachelors study at university. All students achieved NCEA level 3 and met the university entrance requirement. Excludes extramural students.

The line *ef* in figure 15 (and those lines running parallel to it in the three-dimensional representation) represents lines of equal probability, much like a contour line on a map; in the particular case of *ef*, it is the isoline of 0.6 probability.[16] These isolines assist in interpreting the diagram. For example, one can see from the figure that the probability of passing most courses at the lowest level of achievement in both subjects, at point *A*, is just below 0.4.

Lastly, the vector $\overline{AD}$ represents the probability of passing most first-year bachelors courses for the average achievement across both mathematics and English, and matches the result seen in figure 1, in two dimensions, where the results are averaged over all school subjects.

What do the results tell us? Firstly, because the results are almost symmetrical, we can say that university performance increases equally with increasing achievement in English or mathematics.

The results also show that doing well in one subject offsets lower achievement in another, but that doing well in both subjects is associated with the highest level of university performance. We conclude that simply taking English or mathematics is not what leads to better university performance (from figures 9 and 10), but that doing well in one or the other subject, and preferably both, is quite strongly linked to university performance.

It could be argued that the symmetry we see is the result of modelling the results over all tertiary fields of study, with differences between the fields averaging out. We consider fields of study separately in the next section.

We should point out that this symmetry is not seen with all pairs of subjects, as might have been expected given the results in figures 9 and 14.

[16] The value of the isoline is most easily determined by counting down form the topmost isoline, which is 0.9.

Chemistry and English

This section considers the results when controlling for achievement in chemistry and English, for students studying society and culture (figure 16) and in the physical and natural sciences (figure 17). Again, we consider students who have taken both chemistry and English at school.

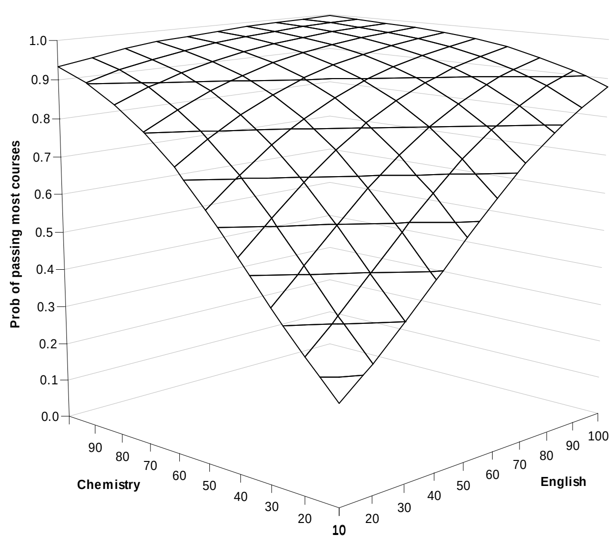
The results in figure 16 are also quite symmetrical, with students with high chemistry achievement and low English achievement performing slightly better (above 0.9 probability) than the complementary situation (below 0.9 probability). In general, about half of the response surface is above a probability of 0.9,[17] indicating a variety of combinations of chemistry and English achievement can lead to high levels of university performance in studies in society and culture.

This symmetry is not unexpected, given the results in figures 11 and 12. There, when we control for achievement in one subject (English or chemistry), taking the other subject or not, in any combination, does not affect university performance in studies in society and culture.

The result when controlling for achievement in chemistry and English for students studying physical and natural sciences at university is shown in figure 17. The lack of symmetry is immediately obvious, and is expected given the results seen in figures 11 and 12.

Figure 16

Expected probability of passing most first-year bachelors courses against school achievement in **chemistry** and **English**, for students studying **society and culture** degrees at university



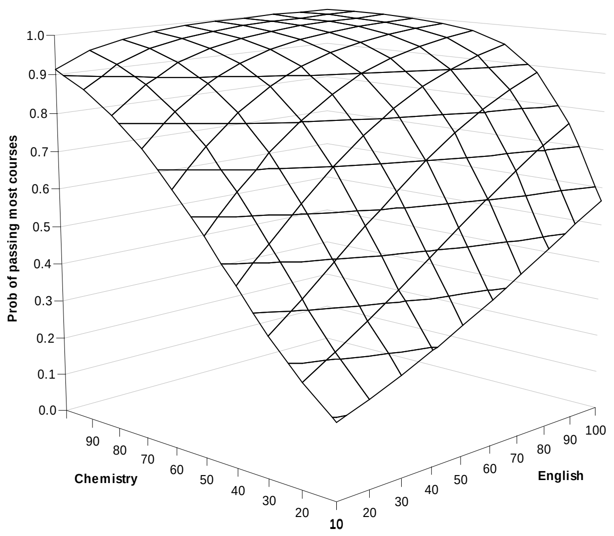
For students in their first year of bachelors study at university. All students achieved NCEA level 3 and met the university entrance requirement. Excludes extramural students.

Figure 17 shows that at low levels of achievement in both subjects, the likelihood of passing most science courses is just below 0.2. With increasing levels of achievement in chemistry, at the lowest level of English achievement, the change in probability rises to 0.9. Yet for the lowest level of chemistry achievement, increasing English achievement raises the probability to nearly 0.6.

[17] The 0.9 probability isoline runs almost from corner to corner of the response surface.

Figure 17

Expected probability of passing most first-year bachelors courses against school achievement in **chemistry** and **English**, for students studying **physical and natural science** degrees at university



For students in their first year of bachelors study at university. All students achieved NCEA level 3 and met the university entrance requirement. Excludes extramural students.

Another way of looking at the results is to consider the relative achievement levels in chemistry and English for a student to have at least a 0.7 chance of passing most of their courses. A student with English achievement of 30 needs a chemistry achievement of 50 to have this chance of passing most first-year courses, whereas a student with English achievement of 60 needs to achieve a score of 30 in chemistry. In other words, doing well in English offsets poor achievement in chemistry in a science degree.[18]

While it is also clear that increasing achievement in chemistry is associated with a greater improvement in the likelihood of passing science courses, a higher likelihood occurs with higher levels of English achievement. In other words, improving achievement in chemistry above a score of 50 (about average) makes little difference to the likelihood of passing science courses once English achievement is also above average. And at the higher levels of English achievement (70 or higher), even students with below-average chemistry achievement (those with scores 30–50) have likelihoods of passing science courses mostly above 0.8.

4.4 Controlling for achievement across school subjects in common

The previous analyses considered the effect on university performance of single or pairs of school subjects. While this is a valid approach, a problem with this method is that a student will have taken a range of other subjects at school, in addition to the one or two being analysed. These other subjects will have provided the student with skills and knowledge, some of which may have been important in determining their performance at university. It is difficult to control for the effects of those other subjects.[19]

An alternative method of analysis involves looking at the results of students who did and did not do a subject, and to consider their school achievement in just the subjects they have in

[18] Of course, it may be that these English students are taking other science subjects at school, but as seen in table 2, this is not as likely as the English students taking other languages and humanities subjects.

[19] The models could have included more subjects, but this would have reduced sample sizes considerably, since each student needs to have done all of the subjects in the model. And limiting the model to those subjects where there are sufficient students doesn't solve the problem.

