Using Institutional Research Data on Tertiary Performance to Inform Departmental Advice to Secondary Students

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Submitted to the *Journal of Institutional Research* July 1, 2011, accepted for publication July 25, 2011

Abstract

This article examines the use of institutional research data on tertiary academic success of students in the first-year Biology program at the University of Canterbury in relation to their secondary school performance in English, Mathematics with Statistics, Biology and Chemistry. This study was commissioned by the School of Biological Sciences to examine the validity of the advice they gave to secondary students considering studying biology at university and was carried out as a joint venture between institutional researchers and departmental academics. We found that students with higher overall first-year university biology performance were more likely to also have taken Chemistry at secondary school. Controlling for overall performance, students taking both Chemistry and Biology as domains for the New Zealand University Entrance qualification (UE) did significantly better in two out of three first-year biology courses than those who had taken only one or neither subject as a domain. The extent of the advantage depended on the type of course; being greatest in the biochemistry-related course and least in ecology-related. We concluded that the advice the School of Biological Sciences had been giving students in secondary school as to the best preparation for (first-year) university studies in biology (emphasising the need to take both the subjects of Biology and Chemistry) was consistent with the institutional performance data of first-year students at university.

Keywords: NCEA, academic advising, biology, first-year performance, academic preparation for university studies

Context

Determining secondary pathways to success at university is of vital interest for educational providers, students and governmental funding agencies. Previous research has linked success in university science degrees with science-rich backgrounds at the secondary level. Green, Brown and Ward (2009) found that secondary school science was a strong predictor of university performance in bioscience subjects where clear connections can be made from secondary to tertiary subject matter. In the New Zealand context, Shulruf, Hattie and Tumen (2008) determined that success in university can be enhanced by the pursuit of

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related disciplinary pathways at secondary level. Schwartz, Sadler, Sonnert and Tai (2008) examined the ‘depth versus breadth’ question with respect to secondary Biology, Chemistry and Physics and subsequent success in tertiary science courses, finding that breadth in secondary experience did not significantly advantage students in their tertiary success, though teaching for depth was positively associated with improved tertiary performance.

Despite these findings, a substantial proportion of New Zealand universities as yet do not have disciplinary prerequisites to enrolment, even in disciplines that have obvious academic pathways at the secondary level. For example, the Biological Sciences program at the University of Canterbury *encourages* students to pursue Biology, Chemistry and Mathematics in secondary school, but this is not a formal prerequisite. This trend is slowly shifting, and having the capacity to advise students how to prepare for successful tertiary studies would be beneficial to students and the university alike.

The aim of this research was to find suitable minima of pathway requirement to assist academic staff in their advisory role to secondary teachers and students as they devise appropriate secondary course selection. We evaluated student performance in 3 first-year core Biology courses as a function of their previous performance in selected subjects at secondary school to determine the degree to which the advice the School of Biological Sciences is currently giving to secondary students and staff can be substantiated with data.

In the next section we introduce the New Zealand secondary education system, followed by a brief description of the first-year Biology courses under investigation. Subsequently, we discuss our data sources, analyses and draw conclusions.

New Zealand’s secondary system

In 2002, the National Certificate of Educational Achievement (NCEA) was introduced as the principal secondary qualification in New Zealand, with the first university intake of NCEA students occurring in 2005. NCEA is divided into three levels, spread across the last three years of secondary school. Students choose domains (subject areas like Biology, Chemistry, English, etc.) which are subdivided into standards (performance objectives). Each standard is worth a certain number of credits that can be endorsed with ‘achieved’, ‘merit’, or ‘excellence’. Standards can be assessed internally (by the school) or externally (via a central examination), depending on the standard. For example, in the domains of Biology and Chemistry, practical lab work is examined internally while theoretical work is examined externally.

To obtain University Entrance (UE), students must (currently) achieve 42 credits at NCEA Level 3 from an approved list of subjects. This includes 14 credits in each of two domains, with a further 14 credits spread over no more than two additional domains. In practice, many students considerably exceed this minimum requirement. For a more detailed discussion on NCEA in New Zealand, see Shulruf, Hattie and Tumen (2008, 2010).

