Towards universal participation in post-16 mathematics: lessons from high-performing countries

Country profile: New Zealand

Population March 2012):	4.43 million[1]
Population aged 5-19:	892,570 (20%)[1]
Approx population of upper secondary age:	312,640 (7%)
Registered school students (July 2011):	762,683[2]
Number of schools (state and private):	2,548[2]

- Primary schools cover Year 1 – Year 8 (ages 5-12/13)
- Secondary schools cover Year 9 – Year 13 (ages 12/13-19)
- There are also intermediate (Years 7-8) and composite (Years 1-13) schools as well as the correspondence school (providing distance education to students living long distances from other schools[3])

Education is compulsory for all children between 6 and 16. Post-compulsory upper secondary students are catered for mostly in secondary schools. Most secondary schools cater for students aged 13-18 (Years 9-13). Whilst New Zealand has strong historic links to England and the UK, the education system is historically less closely related to the English system than Singapore or Hong Kong.

Children may enrol and receive a free education at any state school from their fifth birthday and most start education at the age of five (or younger through various pre-school options). Children may stay in free education until the 1st January following their nineteenth birthday.

New Zealand has a decentralized system. Each school has authority for its day-to-day running and financial management.[4] State and state-integrated schools are required to

[1] http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections/NationalPopulationEstimates_HOTPMar12qtr.aspx
[2] http://www.educationcounts.govt.nz/publications/schooling/2259/school-roll-summary-report-july-2011
[3] http://www.correspondence.school.nz/

develop and implement a curriculum based on The New Zealand Curriculum[5], that is, a curriculum:

- underpinned by and consistent with a set of Principles
- in which the Values set out in the curriculum document are encouraged and modelled and are explored by students
- that supports students to develop a set of specified Key Competencies

The Key Competencies are:

- Thinking
- Using language symbols and texts
- Managing self
- Relating to others
- Participating and contributing

Schools must provide all students in years 1-10 with effectively taught programmes of learning in English, mathematics and statistics, science, technology, social sciences, the arts and health and physical education.

Students in Years 11 to 13 (ages 15/16 to 18) make personal choices from a wide range of courses, which lead to further study or to work and training opportunities. They also undertake studies in greater depth. [6] Students study courses from a number of subjects. Whilst there is no set number of subjects, students generally take a broad range of options. The exemplar Record of Achievement on the NCEA lists achievements in seven subject areas.[7]

In 2011, 6.8% of 15-19 year olds were not in engaged in education, employment or training (NEET)[8]. This figure was lower for age 15, 16 and 17 than at 18 and 19.

1. What is the national policy for, and structure of, mathematics education provision for 16-18/19 year-old (pre-university level) learners?

→ Is upper secondary education compulsory or optional?
→ What is the structure of upper secondary programmes?
→ Is any mathematics compulsory in the upper secondary age group?
→ What, if any, are the mathematics options in upper secondary education?

Education is compulsory until the age of sixteen. However, in 2008, in response to low participation in Senior-Secondary education – Years 11-13 – the Government announced *Schools Plus* with the intention of all students staying in education or structured learning until the age of 18. The Ministry of Education (MoE) respond to this in their Statement of Intent for

[4] Caygill, R. (2008). New Zealand. In I. Mullis, M. Martin, J. Olson, D. Berger, D. Milne & G. Stanco (Eds.), *TIMSS 2007 Encyclopaedia: A Guide to Mathematics and Science Education Around the World* (Vol. 2, pp. 427-439). Boston, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.
[5] Approximately 96% of students attend state and state-integrated schools. Independent schools are not required to use the New Zealand Curriculum but most do follow it in whole or in part.
[6] http://www.inca.org.uk/new-zealand-system-mainstream.html
[7] http://www.nzqa.govt.nz/qualifications-standards/results-2/record-of-achievement/
[8] http://www.dol.govt.nz/publications/lmr/youth/in-the-labour-market/youth-2009_07.asp

2008-2013.[9] Currently, the MoE are working towards increased participation in Senior-Secondary, until the age of seventeen.[10]

The New Zealand National Curriculum covers Years 1-13 (though is not mandatory in years 11, 12 and 13).[11] Mathematics and Statistics is described via one page of introductory information and a series of Achievement Objectives specified at 8 levels of achievement covering the 13 years of schooling. There are three strands:

Number and Algebra

Number involves calculating and estimating, using appropriate mental, written, or machine calculation methods in flexible ways. It also involves knowing when it is appropriate to use estimation and being able to discern whether results are reasonable. Algebra involves generalising and representing the patterns and relationships found in numbers, shapes, and measures.

Geometry and Measurement

Geometry involves recognising and using the properties and symmetries of shapes and describing position and movement.

Measurement involves quantifying the attributes of objects, using appropriate units and instruments. It also involves predicting and calculating rates of change.

Statistics

Statistics involves identifying problems that can be explored by the use of appropriate data, designing investigations, collecting data, exploring and using patterns and relationships in data, solving problems, and communicating findings. Statistics also involves interpreting statistical information, evaluating data based arguments, and dealing with uncertainty and variation.