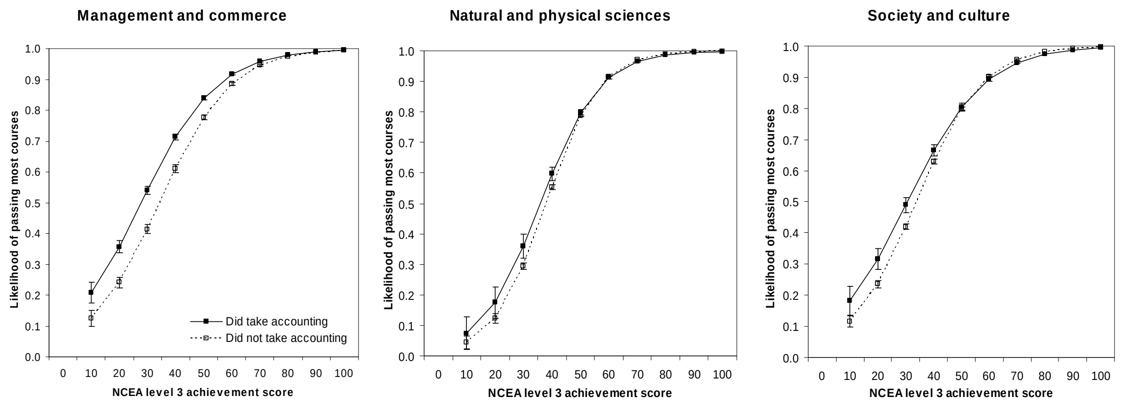
common.[20] For example, university performance can be compared for students who did not do mathematics with students who did do mathematics, controlling for school achievement across these students' subjects *except mathematics*. If taking mathematics at school makes a difference to university achievement, there ought to be differences in university performance between these two groups.

Using this method, we considered the level 3 subjects mathematics, chemistry, accounting and English, and performance at university in management and commerce, science, and society and culture degrees. We modelled university performance as the likelihood of passing most first-year bachelors courses, against overall level 3 school achievement in the common subjects, with a separate model for each of the four school subjects. We also controlled for whether a student took the subject in question or not, and the university field of study. We included all possible interactions of these three variables in the models. Adjusted R^2 values in the four models were over 0.25, and the models predicted the correct outcome for students in about 78 per cent of the cases. The models were therefore robust and reliable. Like our previous analyses, we also excluded students for subjects if the student gained less than 14 credits in that subject.

The results again show that for each school subject considered, overall school achievement was the strongest predictor of university performance. But in nearly every case, university performance was the same whether a student took the subject in question or not. In just four cases was there a difference. The strongest effect was for accounting, for students taking management and commerce studies (figure 18).

Figure 18

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **accounting** or not



Very small, but still statistically significant effects were seen for English in society and culture, and science degrees (figure 19), but only for a narrow range of school achievement. There was also a small difference for students who had taken chemistry at NCEA level 3 and progressed to a science degree at university, again for just a narrow range of school achievement (figure 20). The difference in likelihoods between the two groups of students was generally extremely small, much smaller than the differences seen in figures 9 to 14.

There were no statistically significant differences in university performance between students who did or did not take mathematics in any of the three fields of university study considered (figure 21).

[20] This approach was suggested by Dr. Michael Johnston of NZQA.

Figure 19

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **English** or not

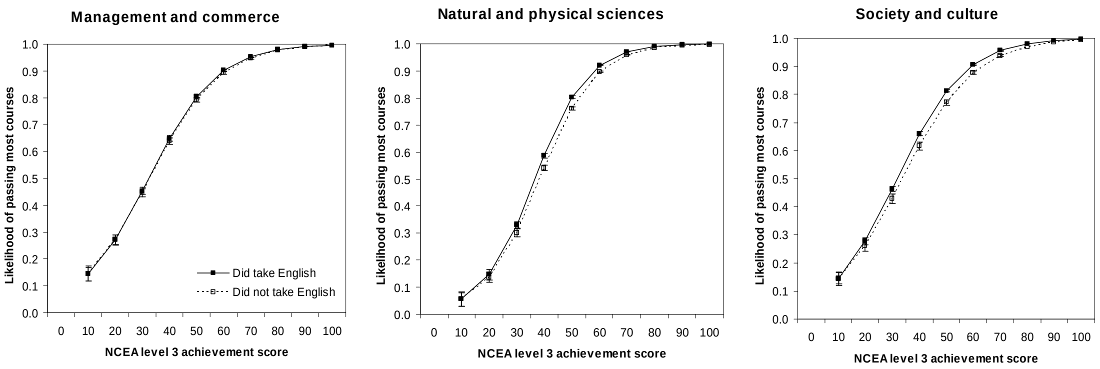


Figure 20

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **chemistry** or not

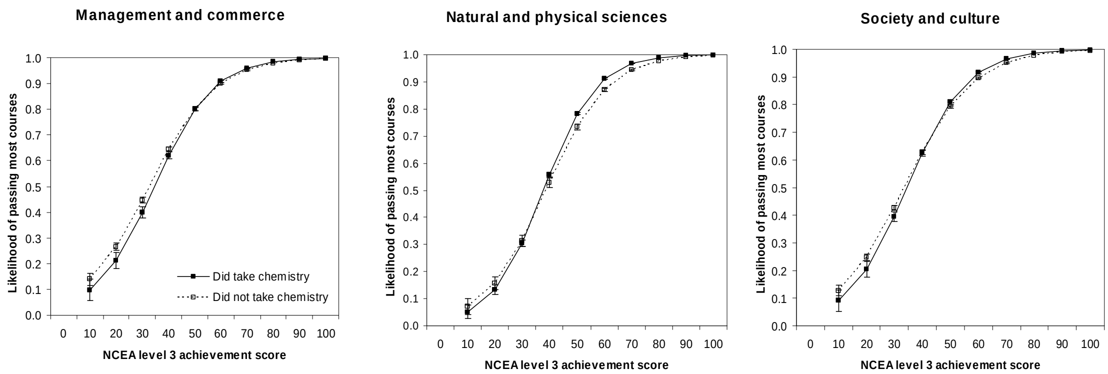
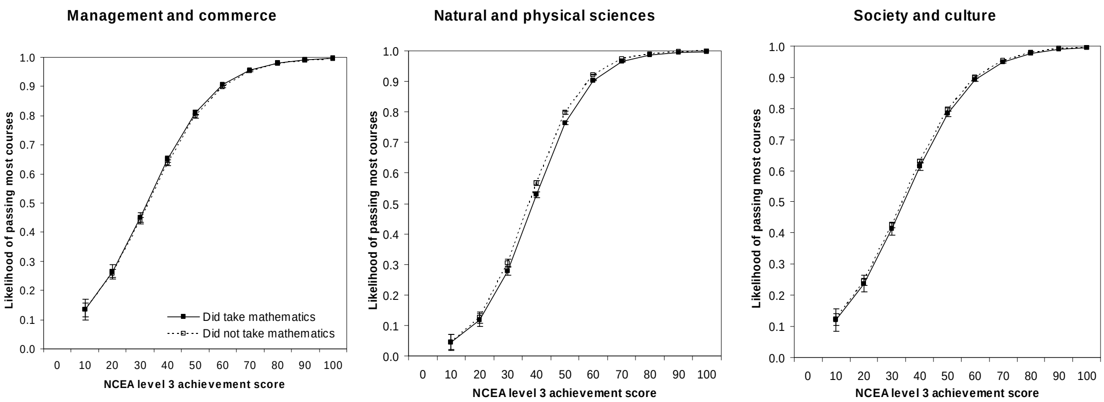


Figure 21

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **mathematics with calculus** or not



It is interesting to note that when we modelled the effect of taking mathematics at school and school achievement on university performance *without* controlling for the interaction between mathematics and school achievement, mathematics was significantly associated with higher university performance. But when we included the interaction between taking mathematics and school achievement, university performance was found to be independent of whether a student took mathematics or not at school. We conclude that taking mathematics is associated with higher university performance only because mathematics students have higher average school achievement.

As a whole, these results confirm our earlier findings. The subject a student takes at school has little bearing on their university performance when we control for school achievement. The strongest association is always between university performance and school achievement. Where higher university performance *is* associated with a particular subject, it is often in subjects that have some relation to the area of university study. This is seen with NCEA accounting, and management and commerce degrees at university, and for chemistry and science degrees. But even where a subject is associated with higher levels of university performance, low levels of school achievement in that subject are associated with low levels of university performance.