First-year Biology core curriculum

The School of Biological Sciences of the University of Canterbury (hereafter referred to as the Department) offers three core courses in the first year: BIOL111, 112 and 113. All three courses use a combination of lecture and laboratory sessions and are required for students wishing to major in Biology:

BIOL111 is an introduction in cell biology and biochemistry, with the cellular nature of life as the core theme. The course covers concepts of cell functions and their relation to cell structure, the structure of biologically relevant molecules and the biochemical interactions between molecules. In addition, the course covers the structure and function of biomolecules, metabolism, cell organisation and cell division.

BIOL112 covers basic principles of evolution and genetics, including the origin, maintenance and loss of genetic variation; ecology and the determinants of the distribution and abundance of organisms, species interactions and food web ecology.

BIOL113 presents an overview of the diversity, evolutionary relationships, structure and function of animals, plants and microbial life on earth. The first half of the course focuses on the diversity, reproduction and structure of bacteria, protists, fungi and plants. The second half examines animals and includes discussion of locomotion, respiration, and circulation, nervous and endocrine systems.

Data

Data collection was influenced by earlier focus group interviews with second-year students. In these interviews, students reported difficulties with the statistics requirements of the first-year courses and the writing requirements of laboratory reports. Students attributed the latter to insufficient preparation in English at secondary school. As a result, we decided to examine secondary student performance in Mathematics with Statistics and English in addition to Biology and Chemistry, which were suggested by the Department.

We retrieved NCEA scores for 448 individual students enrolled in the first-year Biology courses in 2007 and 2008 who had obtained UE through NCEA with at least 42 credits in UE-approved subjects. These students are a subset of the total number of students enrolled in the courses, as students can obtain UE through other means than NCEA. As can be inferred from Table 1, students routinely took more than one course, with many taking all three courses.

Table 1

Number of Students in First-Year Biology Courses With UE via NCEA

	2007		2008		Total NCEA students
	Total	NCEA	Total	NCEA	
BIOL111	289	178	251	165	343
BIOL112	222	124	229	149	273
BIOL113	216	122	232	148	270

Final grades in the three core courses (BIOL111, BIOL112 and BIOL113) were taken from student records. In cases where students took a course multiple times, only the first attempt was used to most closely represent performance based on secondary school preparation. The alphabetic grade of A+ to E (based on cut-off percentages) was converted to a number (Table 2). The grades can, with the exception of the tail ends, be considered interval data, especially because the C- grade (a non-continuing pass) is rarely given (only two students in our sample received this grade).

Table 2

Letter Grades Awarded at the University Of Canterbury's School of Biological Sciences Based on the Cut-Off Percentages Indicated, and the Numeric Grade Scale They Were Converted to For Our Analysis

Letter grade	**A+**	**A**	**A-**	**B+**	**B**	**B-**	**C+**	**C**	**C-**	**D**	**E**
Numeric grade	11	10	9	8	7	6	5	4	3	2	1
Cut-off percentage	85	80	75	70	65	60	55	50	48	40	<40

Analysis

To determine whether there were differences in general academic preparation between students in 2007 and 2008 who obtained UE through NCEA, we performed an independent sample *t* test on the mean number of total credits taken by students in these two years. As this test yielded no significant differences between the two mean scores ($df = 446$, $t = 1.36$, $p = .32$), we merged the datasets from the two years. In 2007 and 2008, the curriculum and the assessments in the Biology courses were not changed substantially. Consequently, we attributed differences in outcome grades to the students, rather than to assessments.

Subsequent data analysis was split into three parts: a χ^2 analysis; a regression and analysis of covariance; and an analysis at the subdomain level. These are described in detail below.

Influence of domains

Our initial analysis concentrated at the domain level to determine which of the four selected domains (Biology, Chemistry, Mathematics with Statistics and English) had an impact on outcome grades in first-year Biology. Cases were sorted on the basis of whether students had sufficient credits (i.e., 14 or greater) to use this domain toward qualifying for UE, and we then cross-tabulated with outcome grades in level one Biology courses (Table 3). For this analysis, we have combined the failing grades (D and E) into one category (F). Because of the binning involved, we treat the categories as ordinal, rather than interval.