At Senior Secondary level, students also have the option of taking an accounting course. This is included within Social Science subjects. The accounting curriculum is designed to:

- give students the tools to make real life financial decisions in a constantly changing and uncertain world
- develop students' skills of preparing and communicating financial information to a wide range of users
- enhance financial literacy
- help individuals and organizations to be accountable to stakeholders for their actions

At all levels of Senior Secondary education there is no prescribed curriculum and teachers have the flexibility to design their own learning programmes. In designing learning programmes, teachers should consider the big goals in mathematics and statistics (such as thinking mathematically and understanding connections between concepts) for their

[9] NZ Herald. (2008). *Clark sets 2014 deadline for education to age 18*, The New Zealand Herald, Friday September 19th 2008. Retrieved from http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=10533068 and http://www.minedu.govt.nz/theministry/publicationsandresources/statementofintent/soi2008/strategic_direction.aspx
[10] Ministry of Education. (2011). *Ministry of Education Annual Report 2011*. Wellington: Ministry of Education.
[11] http://www.inca.org.uk/1281.html#5.4.2

students. They make links to the values, principles, and key competencies in The New Zealand Curriculum and consider carefully the pedagogy and assessment that they will use.[12]

The three years of Senior-Secondary education are aligned with the three levels of the National Certificate of Educational Achievement (NCEA). The NCEA was introduced across New Zealand between 2002 and 2004 following the *Achieve 2001* project and has led to a rise in students remaining in education in Years 12 and 13.[13] Whilst students usually work at the level for their year (see Table 1) they may work at any level, adding in courses or extending their learning.

Table 1: Alignment between School Year, Curriculum Level and NCEA Level [Note: There is not an exact correspondence between year and level.]

Year	NZ Curriculum Level	NCEA Level	Credits Required
Year 11	Level 6	NCEA Level 1	80 credits at Level 1 including literacy and numeracy standards
Year 12	Level 7	NCEA Level 2	80 credits - 60 or more of the credits must be at level 2 or above
Year 13	Level 8	NCEA Level 3	80 credits - 60 or more of the credits must be at level 3 or above
		UE (University Entrance)	

The only compulsory element is in NCEA Level 1 where students must gain 10 credits from specified literacy standards and 10 credits from specified numeracy standards as part of their 80 credits.[14]

Subject choices in Years 12 and 13 may reflect future intentions, although some students have reported concerns where schools do not offer access to particular options.[15]

Schools provide Senior Secondary options in mathematics in the form of:

- General mathematics
- Statistics & modelling (usually at NCEA level 3)
- Calculus (usually at NCEA level 3)

[12] http://seniorsecondary.tki.org.nz/Mathematics-and-statistics/Learning-programme-design
[13] Absolum, M., Flockton, L., Hattie, J., Hipkins, R., & Reid, I. (2009). *Directions for Assessment in New Zealand: Developing students' assessment capabilities*. Wellington: Ministry of Education.
[14] http://www.nzqa.govt.nz/about-us/our-role/legislation/nzqa-rules/secondary-schools-supporting-information/literacy-numeracy-2011/
[15] Meyer, L., McClure, J., Walkey, F., McKenzie, L., & Weir, K. (2006). *The Impact of the NCEA on Student Motivation.* Wellington: College of Education and School of Psychology, Victoria University of Wellington. (page 68)

2. What are the overall participation rates in mathematics study for 16-18 year-olds both as proportions of students and proportions of the age cohort?

→ What are current levels of participation in mathematics overall amongst the upper secondary cohort and age group?
→ What are the current levels by gender?
→ How have these participation rates changed over time?

Table 2 shows the total number of students enrolled in Senior Secondary education, split by gender, in July 2011. This shows a higher number of male students in Year 11 and a higher number of female students in Years 12-13, although the numbers are roughly equal.

Table 2: Number and Percentage of Students by Year Level and Gender at 1 July 2011[16]

	Male		Female		Total
	Number	Percentage	Number	Percentage	Number
Year 11	32,190	51.2%	30,688	48.8%	62,878
Year 12	27,713	49.4%	28,394	50.6%	56,107
Year 13	22,473	48.1%	24,291	51.9%	46,764
Total	82,376	49.7%	83,373	50.3%	165,749

Table 3 shows how enrolment numbers for Years 11-13 have changed between 2000 and 2011.

Table 3: Number of Students by Year Level Enrolled from 2000-2011[17]

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Year 11	53,653	54,184	55,837	58,230	60,378	62,324	63,726	62,832	62,394	62,832	62,980	62,878
Year 12	45,748	45,541	46,701	47,825	49,679	49,750	50,567	52,911	52,675	54,257	55,482	56,107
Year 13	32,605	32,276	33,720	34,043	34,682	35,811	36,620	38,303	40,367	42,899	45,344	46,764

This table suggests an increase in enrolments across Years 11-13 over the last twelve years in excess of population growth in New Zealand. Retention in Senior-Secondary education has increased, partly in response to the relatively weak economic environment of 2009–2010.