4.5 Controlling for achievement in one school subject in narrow fields of university study

It is usually the case that first-year university students enrol in a broad range of courses, with specialisation occurring in the second year. For example, first-year science degree students may opt to take a subject offered by one of the non-science faculties, while business degree students may be encouraged or required to take statistics and computing, in addition to economics and management. Measuring university performance in broad fields of study, as we have done so far, is therefore appropriate for first-year students. However, some of these broad fields of study cover a range of different disciplines. For example, the broad field of study of society and culture contains degrees in arts, social sciences, law, and language and literature studies, while management and commerce includes accounting, management and finance, but not economics. It may be the case that, on average, a school subject has no association with university performance in a broad field, because a positive association in one of the component degrees may be balanced by no association in another. Therefore, we also analyse performance *at course level* at a more narrow level of definition of the field of study.

We considered courses in the fields of mathematical sciences, chemical sciences, accountancy, economics, law, and language and literature. We then modelled the likelihood of passing most courses (more than 75 per cent) *in these courses in a specific field of study*, against whether a student took a particular school subject or not, and the level of school achievement over all level 3 subjects.[21] In effect, this shift explores the question: is the knowledge and skills acquired in a particular school subject a prerequisite for success in a university course? Students with less than 0.25 EFTS in a particular field of study are excluded, which corresponds to less than two papers in a year of study. The school subjects considered were mathematics with calculus, chemistry, accounting and English. Each school subject was modelled separately, and all two-way interaction effects were included in the models. Each model had an adjusted R^2 of about 0.30, and a C statistic of about 0.80, with a total sample size of 15,267 students. Table 4 in the appendix shows the relative sample sizes for the different school subject/university degree groups for each model used in this section.

Accounting

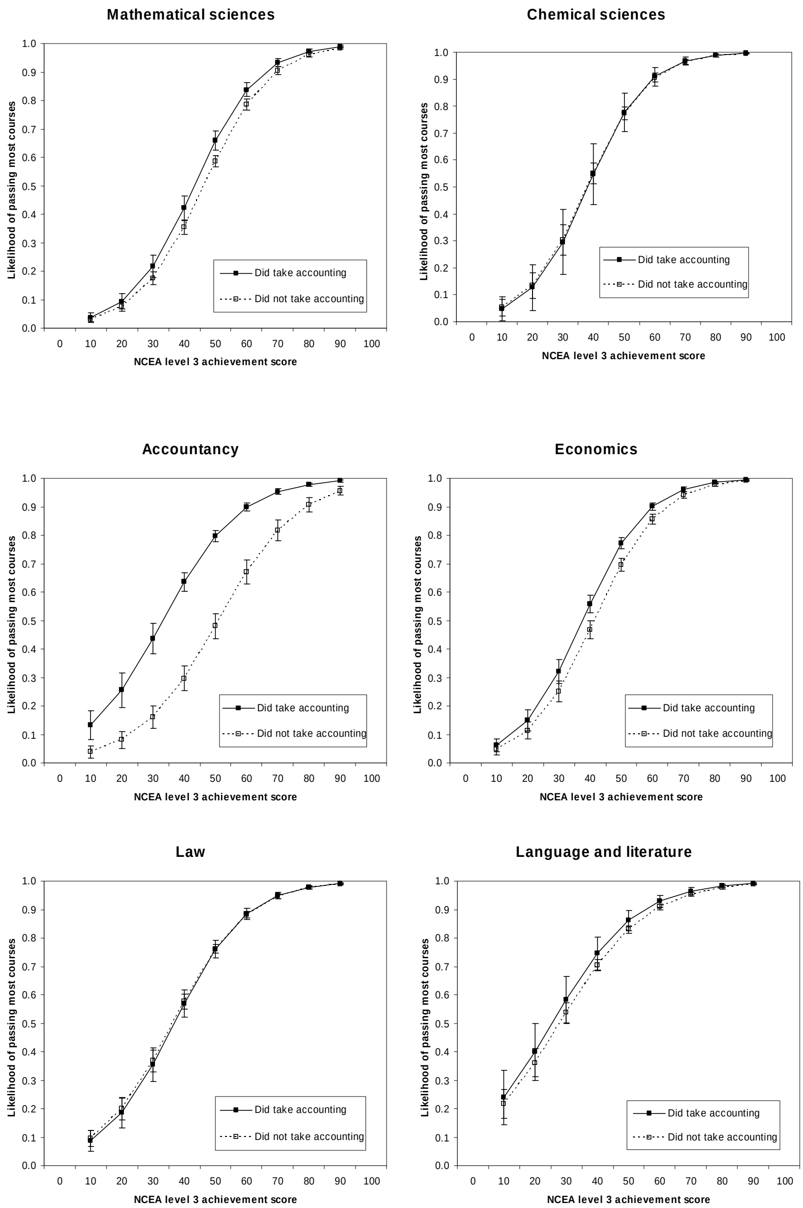
For students who took accounting at school (figure 22), those who went on to study accounting at university show significantly higher levels of university performance when compared to students who did not take accounting with the same level of school achievement. This was the strongest association seen for any school subject/university course combination.

There is a weak association between taking accounting and performance in economics at university, even though there is a relatively strong likelihood that students who took accounting at school also took economics (table 2). There is also a weak association with performance in mathematical science courses. In these two latter results the higher performance occurs only for a narrow range of school achievement.

[21] We have used school achievement measured over all level 3 subjects, rather than ‘subjects in common’, as we did in section 4.4, because the more complicated analysis produced essentially the same results as the simpler one.

Figure 22

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **accounting** or not



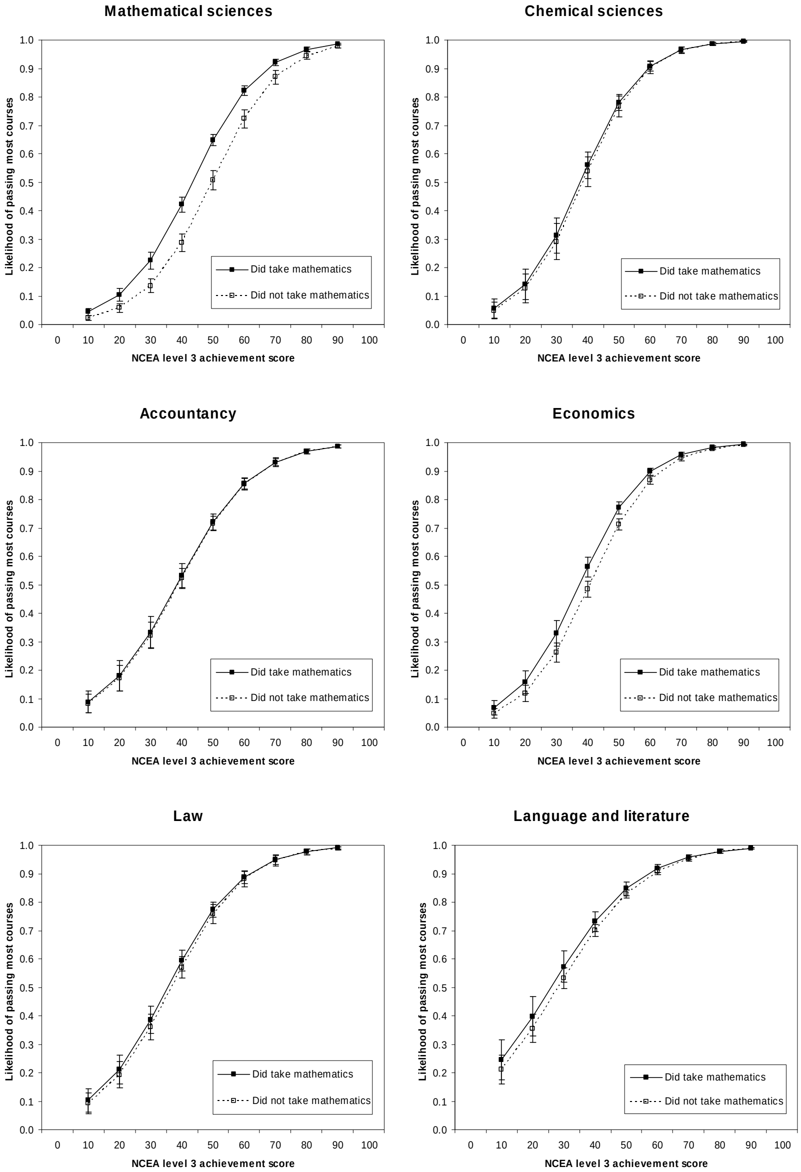
There is no significant difference in performance in any of the other three fields of study, for students who did or did not take accounting at school, at any level of school achievement. However, there are substantial differences in performance between students with different levels of school achievement. Higher university performance is seen for students with higher levels of school achievement, regardless of whether they took school accounting or not. And for most students, this even occurs for those in accountancy. In other words, a student with higher NCEA achievement who *did not* do accounting at school is likely to do better in accountancy at university than a lower ability student who *did* do accounting at school. Simply taking accounting at school is not necessarily associated with higher levels of performance in accountancy studies at university—a student must take accounting *and* achieve well across their NCEA subjects. This finding can also be made for each of the school subjects considered in the following pages.