Table 3

Chi-Square Analysis for the Domains of Biology, Chemistry, Math With Statistics and English by Outcome Grade in the Biology Courses

		BIOL111				BIOL112				BIOL113			
Domain	**Grade**	**Has domain status**		**Has no domain status**		**Has domain status**		**Has no domain status**		**Has domain status**		**Has no domain status**	
Biology	F	13	5.7%	17	14.0%	21	10.8%	16	20.0%	12	6.4%	19	22.1%
	C	51	22.2%	32	26.4%	40	20.5%	33	41.3%	42	22.3%	21	24.4%
	B	89	38.7%	43	35.5%	81	41.5%	22	27.5%	95	50.5%	37	43.0%
	A	77	33.5%	29	24.0%	53	27.2%	9	11.3%	39	20.7%	9	10.5%
	Total	230		121		195		80		188		86	
		$\chi^2 = 9.74$ ($p = .021$)		$\gamma = .24$ ($p = .006$)		$\chi^2 = 22.15$ ($p < .001$)		$\gamma = .43$ ($p < .001$)		$\chi^2 = 17.23$ ($p = .001$)		$\gamma = .36$ ($p < .001$)	
		Significant but weak				Significant and moderate				Significant but weak			
Chemistry	F	5	2.7%	25	14.9%	6	5.6%	31	18.6%	1	1.0%	30	16.9%
	C	22	12.0%	61	36.3%	15	13.9%	58	34.7%	10	10.4%	53	29.8%
	B	69	37.7%	63	37.5%	43	39.8%	60	35.9%	51	53.1%	81	45.5%
	A	87	47.5%	19	11.3%	44	40.7%	18	10.8%	34	35.4%	14	7.9%
	Total	183		168		108		167		96		178	
		$\chi^2 = 75.05$ ($p < .001$)		$\gamma = .67$ ($p < .001$)		$\chi^2 = 45.36$ ($p < .001$)		$\gamma = .59$ ($p < .001$)		$\chi^2 = 51.72$ ($p < .001$)		$\gamma = .70$ ($p < .001$)	
		Significant and strong				Significant and moderate				Significant and strong			
Maths with Statistics	F	12	6.3%	18	11.1%	13	8.6%	24	19.5%	13	8.4%	18	15.1%
	C	44	23.3%	39	24.1%	41	27.0%	32	26.0%	28	18.1%	35	29.4%
	B	71	37.6%	61	37.7%	59	38.8%	44	35.8%	87	56.1%	45	37.8%
	A	62	32.8%	44	27.2%	39	25.7%	23	18.7%	27	17.4%	21	17.6%
	Total	189		162		152		123		155		119	
		$\chi^2 = 3.26$ ($p = .35$)				$\chi^2 = 7.72$ ($p = .052$)				$\chi^2 = 11.16$ ($p = .011$)		$\gamma = .22$ ($p = .024$)	
		Not significant				Not significant				Significant but weak			
English	F	9	6.0%	21	10.4%	12	10.4%	25	15.6%	14	11.7%	17	11.0%
	C	27	18.0%	56	27.9%	21	18.3%	52	32.5%	19	15.8%	44	28.6%
	B	60	40.0%	72	35.8%	45	39.1%	58	36.3%	62	51.7%	70	45.5%
	A	54	36.0%	52	25.9%	37	32.2%	25	15.6%	25	20.8%	23	14.9%
	Total	150		201		115		160		120		154	
		$\chi^2 = 8.84$ ($p = .032$)		$\gamma = .24$ ($p = .003$)		$\chi^2 = 14.73$ ($p = .002$)		$\gamma = .33$ ($p < .001$)		$\chi^2 = 6.66$ ($p = .083$)			
		Significant but weak				Significant but weak				Not significant			

Note. Plus and minus grades have been collapsed into a single letter grade category. χ^2 indicates the significance of grade on domain completion. γ is the Goodman and Kruskal gamma statistic and indicates the strength of the association between outcome grades and domain completion

Counter to the anecdotal evidence provided by students, when examined at the domain level, neither English nor Maths with Statistics was a useful predictor of outcome grades in the three 100 level Biology courses. Although the χ^2 analysis showed some statistically significant dependence for English (BIOL111 and 112) and Mathematics with Statistics (BIOL113), the strength of these associations, as demonstrated by the gamma coefficient, were weak. In contrast, all three core courses displayed significant dependence on both Biology and Chemistry domains and showed stronger correlations between having domain status and outcome grades achieved. Consequently, we have focused our attention on Biology and Chemistry in the subsequent analyses to assess their influence on success in the first-year university Biology curriculum.