- 59% of the 2004 Year 11 cohort remained in education until the end of Year 13
- 71% of the 2008 Year 11 cohort remained in education until the end of Year 13[18]
- 84% of students remained in education until their 17th birthday, although there are retention differences based on gender and for Māori and non-Māori students.[19]

Participation levels in mathematics are high in New Zealand. Entry data for the NCEA L2 qualification (usually from year 12) shows Mathematics is the second (to English) most popular subject. The entry data for the NCEA L3 qualification (usually from year 13) shows

[16] Adapted from: http://www.educationcounts.govt.nz/publications/schooling/2259/school-roll-summary-report-july-2011
[17] Ministry of Education. (2012). *Time series for trend analysis.* Wellington: Indicators and Reporting Team, Ministry of Education.
[18] New Zealand Qualifications Authority. (2011). *Annual Report on NCEA & New Zealand Scholarship Data & Statistics (2010).* Wellington: New Zealand Qualifications Authority. (page 7)
[19] http://www.educationcounts.govt.nz/indicators/main/student-engagement-participation/1955

Statistics is the most popular subject and Calculus is the third most popular subject. Twice as many students enter Statistics as enter for Calculus. The two different subjects at year 13 is an important factor contributing to high levels of participation. One of the main reasons why Statistics is so popular appears to be that it has direct application to many of the other subjects that students are studying –in both the sciences and the social sciences. Calculus is often seen by students as having more limited application to the other subjects' studied and is designed to lead to the 'traditional options of mathematics, physical sciences and engineering.[20]

In mathematics, male students make up 51.5% of enrolments, outnumbering females in all subject areas with the exception of mathematics with statistics. [21] Table 4 shows enrolments in each mathematics option across the three years of Senior-Secondary education split by gender. This, in part, reflects the compulsory options and different NCEA Levels. In 2009:

- 97% of Year 11 students participated in at least one mathematics course at typical level or above for Year 11 candidates (NCEA Level 1)
- 79% of Year 12 students participated in at least one mathematics course at typical level or above for Year 12 candidates (NCEA Level 2)
- 58% of Year 13 students participated in at least one mathematics course at typical level or above for Year 13 candidates (NCEA Level 3)[22]

Table 4: Secondary Subject Roll by Year Level & Subject Name (1 July 2011)[23]

	Year 11		Year 12		Year 13		Totals Years 11-13
	Male	Female	Male	Female	Male	Female	
Mathematics	30,359	29,464	22,774	21,788	3,622	3,298	111,305
Mathematics (Remedial)	191	232	141	111	1	17	693
Mathematics with Calculus	13	15	284	149	5,274	3,221	8,956
Mathematics with Statistics	165	210	846	836	7,537	7,581	17,175
Totals	30,728	29,921	24,045	22,884	16,434	14,117	138,129

Table 5 shows how these enrolments have changed since 2003. This table suggests that there has been an overall increase in the number of students studying some mathematics (+11%). This is slightly lower than the increase in Senior-Secondary enrolments over the same period (+18%) and there are differences across subject options. The number of students taking Mathematics with Calculus declined between 2003 and 2006. Enrolments have increased since but are slightly below earlier (2003) levels. Enrolments in Mathematics with Statistics also declined in the same time period, but have risen more quickly than mathematics with calculus as overall enrolment has increased.

[20] Information provided by country expert
[21] http://www.educationcounts.govt.nz/publications/schooling/2259/school-roll-summary-report-july-2011; http://www.educationcounts.govt.nz/__data/assets/file/0003/87492/maths-2004-2009_for-web.xls
[22] http://www.educationcounts.govt.nz/statistics/schooling/ncea-attainment/ncea-achievement-data-roll-based/participation-and-attainment-in-maths-in-national-certificate-of-educational-achievement
[23] Adapted from: Ministry of Education. (2012). *Secondary Subject Roll by Learning Year Level & Subject Name (July 2011).* Wellington: Indicators and Reporting Team, Ministry of Education.

The participation in advanced mathematics (NCEA Level 3 mathematics with calculus and mathematics with statistics) in 2009 has been estimated to be:

- 40% of all 17/18 year olds in education, employment or training,[24]
- 66% of all 16/17 year olds in education, employment or training. [25]

Note that these estimates indicate the proportions of students who are doing *some* advanced mathematics. The proportions of Level 3 completions (or achievements) are somewhat lower than enrolments. Roughly 70% of those participating in NCEA Level 3 mathematics with statistics or mathematics with calculus actually achieve the required number of credits (14) in Level 3 for the particular mathematics domain to counts as a subject for university entrance, although these credits in each domain could still contribute to their NCEA Record of Achievement and to overall 42 Level 3 credits required for university entrance.[26] Hence, it seems that the New Zealand system allows students the flexibility to take some mathematics in upper secondary (and rewards them for doing so). Around 13% of the Y13 cohort completes credits in both Mathematics with Calculus and Mathematics with Statistics.[27]

The participation rates in 2011 in some mathematics are 96%, 84% and 65% for Y11, Y12 and Y13 respectively. These are equivalent to 96% of 15/16 year olds in education, employment of training, 71% of those 16/17 year olds and 44% of those 17/18 year olds.[28] [29] Hence, using the Y12 figure, most students in upper secondary study some mathematics, although this figure drops for Y13.

The Level 3 participation rate at Y13 is amongst the highest participation rates in advanced mathematics internationally, although it is important to emphasise that around a quarter of these students are only participating in one or two Level 3 courses in either of the mathematics domains.[30] However, even allowing for these students, the participation rate is still high. It is also worth noting that the system provides flexibility for students who may be taking mathematics domain courses at different levels. It is likely that a significant minority of the 16/17 year olds in Y12 who are taking Level 2 mathematics subdomain courses are also taking Level 1 mathematics courses. This flexibility may be one contributory factor in the high level of participation.