Mathematics with calculus

Figure 23 shows the results for students who took mathematics with calculus at school, for the same 6 fields of study at university.

Figure 23

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **mathematics with calculus** or not



The data shows there is a moderate association between performance in mathematics at school and performance in mathematical science studies at university, and a weaker association with performance in economics. Interestingly, there is no association with performance in accountancy despite the fact that having taken accounting has a small association with performance in mathematical sciences at university.

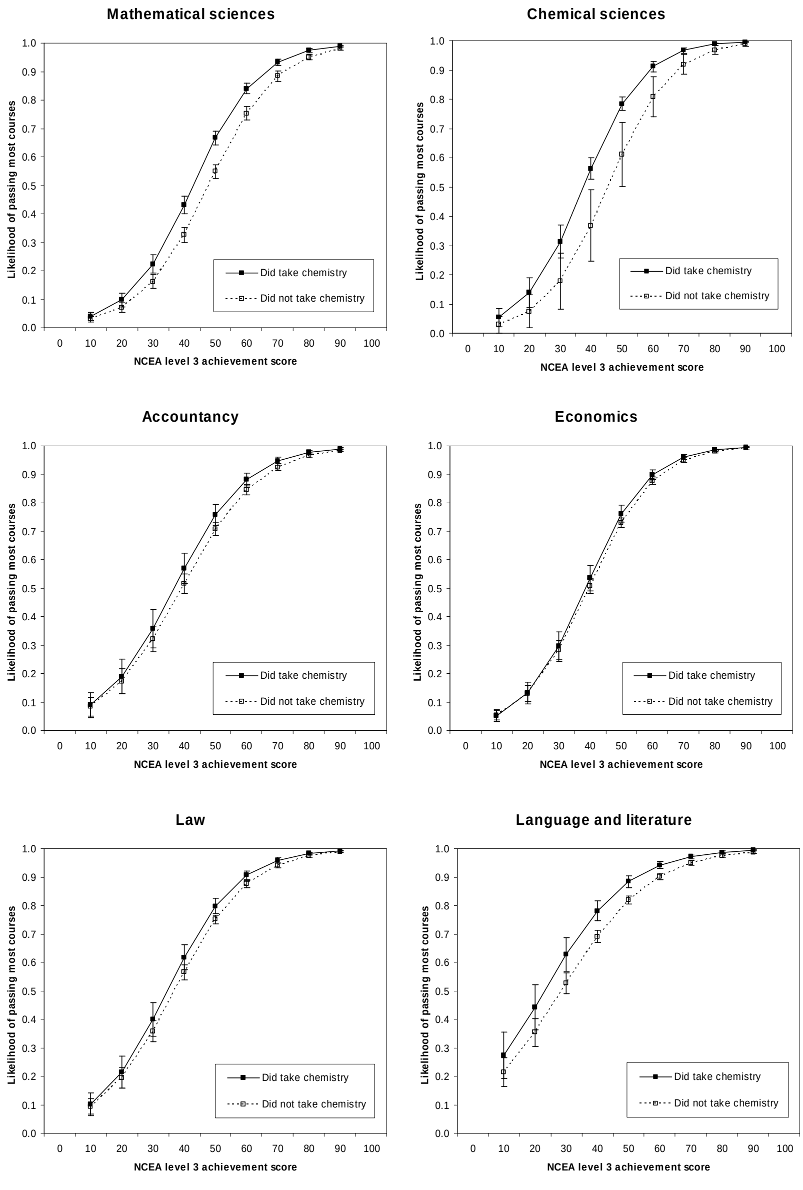
We also checked the results of taking mathematics at school on accountancy at university when *not* controlling for school achievement. Students who took mathematics at school showed a probability of passing most first year accountancy courses of 0.78±0.02 (probability and 90 per cent confidence limit), compared to 0.71±0.02 for students who did not take mathematics. The conclusion would have been that mathematics is positively associated with better performance in accountancy. Yet when controlling for school achievement, there is no difference in performance between these two groups of students.

Chemistry

Figure 24 shows the results for level 3 chemistry.

Figure 24

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **chemistry** or not



It is immediately apparent that few students go on to study chemical sciences at university who have not taken chemistry at school, as shown by the wide confidence limits in the graph for chemical sciences in figure 24.

We see that, when controlling for school achievement, taking chemistry at school is associated with higher performance in chemical science studies at university, and also with higher performance in mathematical science studies. In both cases, the association only occurs in a limited range of school achievement, although the range would include the majority of students.

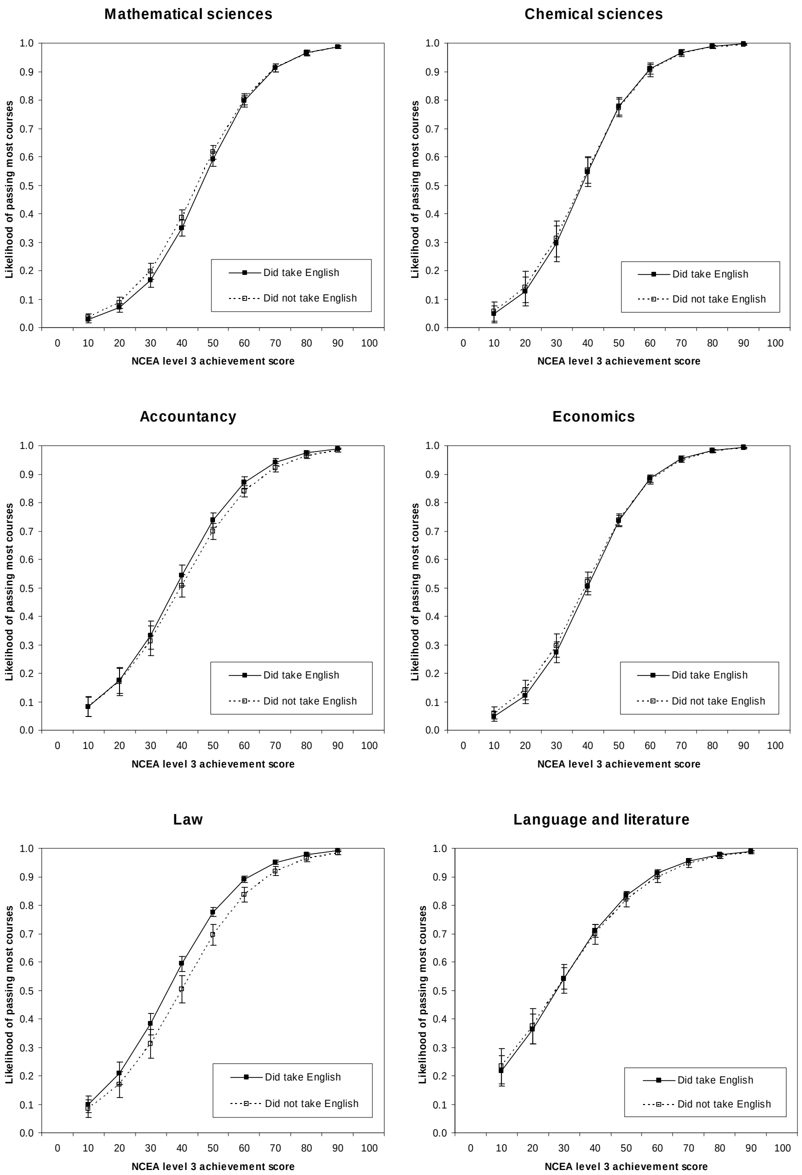
There is also a weak association with performance in language and literature degrees, but again for a narrow range of school achievement.