Biology and Chemistry performance based on domain status

James, Montelle and Williams (2008), examining NCEA results and success in university mathematics, plotted the university mathematics course grade as a function of the number of credits in NCEA mathematics. Because pathways into university Biology are not as clear-cut as pathways into mathematics, we divided the sample instead into four groups based on whether students achieved domain status in Chemistry and/or Biology in secondary school (Table 4).

Table 4

Enrolment, Secondary Credits Passed, and Outcome Grades in BIOL111, 112 and 113 by Domain Eligibility Based on Four Categories: Students With Both Chemistry and Biology as a Domain For University Entrance, Students With Only Chemistry as a Domain, Students With Only Biology as a Domain; and Students With Neither Biology and Chemistry as a Domain

	Chemistry + Biology	**Chemistry only**	**Biology only**	**Neither**
Overall mean number of credits passed (standard deviation)	98.7 (19.3)	99.2 (20.4)	74.2 (17.9)	66.7 (15.9)
Overall range of credits passed	43–160	45–144	43–120	42–102
Number of students, BIOL111	125	57	102	59
Number of students, BIOL112	90	18	104	61
Number of students, BIOL113	79	17	109	65
Mean grade BIOL111 (standard deviation)	8.2 (2.2)	7.8 (2.1)	6.0 (2.3)	4.8 (2.2)
Mean grade BIOL112 (standard deviation)	7.7 (2.4)	6.7 (2.3)	5.8 (2.5)	4.6 (2.3)
Mean grade BIOL113 (standard deviation)	7.8 (1.9)	7.4 (2.1)	5.8 (2.1)	4.9 (2.4)

The credit range in Table 4 indicates that students who had both domains, or only Chemistry as a domain, typically had more total level three NCEA credits than students who only had Biology or had neither domain. In addition, students who took both Chemistry and Biology or Chemistry alone, obtained a higher mean outcome grade in all three core courses than those who had Biology only or neither domain. Last, Figure 1 shows a clear absence of data points in the lower right (high numbers of credits and low outcome grades) and, to a lesser extent, in the upper left quadrant (few credits but high outcome grades). These three observations are consistent with the finding that more apt students generally take more standards (Meyer, McClure, Walkey, McKenzie, & Weir, 2006) and that the domain status of Chemistry is associated with higher outcome grades.

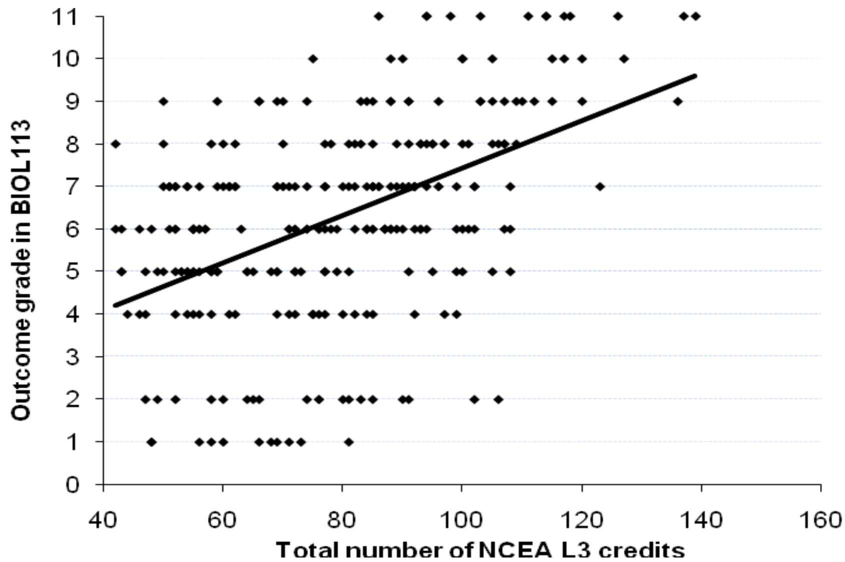

Figure 1

Example of the distribution of outcome grades in relation to the total number of NCEA credits achieved. The solid line indicates the linear regression fit. As a result of the resolution on the vertical axis, multiple data points can be represented by a single dot in the figure.