[24] This figure is calculated by taking the Y13 advanced mathematics participation proportion for 2009 (58%), a proportion of the 2009 Y13 school cohort (42899) and scaling this down to be a proportion of in education, employment or training (EET) cohort. We have estimated the 2009 EET cohort using the 2007 Y11 school cohort (62832). This is likely to be a slight underestimate of the actual participation figure, because the Y11 cohort may be a slight overestimate of the education, employment and training cohort (since the proportion of NEETs rises slightly from just over 4% at age 16 to over 10% at age 18).
http://www.dol.govt.nz/publications/lmr/youth/in-the-labour-market/youth-2009_07.asp

[25] This figure is calculated by scaling down the proportion of Y12 students participating in Level 2 mathematics with statistics or mathematics with calculus (79%) on the basis that 84% of students remain in education until their 17th birthday.

[26] It is likely that almost all of those participating in NCEA level 3 mathematics options do achieve NCEA level 2 in either or both of mathematics with statistics or mathematics with calculus.

[27] Information provided by country expert and based on aggregate data over 6 years up to 2009.

[28] These figures are estimated on the same basis as for the advanced mathematics estimates above.

[29] Accounting is excluded from these figures on the basis that this is vocationally orientated.

[30] Hodgen, J., Pepper, D., Sturman, L., & Ruddock, G. (2010). *Is the UK an outlier? An international comparison of upper secondary mathematics education*. London: The Nuffield Foundation.

Table 5: Number of Students by Subject Option Enrolled between 2003-2011[16]

	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mathematics	95,858	101,305	101,741	107,500	110,599	110,613	110,353	111,456	111,305
Mathematics (Remedial)	2,411	2,865	3,297	2,057	1,612	1,393	939	774	693
Mathematics with Calculus	11,399	9,531	8,325	8,033	8,541	8,644	8,816	8,839	8,956
Mathematics with Statistics	14,685	13,800	13,535	13,314	13,727	14,206	15,383	16,289	17,175
Totals	126,356	129,505	128,903	132,910	136,486	136,864	137,500	139,368	140,140

3. What are the patterns of participation in terms of following different routes involving mathematics?

→ What are current levels of participation in different mathematics options amongst the upper secondary cohort and age group?

See Section 2.

4. What is the content and level of the different kinds of provision?

→ What is the structure and content of the mathematics options?
→ How is teacher education organised in order to offer the mathematics options?

New Zealand has recently been through a period of major curriculum reform with the New Zealand Curriculum for English-medium teaching and learning released in November 2007.[31] The Curriculum has five key competencies which underlie all subject areas, including mathematics:

- thinking
- using language, symbols, and texts
- managing self
- relating to others
- participating and contributing

The curriculum is divided into eight learning areas, one being Mathematics and Statistics. The curriculum documentation defines Mathematics and Statistics as:

> *Mathematics is the exploration and use of patterns and relationships in quantities, space, and time. Statistics is the exploration and use of patterns and relationships in data. These two disciplines are related, but they use different ways of thinking and solving problems. Both equip students with effective means for investigating, interpreting, explaining, and making sense of the world.*

Mathematics and Statistics is then further divided into three learning strands:

- Number & Algebra
- Geometry & Measurement
- Statistics

[31] Ministry of Education. (2007). *The New Zealand Curriculum: for English-medium teaching and learning in years 1–13.* Wellington: Ministry of Education.

In Years 12 and 13, Number & Algebra and Geometry & Measurement are combined, giving two learning strands:

- Mathematics
- Statistics

The statistics course is considered to be an advanced mathematics course. Part of the Statistics course involves carrying out investigations using the statistical enquiry cycle. This includes finding, using and assessing appropriate models, e.g. linear regression for bivariate data and additive models for time series data. Also in investigating situations involving elements of chance students are expected to be able to identify and apply appropriate distribution models – e.g. Poisson, binomial and normal. The use of appropriate technology is encouraged in the statistics course. Statistics is regarded as having equal status and value as most other subjects at NCEA Level 3.[32]

Achievement objectives for each level further break down the content of each strand. These are all available online.[33] As an example, Level 8 Statistics (usually Year 13) requires students to:

- Carry out investigations of phenomena, using the statistical inquiry cycle:
  A. conducting experiments using experimental design principles, conducting surveys, and using existing data sets
  B. finding, using, and assessing appropriate models (including linear regression for bivariate data and additive models for time-series data), seeking explanations, and making predictions
  C. using informed contextual knowledge, exploratory data analysis, and statistical inference
  D. communicating findings and evaluating all stages of the cycle

- Make inferences from surveys and experiments:
  A. determining estimates and confidence intervals for means, proportions, and differences, recognising the relevance of the central limit theorem
  B. using methods such as resampling or randomisation to assess the strength of evidence

- Evaluate a wide range of statistically based reports, including surveys and polls, experiments, and observational studies:
  A. critiquing causal-relationship claims
  B. interpreting margins of error

- Investigate situations that involve elements of chance:
  A. calculating probabilities of independent, combined, and conditional events
  B. calculating and interpreting expected values and standard deviations of discrete random variables
  C. applying distributions such as the Poisson, binomial, and normal

[32] Information provided by country expert
[33] http://seniorsecondary.tki.org.nz/Mathematics-and-statistics/Achievement-objectives/Achievement-objectives-by-level