English

The results for students who took level 3 English or not are shown in figure 25.

Figure 25

Expected probability (and 90 per cent confidence limits) of passing most first-year bachelors courses by selected fields of study, by school achievement, for students who took level 3 **English** or not



There are no strong associations between the performance at university and taking English at school, but a weak association can be observed for performance in law studies. Interestingly, no association is seen in language and literature studies. A weak association was seen for communication and media studies (but that result is not shown).

Summary

In this section we have shown that when considering specific subjects taken at school and narrow fields of study at university, particularly where the school subject and degree study are common subject areas, an association is found between better performance at university and the taking of those subjects. Associations were found for accounting at school and accountancy studies at university, mathematics and mathematical sciences, chemistry and chemical sciences, and English and law studies. However, accounting at school is also associated with higher performance in mathematical sciences and economics, while mathematics at school is associated with better performance in economics, but not accounting. Studying chemistry at school is also associated with better performance in mathematical sciences, and language and literature studies.

These results broadly mirror our earlier findings, when the university study was considered at a broad level. Accounting at school was associated with higher performance in management and commerce (figure 18), which includes accountancy studies; chemistry or mathematics at school were associated with better performance in science degrees (figures 20 and 21), which includes mathematical and chemical sciences; and English at school was associated with better performance in society and culture (figure 19), which includes studies in law.

Most of the associations are weak. For students with the same level of school achievement, there is little difference in performance. In most cases, there are no differences in performance across the entire range of school achievement. Accounting at school and accountancy studies at university is the exception; large differences in performance occur between students who did or did not do school accounting, and statistically significant differences occur across the entire range of school achievement. However, even for accounting, and in every other case, students with low school achievement have markedly lower performance at university compared to students with higher school achievement whether or not they have taken the preparatory subject at school. Where a school subject *is* associated with higher levels of university performance, the level of improvement is much less than the increase in performance seen for students with higher school achievement, irrespective of whether or not they took the particular school subject that is associated with the higher performance.

We analysed a wider range of university courses in fields of study and school subjects than we have reported in this section. An interesting result (for which we do not provide the data here), was that for students who took accounting at school, and studied creative arts at university, there was a *negative* association between taking the subject at school and university performance. This contrasted with the strong *positive* association found for students who took accounting at school and enrolled in accountancy studies. On the other hand, for students who took visual arts at school, the associations were reversed at university. For these students, the positive association was for performance in creative arts at university, and the negative association was found for performance in accountancy studies. These results suggest that preferences for a way of thinking and working— accuracy versus creativity, numeracy versus artistry—may be important in both the choice of school subject and degree study, and is clearly associated with student performance, although we are not suggesting these are mutually exclusive dichotomous preferences. Other studies have also found that university performance can be associated with personal preferences (Felder, Felder and Dietz 2002).

4.6 Controlling for achievement in two school subjects for accountancy students

This last section explores in a little more detail the association between taking accounting at school, and performance in accountancy courses at university. We were interested to see what impact a second school subject had on the relationship between accounting and accountancy, given it was the strongest association found between a school subject and a course of study at university. As noted previously in this report, when controlling for one school subject, it may be that another school subject taken by a student is more strongly associated with better performance at university. Checking how two subjects together are associated with university performance will enable us to see if there are interactions between them.

We modelled, using logistic regression, the likelihood of passing most first-year accountancy courses, controlling for school achievement, and investigating the effect of whether a student had taken accounting or not, and taken another school subject, or not. We used backward selection[22] to limit the models to just those variables and interactions which were significant in a model. The other school subjects considered were: economics, physics, biology, statistics and modelling, mathematics with calculus, English and chemistry. A separate model was run for each of these school subjects. We tested the correlation between accounting and every other subject considered and found that the correlations were not strong enough to cause problems in the models.

In the results below, unless otherwise stated, school achievement was set to the average school achievement score for accountancy students.

- Economics and physics had no association with performance in accountancy when accounting was also taken at school, when controlling for school achievement. A student with average school achievement had a likelihood of passing most first-year accountancy courses of 0.57±0.04 (estimate and 90 per cent confidence limit) if they did not take accounting at school, versus a likelihood of 0.85±0.02 if they did. These likelihoods can be seen in figure 22.

- Taking biology at school was positively associated with better performance in accountancy courses, independent of the effect of taking accounting at school, when controlling for school achievement. That is, there was no interaction between these two school subjects. Students with average school achievement who took biology showed better performance in university accountancy, regardless of whether they took accounting at school or not. However, students who took accounting at school showed higher absolute levels of performance. The likelihood of passing most first-year accountancy courses for students who did *not* take biology and did not take accounting was 0.53±0.05, and 0.84±0.02 for those that did take accounting. For students who *did* take biology, the likelihoods were 0.66±0.06 and 0.90±0.03 respectively.

- Statistics and mathematics showed significant interactions with accounting at school, again after controlling for school achievement. Taking accounting at school was positively associated with better performance in accountancy at university, with or without also taking mathematics or statistics at school. On the other hand, taking mathematics was not associated with better performance, regardless of whether a student did or didn't also take accounting at school. Taking statistics was associated with better performance in accountancy at university only when accounting was not also taken at school. Table 3 shows the expected likelihoods of passing most first-year accountancy courses for these school subjects.

Table 3

Expected likelihood (and 90 per cent confidence limits) of passing most first-year accountancy courses at university, for students with average school achievement, and whether a student took accounting, and mathematics with calculus, or statistics and modelling, at school

Took accounting at school	*Took mathematics at school*		*Took statistics at school*	
	No	Yes	No	Yes
No	0.54±0.06	0.62±0.07	0.44±0.09	0.61±0.05
Yes	0.86±0.02	0.83±0.03	0.88±0.04	0.85±0.02

[22] Backward selection involves starting with a model which includes all variables and their interactions, and then iteratively removing those variables and interactions that are the least significant. The level of significance was set at 0.05. The number of students, and the number of starting parameters in the models, indicated that backward selection was an appropriate method for model selection.

- When controlling for school achievement, taking English at school is associated with better performance in accountancy at university when students also took accounting, but not when students did not take accounting. That is, taking English *and* accounting showed a stronger association with university performance in accountancy studies than for students who took accounting at school without English. For students who did not take accounting at school, the likelihood of passing most first-year accountancy courses was 0.57±0.06 for students who also took English, and 0.58±0.07 for those that did not. The likelihoods increased to 0.82±0.03 for students who just took accounting without English at school, and 0.88±0.02 if they took accounting and English.

- Taking chemistry at school was also positively associated with better performance in accountancy at university, independent of taking accounting at school, but unlike the other school subjects described above, the effect varied with school achievement. The expected likelihoods from the model for chemistry and accounting are presented in table 4.