To ascertain if domain status is a determining factor in the outcome grade, it is necessary to control for the number of credits a student takes. This was done in a two-step process. First, we examined the linear relationships of the total number of credits the students took in secondary school and the outcome grade for the four different groups (Table 5).

Table 5

Pearson Correlation Coefficients Between Outcome Grade in Biology Courses and Total Number of NCEA Credits for the Four Groups of Domain Status

	Chemistry + Biology	Chemistry only	Biology only	Neither	All students
Bi01111 grade	.488*	.313*	.290*	.027	.524*
	(*n* = 125)	(*n* = 57)	(*n* = 102)	(*n* = 59)	(*n* = 343)
Bi01112 grade	.503*	.154	.417*	.045	.492*
	(*n* = 90)	(*n*=18)	(*n* = 104)	(*n* = 61)	(*n* = 273)
Bi01113 grade	.519*	.164	.349*	.045	.479*
	(*n* = 79)	(*n* = 17)	(*n* = 109)	(*n* = 65)	(*n* = 270)

* $p < .05$

Note that the non-significant results for Chemistry only in BIOL112 and BIOL113 may be due to the small size of the group.

Next, we examined groups that had significant relationships between outcome grade and NCEA credits using ANCOVA analysis, with group membership as a factor and the total number of credits as the covariate. We allowed for an interaction between total credits and group membership, but removed the interaction term from the model as no significant interactions were found, allowing the variance to be absorbed into the main effects. In addition, the non-significant result for a *lack of fit* test for all three courses indicate that linear fits are acceptable. The results of the ANCOVA analysis for each course are described below.

BIOL111

The total credits covariate was significantly related to student outcome grades (Table 6). After controlling for the covariate, group membership was significant as well (Table 7). Pair-wise comparisons between the groups showed that students who had taken Biology and Chemistry did significantly better than those who had taken Biology only. No significant differences were found between Biology and Chemistry, and Chemistry only, and between Chemistry only and Biology only. The overall corrected model explained around 30% of the observed variance.

Table 6

Summary statistics for the ANCOVA analysis for BIOL111

Source	*df*	*F*	*p*	partial η^2
Total credits	1	48.7	< .001	.149
Intercept	1	29.9	< .001	.097
Group membership	2	5.4	.005	.037
Error	279			
Corrected model	3	39.1	< .001	.296

Table 7

Pair-wise comparisons between groups for BIOL111

Group 1	Group 2	Estimated mean group 1*	Estimated mean group 2*	Difference	Standard error of the difference	*p*
Chemistry + Biology	Chemistry	7.79	7.30	.49	.33	.142
Chemistry + Biology	Biology	7.79	6.75	1.04	.32	.001
Chemistry	Biology	7.30	6.75	.55	.39	.152

* Means are calculated based on a Total credit score of 89.48

BIOL112

The total credits covariate was significantly related to student outcome grades (Table 8). After controlling for the covariate, group membership was not a statistically significant predictor for outcome grade. The overall corrected model explained about 31% of the observed variance.

Table 8

Summary Statistics for the ANCOVA Analysis for BIOL112

Source	df	*F*	*p*	partial η^2
Total credits	1	50.2	< .001	.208
Intercept	1	3.0	.083	.016
Group membership	1	1.0	.323	.005
Error	191			
Corrected model	2	42.2	< .001	.307

BIOL113

The total credits covariate was significantly related to student outcome grades (Table 9). After controlling for the covariate, group membership also had a significant effect on grades in BIOL 113 (Table 10). Pair-wise comparisons between the groups showed that students who had taken Biology and Chemistry did significantly better than those who had taken Biology only, and the overall corrected models explained around 33% of the observed variance.