The Mathematics and Statistics Matrix produced by the NCEA sets out the assessment standards for levels 1 – 3 of Mathematics and Statistics. It provides further information on the content of these courses.[34]

General mathematics at NCEA Level 1 is judged to be equivalent to GCSE Mathematics.[35]

The NCEA Level 3 Statistics & modelling and Calculus courses are judged to contain content equivalent to Mathematics GCE AS/A2, although the each individually is not as extensive as a full Mathematics A-level in England[36]. Similarly, the combined content of NCEA Level 3 Statistics & modelling and Calculus courses is judged to be more extensive than a single A-level but less extensive than the combination of A-level Mathematics and Further Mathematics. Both NCEA Level 2 Statistics & modelling and Calculus contain some content equivalent to AS Mathematics, although in the case of Level 2 Statistics & modelling much of the content is best described as using basic (GCSE equivalent) mathematics in more complex contexts.[37]

[34] Accessed from: http://ncea.tki.org.nz/Resources-for-aligned-standards/Mathematics-and-statistics
[35] http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/subjects/mathematics/levels/
[36] Here, the subject domain is considered as consisting of courses equivalent to the minimum number of credits (14) required for university entrance.
[37] http://www.nzqa.govt.nz/qualifications-standards/qualifications/ncea/subjects/mathematics/levels/

		Level 3		
Level 1	**Level 2**	**Statistics and Modelling**	**Calculus**	**CAS Calculus**
AS91026 **1.1** Apply numeric reasoning in solving problems 4 credits Internal	AS91256 **2.1** Apply co-ordinate geometry methods in solving problems 2 credits Internal	AS90641 **S3.1** Determine the trend for time series data 3 credits Internal	AS90635 **C3.1** Differentiate functions and use derivatives to solve problems 6 credits External	AS90833 **CAS3.1** Demonstrate an understanding of calculus concepts when solving differentiation and integration problems 7 credits External
AS91027 **1.2** Apply algebraic procedures in solving problems 4 credits External	AS91257 **2.2** Apply graphical methods in solving problems 4 credits Internal	AS90642 **S3.2** Calculate confidence intervals for population parameters 3 credits External	AS90636 **C3.2** Integrate functions and use integrals to solve problems 6 credits External	AS90834 **CAS3.2** Demonstrate an understanding of equations and expressions when solving problems 7 credits External
AS91028 **1.3** Investigate relationships between tables, equations and graphs 4 credits External	AS91258 **2.3** Apply sequences and series in solving problems 2 credits Internal	AS90643 **S3.3** Solve straightforward problems involving probability 4 credits External	AS90637 **C3.3** Solve problems and equations involving trigonometric functions 4 credits Internal	AS90835 **CAS3.3** Demonstrate an understanding of patterns and relationships when solving problems 7 credits External
AS91029 **1.4** Apply linear algebra in solving problems 3 credits Internal	AS91259 **2.4** Apply trigonometric relationships in solving problems 3 credits Internal	AS90644 **S3.4** Solve equations 4 credits External	AS90638 **C3.4** Manipulate real and complex numbers, and solve equations 5 credits External	AS90836 **CAS3.4** Demonstrate an understanding of mathematical concepts without the use of electronic technology 5 credits Internal
AS91030 **1.5** Apply measurement in solving problems 3 credits Internal	AS91260 **2.5** Apply network methods in solving problems 2 credits Internal	AS90645 **S3.5** Select and analyse continuous bi-variate data 3 credits Internal	AS90639 **C3.5** Sketch graphs of conic sections and write equations related to conic sections 3 credits External	
AS91031 **1.6** Apply geometric reasoning in solving problems 4 credits External	AS91261 **2.6** Apply algebraic methods in solving problems 4 credits External	AS90646 **S3.6** Use probability distribution models to solve straightforward problems 4 credits External		
AS91032 **1.7** Apply right-angled triangles in solving measurement problems 3 credits Internal	AS91262 **2.7** Apply calculus methods in solving problems 5 credits External	AS90647 **S3.7** Use a mathematical model involving curve fitting to solve a problem 3 credits Internal		

		Level 3		
Level 1	**Level 2**	**Statistics and Modelling**	**Calculus**	**CAS Calculus**
AS91033 **1.8** Apply knowledge of geometric representations in solving problems 3 credits Internal	AS91263 **2.8** Design a questionnaire 3 credits Internal			
AS91034 **1.9** Apply transformation geometry in solving problems 2 credits Internal	AS91264 **2.9** Use statistical methods to make an inference 4 credits Internal			
AS91035 **1.10** Investigate a given multivariate data set using the statistical enquiry cycle 4 credits Internal	AS91265 **2.10** Conduct an experiment to investigate a situation using statistical methods 3 credits Internal			
AS91036 **1.11** Investigate bivariate numerical data using the statistical enquiry cycle 3 credits Internal	AS91266 **2.11** Evaluate a statistically based report 2 credits Internal			
AS91037 **1.12** Demonstrate understanding of chance and data 4 credits External	AS91267 **2.12** Apply probability methods in solving problems 4 credits External			
AS91038 **1.13** Investigate a situation involving elements of chance 3 credits Internal	AS91268 **2.13** Investigate a situation involving elements of chance using a simulation 2 credits Internal			
	AS91269 **2.14** Apply systems of equations in solving problems 2 credits Internal			

The Ministry of Education is in the process of developing teaching and learning guides for Senior-Secondary subjects, supporting teachers in planning programmes in alignment with The New Zealand Curriculum. However, there is no prescribed curriculum for any year level and schools and teachers design learning programmes to meet the diverse needs of their students.