    - For students with average school achievement (which for these accountancy students was 54.6), taking either accounting or chemistry at school was associated with better performance in university accountancy studies, independent of whether the student also took chemistry or accounting at school, although taking accounting alone was associated with better performance than taking chemistry alone.

    - For below-average school achievement (set at 1 standard deviation below the average, or at a score of 41.2), taking accounting at school was associated with improved performance when chemistry was *not* taken, and chemistry was associated with better performance when accounting was *not* taken. Chemistry was not associated with improved performance when accounting was also taken, but accounting was associated with slightly better performance if chemistry was also taken.

    - For above-average school achievement (set at 1 standard deviation above the average, or at a score of 68.0), taking accounting at school was associated with better performance regardless of whether chemistry was also taken or not, but chemistry was associated with better performance only if accounting was also taken at school. Without accounting, taking chemistry was not associated with any improvement.

Table 4

Expected likelihood (and 90 per cent confidence limits) of passing most first-year accountancy courses at university, by school achievement, and whether a student took accounting or chemistry at school

School achievement	*Took accounting at school*	*Took chemistry at school*	
		No	Yes
Below average	No	0.26±0.05	0.49±0.09
	Yes	0.64±0.04	0.69±0.09
Average	No	0.50±0.06	0.67±0.07
	Yes	0.84±0.02	0.91±0.07
Above average	No	0.73±0.09	0.81±0.09
	Yes	0.94±0.02	0.98±0.02

Summary

Accounting at school continued to show a strong association with performance in accountancy studies at university, but other school subjects variously modified the relationship. However, no consistent picture emerges. Some subjects do not affect the relationship, whereas others are related by second-order interactions (where the result depends on both school subjects), while others are related by third-order interactions (where the result depends on both school subjects and also on the level of school achievement). In practice, trying to predict what suite of school subject might be useful prerequisites for further study at university will be problematic. This is underscored by the results in this section: taking biology is associated with better performance in accountancy, while taking economics or mathematics at school is not. In our analysis we have only controlled for two subjects, yet it is likely that including a third or fourth school subject will result in even greater diversity of relationships.[23]

In spite of the diversity in the relationships, the results show that taking accounting at school is strongly associated with better performance in accountancy at university, regardless of what other subjects are taken. It is interesting to speculate on why this relationship is so strong, given that the association seen with other subjects and university courses, when there was an association, was far weaker.

If the topics covered in the school and university studies overlap to a large extent, then we might presume that students who took the school subject, and continued on with that subject at university, would have an advantage over students who did not take the subject at school. Similarly, if there was little or no overlap between the school curriculum in a subject and the topics covered at university for that subject, then we might presume that having taken the subject at school might offer less advantage to those students. The determining factor affecting performance would be the propensity for a student to learn new material, which would be indicated by their ability to have done this previously—in other words, their level of school achievement. Of course particular skills or knowledge learned at school that are not taught at university, would also give a student an advantage.

While we cannot test this hypothesis, it may be that the reason we find accounting at school is more strongly associated with performance in university accountancy courses is that there is a large degree of overlap between the school and university course material. The smaller levels of association found between other school subjects and university courses might be due to some overlap in course material, but not enough to give students who had previously seen this material at school an advantage. Either way, students who had demonstrated an ability to learn new material, as indicated by their school achievement score, would perform better than those who had not.

This is supported by our results. The most consistent result of the analyses in this section was the strong association between school achievement and performance in accountancy at university. In each case, whatever variables or interactions were eliminated from the models using the backward selection process, school achievement remained in the models, and consistently it was this variable which had the highest association with the likelihood of passing most first-year accountancy courses, regardless of what other subjects were taken at school.

[23] Our explorations showed that this was likely, but student numbers in the extra categories become too small to model reliably.

5 DISCUSSION

In general, the choice of subjects at level 3 of NCEA is not strongly associated with university performance; instead, university performance is more closely associated with how well a student achieves at school, more or less independently of what subjects are studied at school. In addition, this relationship appears to be more or less independent of what is studied at university.

These results may appear to be at odds with the findings of most other research, where some school subjects—in particular mathematics—have been thought to provide some benefit in a range of degree studies. Our study suggests that this finding is likely to be due to selection effects; that is, the students taking mathematics tend to have higher ability, and it is the higher ability that is associated with the good performance at university, not the taking of mathematics.

This is not to argue that specific skills or knowledge gained in particular school subjects are not important in degree study. Our results show that accounting at school appears to be associated with higher performance in management and commerce degrees, particularly in studies in accountancy. The closer the link between the subject area of the school subject and the university study, the more likely there is an association. We have demonstrated this for mathematics and mathematical sciences, chemistry and chemical sciences, and English and law. In any discipline, if there are prerequisite skills or knowledge required of a student, especially if these are fundamental to the particular area of study, then students with those skills and knowledge will be expected to perform better.

In contrast, we have also shown that taking chemistry at school is also associated with better performance in mathematical sciences, and language and literature studies, while accounting at school is associated with better performance in mathematical sciences, but not the reverse. And the example of how accounting is positively associated with university performance in accounting, but negatively with performance in creative arts studies, whereas creative arts students at school show the opposite relationship with accountancy and creative arts studies at university, indicates that factors over and above subject-matter content are likely to be involved.

In addition, the more detailed the examination of the relationship between school subject and university performance, for example, considering two school subjects and performance in a narrow area of study (section 4.6), the more complex the findings. No consistent pattern emerges, even when one school subject is strongly associated with better university performance. For example, when controlling for school achievement, taking biology at school is associated with better performance in accountancy studies at university, but taking mathematics or economics at school is not. These counter-intuitive results suggest that more factors are involved in the relationship between school subjects and university performance than we have been able to include in our analysis.

Numerous studies have shown that prior academic achievement at school is the strongest predictor of university performance, especially in the first year of tertiary study. Even when particular circumstances modify this relationship—students taking a gap year, or studying in some particular fields of study at university—so that school achievement becomes a less strong predictor, it is still the *main* predictor, and this is true for the majority of students (Engler 2010). Whether a student took a particular subject or not makes only minor differences to university performance once we also control for achievement in a second subject, and it does not seem to matter which two subjects we consider. And when we look at achievement across a number of subjects, the differences in university performance become even smaller. We conclude therefore, that academic achievement at school, whether it is measured as an average over all school subjects, or for an individual subject, has the strongest association with first-year university performance. The association, if any, which arises from simply taking a subject, is relatively smaller.

It is worthwhile briefly considering the results of other work in this area, and contrasting their results with those found in this study.

Rauchas et al (2006) find results similar to ours, albeit with a proviso. They considered first-year computer science students in South Africa, and found that high school mathematics had a weak positive correlation with performance in computer science courses. At the researchers' university, mathematics results are used as the primary criterion for admitting students into their computer courses. However, they found that the computer science students had high drop-out and failure rates, even for students who had taken mathematics. They cite Campbell and McCabe (1984) who found that a single high school subject is not useful for predicting success in computer science, but that a better indicator of success is an overall average of the high school results.[24] However, Rauchas et al go on to show that English, when taken as a first language, is a better predictor, but make the point that they believe that it is not about English in particular, but about language appreciation and its use in general, that is the underlying factor.

In our study, we found no association in performance in information technology studies and taking mathematics with calculus at school, after controlling for school achievement.[25]

A second study also supports our findings. Peard (2004) studied the mathematical background of students entering the first year of a Bachelors of Education (primary) at the Queensland University of Technology. He found that, while the entering students had different levels of high school mathematics, there was no justification for denying entry to the course based on their lack, or otherwise, of year 12 mathematics. Peard had small numbers of students in his study, and he noted that his finding may only apply to primary teacher education. When we looked at teacher education students in our cohort,[26] also a small sample, we found that not having taken biology, chemistry or physics resulted in significantly lower university performance, but that whether a student took mathematics or not made no statistical difference.