Table 9

Summary Statistics for the ANCOVA Analysis for BIOL113

Source	df	*F*	*p*	partial η^2
Total credits	1	38.4	< .001	.172
Intercept	1	18.3	< .001	.090
Group membership	1	10.4	.002	.053
Error	185			
Corrected model	2	44.9	< .001	.327

Table 10

Pair-wise Comparisons Between Groups for BIOL113

Group 1	Group 2	Estimated mean group 1*	Estimated mean group 2*	Difference	Standard error of the difference	*p*
Chemistry + Biology	Biology	7.23	6.20	1.02	.32	.002

*Means are calculated based on a Total credit score of 82.14

How much Biology and Chemistry is enough?

The prominence of Chemistry as a domain in the success of student outcomes in two of the three core Biology courses immediately begs the question, ‘how many credits, beyond the domain threshold, are optimum?’ Given it is possible to obtain 24 credits in each of these disciplines, but only 14 credits are required for domain status in UE, should advice to students emphasise a focus on depth over breadth at the secondary level? To answer this, we examined Chemistry and Biology NCEA factors at the subdomain level.

The distribution of outcome grades in the three Biology core courses by number of credits received in each of the two NCEA domains of interest are shown in

Tables 11 and 12 below. As multiple cells in the table have small expected values (< 5), no χ^2 analysis could be performed, hence we present only descriptive statistics.

The column percentages indicate that students who take at least 18 credits in these domains have a substantially larger fraction in the B and A grade categories compared to the students who take less than 18 credits. While the upward trend continues for Chemistry in the third category (more than 21 credits), it flattens for Biology. The upward trend in Chemistry was expected for BIOL111, with its strong emphasis on biochemistry, but was not expected for the other courses.

Table 11

Number of NCEA Chemistry Credits by Outcome Grades BIOL111–113

Course	Grade	14–17 credits		18–21 credits		22–24 credits	
		N	%	*N*	%	*N*	%
Biol 111	F	4	7.1	1	1.3	0	0.0
	C	11	19.6	8	10.5	3	5.9
	B	22	39.3	29	38.2	18	35.3
	A	19	33.9	38	50.0	30	58.8
Biol 112	F	2	4.9	3	6.8	1	4.3
	C	7	17.1	7	15.9	1	4.3
	B	20	48.8	14	31.8	9	39.1
	A	12	29.3	20	45.5	12	52.2
Biol 113	F	1	2.4	0	0.0	0	0.0
	C	4	9.5	6	16.7	0	0.0
	B	29	69.0	14	38.9	8	44.4
	A	8	19.0	16	44.4	10	55.6

Table 12

Number of NCEA Biology Credits by Outcome Grades BIOL111—113

Course	Grade	14–17 credits		18–21 credits		22–24 credits	
		N	%	*N*	%	*N*	%
Biol 111	F	9	9.7	4	4.7	0	0.0
	C	30	32.3	17	19.8	4	7.8
	B	37	39.8	29	33.7	23	45.1
	A	17	18.3	36	41.9	24	47.1
Biol 112	F	13	16.3	4	5.3	4	10.0
	C	21	26.3	12	16.0	7	17.5
	B	35	43.8	31	41.3	15	37.5
	A	11	13.8	28	37.3	14	35.0
Biol 113	F	11	14.1	0	0.0	1	2.7
	C	20	25.6	13	17.8	9	24.3
	B	40	51.3	36	49.3	19	51.4
	A	7	9.0	42	32.9	8	21.6

The trend toward more A grades beyond the 18 credit threshold for both domains is especially worth noting, showing that students perform better in the three core courses when they have achieved more credits—irrespective of domain.

Data such as these can be useful to advise students as well as inform policy discussions regarding prerequisites, albeit with the caveats that association does not imply causation, and that setting prerequisites has implications for enrolment numbers.

For example, while 18 credits of Biology and 18 of Chemistry are associated with higher rates of success in two of the courses, this does not imply that having 18 credits will yield success. In addition, such a requirement would have excluded about 40% of the students in these courses.

Using a blanket credit threshold score has two additional drawbacks: it does not take into account the endorsement of the credits, nor does it provide assistance in choosing which particular standards are most useful.