Guidance on teaching time and teaching approaches

There is no required teaching time to be spent on any subject. Generally Lower-Secondary students spend 3 ½ to 4 ½ hours a week on mathematics.[38] The Ministry of Education draw on research evidence in promoting what they believe to be aspects of effective pedagogy in their curriculum advice through research syntheses[39] that adopt a 'holistic negotiated' approach aimed at both informing the policy process and building professional consensus[40]. These include approaches that:

- create a supportive learning environment
- encourage reflective thought and action
- enhance the relevance of new learning
- facilitate shared learning
- make connections to prior learning and experience
- provide sufficient opportunities to learn
- inquire into the teaching–learning relationship[41]

As schools have freedom in devising their learning programmes there are no Government mandated textbooks and the curriculum is not textbook based. The Government supports the publication of a range of resources that are provided free to schools. Commercial companies also produce a range of materials, but it is up to individual schools to choose how they use these. [42]

Teacher qualifications and training

All subjects at Senior-Secondary level, including mathematics, are taught by specialist teachers. Secondary teachers usually complete a subject degree followed by a one- or two-year postgraduate Diploma of Teaching (Secondary), although other options include a B.Ed/B.Teaching degree. A recent survey (2003) found that 49% of secondary teachers had a Diploma of Teaching, although this was rising amongst the newer generation of teachers to become the norm.[43] Beyond certification, professional development has gained momentum particularly in response to the New Zealand Curriculum and Standards, with a

[38] Caygill, R. (2008). New Zealand. In I. Mullis, M. Martin, J. Olson, D. Berger, D. Milne & G. Stanco (Eds.), *TIMSS 2007 Encyclopaedia: A Guide to Mathematics and Science Education Around the World* (Vol. 2, pp. 427-439). Boston, MA: TIMSS & PIRLS International Study Center, Lynch School of Education, Boston College.
[39] Anthony, G., & Walshaw, M. (2007). *Effective pedagogy in mathematics/Pàngarau: Best evidence synthesis iteration*. Wellington, New Zealand: Ministry of Education.
[40] Ruthven, K. (2011). Using international study series and meta-analytic research syntheses to scope pedagogical development aimed at improving student attitude and achievement in school mathematics and science. *International Journal of Science and Mathematics Education, 9*(2), 419-458.
[41] http://nzcurriculum.tki.org.nz/Curriculum-documents/The-New-Zealand-Curriculum/Effective-pedagogy
[42] http://www.inca.org.uk/new-zealand-system-mainstream.html
[43] http://www.educationcounts.govt.nz/indicators/main/effective-teaching/2003

professional development cycle developed and embedded to support the understanding and implementation of the new requirements, with local and regional support clusters.[44]

5. How are the different mathematics options assessed?

→ How and when are students assessed for summative purposes?
→ Are any alternative assessment pathways available?

Throughout Primary and Lower-Secondary schooling, the emphasis of assessment is on teacher professional judgments and assessment for learning practices, rather than summative or national testing, and is the responsibility of the Ministry of Education.[45] Students are generally supportive of a formative assessment approach, provided it details errors and scaffolds remedial action.[46] National Primary School testing in Years 4, 6 and 8 was proposed in the 1998 Green Paper but met strong opposition and was never instigated.[47]

Examinations that contribute credits towards secondary school qualifications are the responsibility of the New Zealand Qualifications Authority (NZQA). The NCEA, as set out in section 1, is the main qualification taken by Senior-Secondary students in Years 11 – 13 (ages 16-19). The standards within each level are designated internal, assessed by schools, or external, assessed by examination. The results are recognised by tertiary institutions and employers.[48] The Level 3 statistics qualification has a much greater level of coursework and teacher assessment than the equivalent calculus option. Whilst the large majority of schools follow and offer the NCEA, there are other options. For instance, in 2011, 25 schools across New Zealand (the majority being independent schools) offered the International Baccalaureate with the assumption that it provides better access to Western Universities.[49]

6. What information is available on students' learning outcomes in secondary education?

→ What research or policy evidence is available on students' expectations, attitudes and attainment in relation to mathematics in lower and upper secondary education?

The last time New Zealand students in Grade 8 took part in TIMSS, attainment results were roughly at the international average. In PISA 2009, New Zealand achieved a mean of 519 which is fairly consistent since 2003.

At Senior-Secondary level, there is growing evidence that students' attitudes may be motivated by the NCEA. Students have different motivational profiles but a number of students are concerned with balancing the work required with the number of credits on

[44] Ministry of Education. (2010). *Professional Development for the National Standards 2010*. Wellington: Ministry of Education.
[45] Ministry of Education. (2011). *Ministry of Education Position Paper: Assessment [Schooling Sector].* Wellington: Ministry of Education.
[46] Rawlins, P. L. C. (2006). *Students' perceptions of the formative potential of standards-based high-stakes secondary school qualifications in New Zealand.* Paper presented at the British Educational Research Association Annual Conference, University of Warwick, 6-9 September 2006.
[47] Crooks, T. J. (2002). *Educational assessment in New Zealand schools. Assessment in Education: Principles, Policy & Practice,* 9(2), 237-253.
[48] http://www.inca.org.uk/new-zealand-system-mainstream.html
[49] Hara, K. (2011). *Educational change beyond borders: International Baccalaureate in New Zealand.* Ph.D. Thesis, Auckland University of Technology, Auckland.