Alcock et al (2008) considered the influence of secondary mathematics on the performance of students in introductory business courses in Australia. They indicate that there is a 'clearly-established benefit' of studying secondary school accounting for tertiary accounting students, but almost no advantage to performance in accounting and finance courses from having studied mathematics, despite the fact that mathematics is often required as a pre-requisite for such courses. This study did try to control for prior student achievement, using an inter-tertiary university entrance score, and their study only included students in the top 10 per cent of school achievement. They found that high school mathematics *was* a good predictor of success in introductory business coursework and business law. But this study did not consider student achievement in the high school subjects, and did not consider the case for students who did not take mathematics.

Our study found no association between the performance in accountancy degrees and taking mathematics at school, after controlling for school achievement. There was a weak association for performance in economics courses. Rather, it was accounting at school that was strongly associated with performance in accountancy courses.

[24] What Campbell and McCabe actually said was that persistence in a computer science, engineering, or other science programme is related to students' mathematics and English scores in high school, their overall high school rank, and their background in high school mathematics and science.

[25] Results not presented.

[26] Results not presented.

Kok (2007) considered the influence of secondary school mathematics on the study of law in South Africa. Kok finds that it is students with mathematics and physical science at matriculation[27] that outperform students who do not take these school subjects. Kok finds that while A and B standard students in languages outperform the average law student, 'even D and E candidates in mathematics (HG) and science (HG) perform better than the average'. Kok acknowledges that the mathematics and sciences students are probably an 'elite' group in terms of academic ability or 'intelligence', but does not control for this.

Our study found no association between performance in law degrees and taking mathematics at school, when controlling for school achievement.

Sadler and Tai (2007) analysed students enrolled in tertiary courses in biology, chemistry and physics in the United States, controlling for years of instruction in high school biology, chemistry, physics and mathematics, amongst other factors. They found that high school biology helped in biology courses at university, chemistry helped in chemistry, and physics helped in physics, with no cross-disciplinary effect, but that mathematics helped in each of the tertiary fields of study, including biology. Sadler and Tai do control for student achievement, using SAT/ACT exam scores,[28] and the last high school grade in mathematics and English. Interestingly, their results show that students' tertiary grades were significantly associated with the students' SAT/ACT exam score, in addition to the years of instruction in the high school subjects.

When we considered the same group of disciplines as Sadler and Tai, we found somewhat different results. In our study, we found like-for-like associations for all disciplines except school physics and physics and astronomy courses, and that taking mathematics at school was *only* associated with higher performance in mathematical science. We also found that chemistry at school was associated with better performance in mathematical science.

Most of our results are based on broad fields of study assigned to degrees at university, such as management and commerce, society and culture, and physical and natural sciences. Most of the previous literature on this topic has considered university performance in courses within degrees, such as Introductory finance, Fundamental algorithmic concepts, or Business law. There may be a stronger association between the subjects taken at school and the field of these courses than to the range of courses taken by a student as part of a higher degree. However, when we considered specific fields of study, such as mathematical science, chemical science, or law, we found essentially the same results as when we used broad fields of study. It appears that only for related topics—mathematics and mathematical science, chemistry and chemical science, for example—is a particular school subject associated with an increase in university performance, but the increase in performance is more often than not marginal.

There are three main implications arising from this study.

- Firstly, there are implications for universities, and the changes some of them are making to student selection rules.

- Secondly, the results of this study have implications for the New Zealand Qualifications Authority, which is currently reviewing the university entrance requirements. Part of that review is to consider what form the common entrance standard should take, and what it might comprise. The results of this study and our previous analysis (Engler 2010) provide some evidence to inform this process.

[27] The subjects needed to be taken at the Higher Grade (HG) standard, compared to the Standard Grade.

[28] SAT is the Scholastic Aptitude (or Assessment) Test, a standardised test for college admission, and ACT is American College Testing, a standardised test for high school achievement and college admission.

- Thirdly, school students, and by implication their teachers and parents, may find some relevance in these results, particularly in regard to their motivation to do well at school.

Universities are facing high levels of demand for degree level study, but their enrolments are constrained by the number of places funded by government. In response, some universities are altering their general admissions criteria. While young students are still required to meet the university entrance requirement, several universities have indicated they will now also give preference to students with higher levels of school achievement. While these changes will *generally* identify students more likely to perform well at university, the findings of our earlier study (Engler 2010) suggest the proposed changes will disadvantage some identifiable groups of below-average students at school who, counter-intuitively, do well at university. That study found that some lower-achieving school students from low-decile schools may actually out-perform higher-achieving school students from other schools. The salient point is that school achievement is generally a good predictor of university performance, but not in all cases. The present study also suggests that any requirement for achievement in a *particular* school subject is also not necessary, at least for students who have met the university entrance requirement, since good achievement in one subject can offset poorer achievement in another. At one institution at least, level 3 chemistry is a prerequisite for enrolment in chemical science courses at stage one. Our results would suggest this is unnecessary. Students perform almost equally as well in these degrees whether they took school chemistry or not. The better indicator of performance is how well a student achieved at school, irrespective of what subjects they took.

The NZQA is reviewing the university entrance requirement. Our finding that the school subjects a student has taken are only weakly associated with university performance, if at all, may be important to that review. Our findings suggest a university entrance requirement based on student achievement would be more appropriate. But, basing university entrance solely on school achievement is not going to select all students who are likely to demonstrate high levels of performance at university.

Lastly, the findings are relevant to school students, their caregivers and teachers. There is evidence to suggest that when the NCEA was first introduced in 2002, students did only enough work to gain the amount of credits needed to achieve a particular qualification level (Meyer at al 2006). There was no advantage to them in working harder to gain credits since a credit earned with an achieved grade counted equally toward their credit totals as did a credit earned with a merit or excellence grade.

In 2007, the NCEA reporting system was changed to include endorsements on certificates of school achievement. Previously, a certificate only showed that a student had gained a particular NCEA level. With the change, the certificate also indicated whether the student achieved the NCEA level with merit or excellence. This had the effect of generally increasing student motivation (Meyer et al 2009); only about 10 per cent of students surveyed indicated the change did not matter to them.

The knowledge that university performance is more closely linked to the level of achievement may motivate some students. This will be reinforced by the higher entry requirements being imposed by the universities.

Engler (2010) discussed the factors that influence university performance, which included:

- motivation
- self-discipline
- confidence
- study habits
- time management skills
- family and peer support
- attending an institution of choice
- studying preferred courses or subjects.

Engler concluded that the NCEA level 3 achievement score, which is used to measure school achievement in that study and this one, is a proxy for some or all of the factors listed above. In general, these factors are independent of what is being studied.[29] Motivated, self-disciplined students with good study habits and time management skills will perform well at school, and these same attitudes and traits will stand them in good stead at university. Certainly, there needs to be an adjustment to university life and its study regime, but ultimately, successful students are those who learn new material, and then demonstrate their mastery of that material in tests or examinations of one form or another. It is therefore not surprising that the students who do well at school do well at university, nor is it surprising, that this is essentially independent of the subjects taken at school.

[29] The exception is the last factor, studying preferred courses or subjects. Clearly, having an interest in the subject matter helps motivation. But it would be wrong to conclude that, say, only mathematics students prefer to study mathematics.

6 DATA AND DEFINITIONS

We used two sources of data in our study. School achievement data was provided by the New Zealand Qualifications Authority. This data was linked, via the national student number,[30] to tertiary enrolment data supplied by tertiary education providers to the Ministry of Education. The study population was confined to first year intramural domestic students studying for a bachelors degree at a university. In addition, students were selected if they had gained NCEA level 3 and university entrance. Students varied between 17 and 20 years of age, and were studying in the years 2006 to 2008. When considering a particular subject, we excluded students who had gained less than 14 credits in that subject.