Are all standards of equal importance?

While students tend to take more than the required 42 credits, they will operate with a certain level of strategic thinking regarding which standards to take in the final years of secondary school. In providing advice to secondary students, one question that will almost certainly be asked would be ‘what standards do I have to take?’ To this end, this final part of analysis has examined the individual standards in Biology and Chemistry to see if any of them were associated with higher performance in the courses. The NCEA level 3 standards for Chemistry and Biology are listed in Tables 13 and 14, and more details on the standards can be found on the New Zealand Qualifications Authority (NZQA) website.

Table 13

Chemistry Level 3 NCEA Standards

Number	Description	Internal/ external exam	Credits
90694	Carry out an extended practical investigation involving quantitative analysis	Internal	4
90695	Determine the concentration of an oxidant or reductant by titration	Internal	2
90696	Describe oxidation-reduction processes	External	3
90698	Describe aspects of organic chemistry	External	5
90700	Describe properties of aqueous systems	External	5
90780	Describe properties of particles and thermo chemical principles	External	5

Table 14

Biology Level 3 NCEA Standards

Number	Description	Internal/ external exam	Credits
90713	Carry out a practical investigation into an aspect of an organisms ecological niche with guidance	Internal	4
90714	Research a contemporary biological issue	Internal	3
90715	Describe role of DNA in relation to gene expression	External	4
90716	Describe animal behaviour and plant responses in relation to environmental factors	External	4
90717	Describe processes and patterns of evolution	External	3
90718	Describe applications of biotechnological techniques	Internal	3

As noted earlier, standards can be endorsed with achieved (A), merit (M) and excellence (E). In the NCEA data as provided by NZQA, several other labels also exist: 'Y' (absent from exam but scheduled to take it), 'V' (did not attempt), 'N' (attempted but not achieved) and 'Z' (missing exam paper). In our analysis, all these entries were recoded into a single pseudo-endorsement 'not applicable' (n/a). In addition, we combined merit and excellence endorsements into a 'merit or above' category (M+), as only a small minority (between 5 and 10%) of students receive excellence endorsements. Finally, following the government's merger of standards 90697 and 90689 (3 credits each) into standard 90780 (5 credits) at the beginning of 2006, we recalculated any 90697 and 90689 credits to 90780 credits using the conversions; M + A = M; N/A + A = A; A + A = A.

Table 15 shows the percentage of students who received a certain endorsement on a standard (n/a, A, M+) and who subsequently earned B or A grades in the courses. Though the actual student numbers are not shown in the table, the distribution of students receiving n/a, A, and M+ is very different for internally assessed standards compared to externally assessed ones, with many more students receiving M+ in the internally assessed standards. Moreover, internally assessed standards can be assessed multiple times, rather than once, as is the norm for externally assessed standards.

Table 15 shows several features. Firstly, for each standard, the percentage of students who did not obtain an 'achieved' endorsement yet still earned B or A grades ranges from 40% (Biology standard 90717 in BIOL112) to 70% (Biology standard 90714 in BIOL111). Second, there is a marked increase in the proportion of B or better grades being awarded between 'not achieved' and 'achieved' endorsements, with this effect being more pronounced in Chemistry than in Biology. Third, the increase in proportion of B and A grades for those receiving M+ is more pronounced in Biology than in Chemistry. Hence there is a role for considering the endorsement alongside the number of credits in the case of Biology.

Table 15

Percentage of Students Receiving a 'B' Grade or Better by Level of Achievement in Individual Biology and Chemistry NCEA Standards

Domain of Biology

	AS90713 INT			**AS90714 INT**			**AS90715 EX**			**AS90716 EX**			**AS90717 EX**			**AS90718 INT**			**AS90719 EX**		
	n/a	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**
BIOL111	66	55	83	70	44	78	58	71	97	62	68	85	55	73	92	65	55	78	63	64	87
BIOL112	48	56	74	57	46	75	48	67	85	45	59	86	40	68	87	49	52	72	47	60	85
BIOL113	59	55	84	64	45	82	59	68	88	55	63	89	53	68	90	60	53	77	61	61	85