offer.[50] Other studies concur with this, citing evidence that the 80-credit requirement encourages a minimalist approach by students.[51]

Anecdotal evidence suggests that students perceive Calculus as a difficult subject and Statistics as an easier subject, although both are at curriculum level 8. Students studying calculus are seen as on a pathway to university where most will continue their study in mathematics, engineering, physical and natural sciences and other similar subjects. While many studying Statistics also go on to university – they tend to study other subjects, such as management and commerce where their knowledge of Statistics is applied.[52]

Mathematical study for the numeracy requirement is compulsory within NCEA Level 1. Table 6 shows the proportion of students meeting the requirement. The percentage of students meeting this standard has steadily increased since 2004, with 85% of students meeting the numeracy requirements in 2010. By the end of Year 13, virtually all students meet the NCEA Level 1 requirements for literacy and numeracy.[53]

Table 6: Proportion of Students who met Literacy and Numeracy Requirements for NCEA level 1 by the end of Year 11 (2004-2010)[54]

	Met both literacy and numeracy requirements		Met literacy requirements		Met numeracy requirements		Candidates	Students
	n	%	n	%	n	%	n	n
2004	39910	66.1	42710	70.7	46810	77.5	54366	60378
2005	42158	67.6	44675	71.7	48590	78.0	55888	62324
2006	45675	71.7	47636	74.8	52052	81.7	59009	63726
2007	46096	73.4	47764	76.0	52435	83.5	59097	62832
2008	45959	73.7	47691	76.4	52254	83.7	58789	62394
2009	47145	75.0	48903	77.8	53069	84.5	59107	62832
2010	47945	76.1	49386	78.4	53811	85.4	59802	62980

7. What vocational education options are available at upper secondary level?

- → What is the structure and content of the vocational courses available?
- → What status do vocational courses have in comparison to other options?
- → What are the participation levels in these courses?
- → How much mathematics is included in vocational education courses and at what levels?

New Zealand is primarily a school-based system, although there are attempts to integrate vocational education into the school curriculum. Technical and vocational education and

[50] Hipkins, R., Vaughan, K., Beals, F., Ferral, H., & Gardiner, B. (2011). *Shaping our futures: Meeting secondary students' learning needs in a time of evolving qualifications: final report of the Learning Curves project (Vol. 2011).* Wellington: New Zealand Council for Educational Research.
[51] Meyer, L., McClure, J., Walkey, F., McKenzie, L., & Weir, K. (2006). *The Impact of the NCEA on Student Motivation*. Wellington: College of Education and School of Psychology, Victoria University of Wellington. (page 67)
[52] Information provided by country expert
[53] Information provided by country expert
[54] http://www.educationcounts.govt.nz/statistics/schooling/ncea-attainment/ncea-achievement-data-roll-based/literacy-and-numeracy-requirements-met

training (TVET) in New Zealand begins in school, linking with that provided by tertiary providers. Tertiary providers of TVET are: Institutes of Technology and Polytechnics (there are 20 in New Zealand), wänanga, private training establishments and workplaces. Some TVET is also provided by Government training schemes and some universities.[55]

A specialist policy development – 'The Youth Guarantee' – was implemented in 2010, aimed at 16-17 year olds who would be at risk of dropping out of or not continuing education. The programmes under this policy are intended to enable more students to gain NCEA level 2 or an equivalent NC and Government has set a target to lift % from current 69% to 85% in 5 years. The new 'vocational pathways' are seen as key to achieving this.[56] The programme recognises that some students appear to be more motivated in non-school settings. It provides free study towards school-level qualifications in settings such as polytechnics, wänanga and private training establishments. Youth Guarantee students will follow a range of vocationally-focused programmes leading to full qualification linked to Levels 1-3 qualifications on the National Qualifications Framework. The programmes must have embedded literacy and numeracy in the course content; provide clear pathways to higher levels of learning with a range of practical, specific and generic skill development; and be delivered face-to-face. Study programmes must be full time for at least one academic year. During the course of study, progression in literacy language and numeracy skills are measured using the Adult Literacy and Numeracy Learning Progressions. Examples of programmes students can follow under the Youth Guarantee (all of which include embedded Literacy and Numeracy) include certificates in:

- carpentry
- plumbing and gas-fitting
- mechanical maintenance
- electrical and related trades
- trades foundation
- office administration and computing
- automotive and mechanical engineering
- catering and hospitality
- rural skills
- computing
- retail
- horticulture
- agriculture
- forestry skills

2000 places on the Youth Guarantee Programme were made available in the academic years beginning 2010 and 2011. These were distributed based on areas of highest need:

Area	**YG Places**
Auckland	810
Canterbury	244
Wellington	185
Waikato	175
Otago/Southland	164
Manawatu-Wanganui	65
Bay of Plenty	80
Northland	80
Gisborne/Hawkes Bay	105
Taranaki	30
Nelson/Tasman/ Marlborough/ West Coast	62
Total	**2000**

[55] http://www.minedu.govt.nz/NZEducation/EducationPolicies/InternationalEducation/ForInternationalStudentsAndParents/ NZEdOverview/Technical_and_Vocational_Education.aspx

[56] Information provided by country expert

From the academic year beginning 2012, the number of places available will be increased greatly to 9616. The Vocational Pathways are currently under consultation and the final Vocational Pathways will be published in November 2012.[57]

At Senior Secondary level students can begin to specialise in vocational learning or combine vocational and general programmes. The NQF allows students to gain credits from across learning providers, and there is funding available for students to pursue vocational curriculum with tertiary providers whilst still enrolled in secondary education. Schools are able to purchase tertiary courses for students through the Secondary-Tertiary Alignment Resource (STAR).