Sample sizes varied between the different models used in the analysis. For the bar graphs (figures 4 to 7) there were at least 50 students in each subject category. Sample sizes for the other figures are given in table 5. The sample sizes varied because we excluded students who had gained less than 14 credits in the particular subjects in a model. Table 6 gives the sample sizes and model fit statistics for the analyses in section 4 (figures 22 to 25).

The requirement for students in the study population to have university entrance derives from the fact that the university entrance requirement is not required for entrance to university for older students. Those 20 years and over can be granted special admission to a university, without the usual prerequisites. Since previous academic success is such an important determinant of performance at tertiary level, it was important to ensure that *all* students could have gained entry to university based on their school qualifications, rather than by special admission.

Scott and Smart (2005) found that extramural students had significantly lower rates of qualification completion, even when controlling for other variables. This is confirmed for students in the present study, where 54 per cent of extramural students passed most of their courses, compared to 76 per cent for intramural students. Extramural students also make up less than 1 percent of students in the data available for this study. For these reasons extramural students are excluded from the study population.

By limiting the study to first-time *first-year* students, vagaries arising from external factors that influence success at university study are reduced, and a stronger link is maintained between success at school and performance at university. It does not however, provide an indication of the overall success in gaining a qualification, which is arguably the ultimate success factor for this group. In spite of this, first year course pass rates are an important guide to later results (Birch and Miller 2006). At least for younger students, passing most or all of the courses in first year is correlated with continuing with study, and a pre-requisite to gaining the overall qualification. Older students are more likely to be studying part-time, which decreases qualification completion rates.

[30] More information on the national student number can be found at http://www.minedu.govt.nz/NZEducation/EducationPolicies/Schools/SchoolOperations/NationalStudentNumber/InformationForParentsAndStudents/FrequentlyAskedQuestions.aspx.

Table 5
Variable combinations, sample sizes and model characteristics used in the analysis

Figure	*Subject 1*	*Subject 2*	*Field(s) of study*	*Adjusted R^2*	*C statistic**	*Sample size*
9.	Achievement in maths & calculus	Did or did not take English	Management & commerce, science, and society & culture	0.15	0.72	7,666
10.	Achievement in English	Did or did not take maths & calculus	Management & commerce, science, and society & culture	0.13	0.71	16,265
11.	Achievement in chemistry	Did or did not take English	Management & commerce, science, and society & culture	0.21	0.77	8,577
12.	Achievement in English	Did or did not take chemistry	Management & commerce, science, and society & culture	0.13	0.71	16,265
13.	Achievement in visual arts	Did or did not take maths & calculus	Management & commerce, science, and society & culture	0.12	0.70	4,985
14.	Achievement in maths & calculus	Did or did not take visual arts	Management & commerce, science, and society & culture	0.14	0.71	7,666
15.	Achievement in maths & calculus	Achievement in English	All fields of study	0.17	0.75	4,785
16.	Achievement in chemistry	Achievement in English	Society and culture	0.19	0.75	1,238
17.	Achievement in chemistry	Achievement in English	Physical and natural sciences	0.32	0.83	2,990
18.	Achievement in NCEA level 3	Did or did not take accounting	Management & commerce, science, and society & culture	0.26	0.78	22,164
19.	Achievement in NCEA level 3 subjects in common	Did or did not take English	Management & commerce, science, and society & culture	0.26	0.78	22,158
20.	Achievement in NCEA level 3 subjects in common	Did or did not take chemistry	Management & commerce, science, and society & culture	0.25	0.78	22,168
21.	Achievement in NCEA level 3 subjects in common	Did or did not take maths & calculus	Management & commerce, science, and society & culture	0.26	0.78	22,164
22.	Overall achievement in NCEA level 3 subjects	Did or did not take accounting	Mathematical and chemical sciences, accountancy, economics, law and language and literature studies	0.31	0.80	15,267
23.	Overall achievement in NCEA level 3 subjects	Did or did not take maths & calculus	Mathematical and chemical sciences, accountancy, economics, law and language and literature studies	0.30	0.80	15,267
24.	Overall achievement in NCEA level 3 subjects	Did or did not take chemistry	Mathematical and chemical sciences, accountancy, economics, law and language and literature studies	0.30	0.80	15,267
25.	Overall achievement in NCEA level 3 subjects	Did or did not take English	Mathematical and chemical sciences, accountancy, economics, law and language and literature studies	0.30	0.80	15,267

* The C statistic is the probability of a student who actually passed most of their courses, having a higher predicted probability of doing this (estimated from the model), than a student who has not actually passed most of their courses.

Table 6
Number of students enrolled in selected university degree course fields of study, by whether a student took a particular school subject (+), or not (-)

	University degree course field of study						
School subject	*Mathematical sciences*	*Chemical sciences*	*Economics*	*Accountancy*	*Law*	*Language & literature studies*	*Total in school subject*
+ accounting	696	100	1,736	1,412	635	214	4,793
- accounting	2,041	1,053	1,475	443	2,678	2,784	10,474
+ mathematics	1,906	725	1,408	901	916	693	6,549
- mathematics	831	428	1,803	954	2,397	2,305	8,718
+ chemistry	1,316	1,092	760	443	806	637	5,054
- chemistry	1,421	61	2,451	1,412	2,507	2,361	10,213
+ English	1,254	562	1,896	938	2,770	2,405	9,825
- English	1,483	591	1,315	917	543	602	5,442
Total in degree	2,737	1,153	3,211	1,855	3,313	2,998	15,267

A note on the use of logistic regression

The relationship between university performance and achievement in secondary school subjects can be investigated in a number of ways. University performance can be measured as a percent of courses passed, instead of the measure we adopted, the proportion of students that passed most—more than 75 per cent—of their courses. It can be argued that using the probability measure is less efficient, since the data contains the number of courses passed or failed, which is a nearly continuous variable. We chose to use the probabilistic measure because the logistic regression models are simpler, and are less constrained by assumptions, than those regression models that use a continuous variable as the outcome measure. We also believe that predicting the proportion of courses a student passes still leaves open the question as to what constitutes good performance at university. We have used passing more than 75 per cent of first-year courses in a particular field of study (either broadly or narrowly defined), in line with other reports (Earle 2008), although when we explored the data, the results were almost no different had we used a value of 100 per cent. Of course, the best measure of university performance is whether a student eventually gains a qualification or not. It is not possible to use this latter measure with our current data, but it is an area that will be considered in the future, as more years of data become available.

A note on the use of confidence limits

The data is in this report is mostly presented in graphical form, with means and 90 per cent confidence intervals. 90 per cent confidence intervals are used so that readers, when comparing the intervals between two means, can be at least 95 per cent certain that the means are significantly different. The reasons why this apparently counter-intuitive approach is used can be found in Schenker and Gentleman (2001).

Statistical package used

The logistic regression analysis was performed using the SAS® statistical package, version 9.1.3.

APPENDIX A LIST OF APPROVED SUBJECTS

This list is reproduced from the New Zealand Qualifications Authority website.[31]

Accounting
Agriculture & Horticulture
Biology
Chemistry
Chinese
Classical Studies
Computing
Cook Islands Māori
Dance
Design (Practical Art)
Drama
Economics
English
French
Geography
German
Graphics
Health Education
History
History of Art
Indonesian
Japanese
Korean
Latin
Mathematics with Calculus
Statistics and Modelling
Media Studies
Music Studies
Painting (Practical Art)
Photography (Practical Art)
Physical Education
Physics
Printmaking (Practical Art)
Samoan
Science
Sculpture (Practical Art)
Spanish
Social Studies
Technology
Te Reo Rangatira or Te Reo Māori

[31] http://www.nzqa.govt.nz/qualifications-standards/awards/university-entrance/approved-subjects-for-university-entrance/

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