Domain of Chemistry

	AS90694 INT			**AS90695 INT**			**AS90696 EX**			**AS90698 EX**			**AS90700 EX**			**AS90780 EX**		
	n/a	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**	**n/a**	**A**	**M+**
BIOL111	63	68	86	50	50	78	51	71	93	49	87	88	56	80	96	48	75	96
BIOL112	56	54	85	49	58	68	50	72	79	47	83	79	56	71	79	50	71	78
BIOL113	59	69	94	51	66	76	54	78	88	57	83	85	62	70	96	54	79	88

This first feature of Table 15 might indicate that no one standard is absolutely crucial to first-year success. To verify this, we asked instructors teaching the 100-level courses to evaluate the details of each standard, as outlined on the NZQA website, for its usefulness in preparation for each course. For BIOL111, all Chemistry standards were considered relevant for BIOL111. In contrast, only standard 90694 (practical work) was considered relevant for BIOL112, and none for BIOL113. In addition, instructors indicated that Chemistry standards 90696, 90698 and 90700 were not necessarily relevant for the core courses, but instead would be useful general knowledge. So while the importance of Chemistry is clear from Table 15, the instructors' comments provide a more nuanced picture about the relationship between secondary school Chemistry and success in first-year university Biology.

Conclusions

Based on our analyses, we firstly observe that there may be a mismatch between students' secondary preparation in Mathematics with Statistics and English, and the expectations of the first-year courses. We found no association between preparation in these areas and student performance in the courses. Even students with more than sufficient preparation in those subjects identified difficulties. However, writing laboratory reports and interpreting advanced statistics are not part of the NCEA curriculum, yet they are skills required and assessed in first-year university Biology courses. University teachers will need to consider this when designing both their curriculum and student advice.

Second, our ANCOVA analysis revealed a relationship between the number of credits a student takes and their first-year university performance. Students who perform better in first-year Biology generally have taken more NCEA Level 3 credits. Further, we found that students who had taken Chemistry in addition to Biology performed better in two of the three courses, even though the first-year curriculum does not always focus on Chemistry. In addition, there appears to be a threshold of 18 credits in the domains of Biology and Chemistry, based on the distribution of grades in Tables 11 and 12. Students who obtained 18 credits also had higher proportions of B and A grades compared to students who were in the 14–17 credit band. This implies that domain status only (14 credits) may not be optimal preparation.

In this study, we only considered the total number of credits students obtained. Comer, Brogt, and Sampson (2011) examined endorsements of credits in some detail and found slight improvements in associations. While weighting credits for endorsement (e.g., Shulruf, Hattie, & Tumen, 2010) can be useful from a researcher's point of view, at the practical level of providing advice to secondary students, it is perhaps more prudent to prioritise the accumulation of a total number of credits over more complicated metrics using weighted endorsements.

Finally, evidence suggests that for some (externally assessed) standards, improvement in endorsement is positively associated with outcome grades. The quality jump occurs first in Chemistry (from n/a to Achieved) and then in Biology (from Achieved to M+). However, based on our data, it is not possible to offer recommendations for students to take specific standards, as around half the students who get an A in the course fell in the 'n/a' category.

This work has identified the value of prior disciplinary learning in university success and that the Department's original advice to secondary students can be tightened. In areas where a clear secondary disciplinary pathway exists, such as Biology, students not taking this pathway as part of their University Entrance will be disadvantaged. Based on these findings, we would give the following advice to secondary students considering studying biology at university:

> Include both Chemistry and Biology as a domain for University Entrance
> Attempt at least 18 credits in each domain
> Focus on externally assessed standards.

Acknowledgments

The authors thank John Edwards of the Planning, Information and Reporting Unit of the University of Canterbury for his assistance in obtaining and cleaning the data, the staff of the School of Biological Sciences teaching in BIOL111, 112 and 113 for their feedback on the NCEA standards and Michael Johnston from the New Zealand Qualifications Authority for his useful comments on the draft of this manuscript. EB thanks Sanlyn Buxner for her feedback about educational statistics. This project was reviewed and approved by the University of Canterbury Human Ethics Committee, proposal number HEC 2009/169.

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