STAR provides funds to meet the needs of students in Years 11 – 13 and aid in the transition between school and work. It is particularly focused on at-risk students.[58] The STAR programme introduces non-National Curriculum courses to Senior Secondary students which:

- include work-based learning
- lead towards credit for unit standards for vocational, education and training courses at level 1 or above
- lead to a quality assured tertiary qualification at a level beyond that of a typical year 13 course that is usually offered in a senior secondary school
- include short introductory courses giving students a taste of a tertiary education or work experience[59]

As the STAR programme is planned and offered by schools having identified their students' learning needs, different schools offer different programmes and options.[60]

In addition to the focus on at-risk students, high-achieving Senior Secondary students may also enrol in university papers offered through STAR. These may be taught by schools or at university campuses and are assessed through coursework and / or exams with the credits counting towards the NCEA and to future degree study. As an example, in mathematics, the University of Waikato offer papers in:

- Introduction to calculus
- Introduction to algebra
- Statistics for science[61]

[57] For further information on the Youth Guarantee see: http://youthguarantee.net.nz/
[58] http://www.minedu.govt.nz/NZEducation/EducationPolicies/Schools/Initiatives/STAR.aspx
[59] http://www.minedu.govt.nz/NZEducation/EducationPolicies/Schools/Initiatives/STAR/AboutSTAR.aspx
[60] http://www2.careers.govt.nz/education-and-training/still-at-school/star-do-tertiary-courses-while-still-at-school/
[61] The University of Waikato. (2012). *UniSTARt – University of Waikato 2012: University Papers for Secondary School Students*. Hamilton: The University of Waikato.

8. What drives the pattern of take-up? How is it linked to the needs of HE, employers and national policy objectives?

→ What are the official criteria, if any, for acceptance to the mathematics options?
→ Are there any unofficial / local criteria for acceptance to the mathematics options?
→ What information, advice or guidance is there about the mathematics options?
→ Are any mathematics recruitment policies targeted to specific groups or types of students?
→ Which subjects and options are students expected or required students to take?
→ Please note the views of, for example, further/higher education institutions, employers, parents or the public more generally
→ Are there 'unofficial' expectations to have particular mathematics qualifications for entry to particular HE courses?

There are no formal criteria for acceptance into Senior-Secondary courses, including mathematics.[62]

There is limited advice or guidance available on subject choices, including mathematics. Many students seem to make subject choices based on personal enjoyment.[63]

The only subject requirement in Senior-Secondary education is the inclusion of Literacy and Numeracy within NCEA Level 1. However, for university entrance, particular credits are required which may not be covered by gaining NCEA Level 3:

- Level 1 or higher: 14 credits in maths or pāngarau (Māori immersion maths).
- Level 2 or higher: 8 credits for English or te reo Māori. This must include four credits in reading and four credits in writing, and be from the NZQA approved list of standards.
- Level 3 or higher: 42 credits. Two of these subjects (14 credits each) must be from the NZQA list of approved subjects. The remaining 14 credits must be from two approved subjects[64] or not more than two additional domains. [65]

Students must have all of these credits for university entrance. Additionally, some competitive university programmes have further entrance requirements. The standard HE / university degree course follows a 3+1 (bachelor degree + honours) format.

The New Zealand Ministry of Education has examined whether different subjects are associated with better perfomance at university.[66] Once prior attainment is controlled for, there were no statistical significant effect of different Level 3 subjects on university performance. In engineering, for example, relatively few students had taken statistics & modeling whilst most had taken mathematics with calculus (and physics)[67]. Those who had taken statistics & modeling performed worse at university engineering, but, as for other

[62] http://www.inca.org.uk/1263.html
[63] Hipkins, R., & Vaughan, K. (2002). *Well I know I need English and Maths*. Paper presented at Pushing the Boundaries: An International Conference for the Careers Industry, Wellington, 28th - 30th November 2002.
[64] Approved subjects are listed on the NZQA website: http://www.nzqa.govt.nz/qualifications-standards/awards/university-entrance/approved-subjects-for-university-entrance
[65] http://www2.careers.govt.nz/education-and-training/tertiary-study-options/ncea-and-getting-into-tertiary-study/
[66] Engler, R. (2010). *Are particular school subjects associated with better performance at university?* Wellington, New Zealand: Tertiary Sector Performance Analysis and Reporting, Strategy and System Performance, Ministry of Education.
[67] Engler, R. (2012). *Studying engineering at university: Who is eligible and who decides to study it?* Wellington, New Zealand: Tertiary Sector Performance Analysis and Reporting, Strategy and System Performance, Ministry of Education.

subjects, once prior attainment had been controlled for, there was no significant difference between the two Level 3 mathematics options.

Students are expected to received careers and transitions guidance from Year 7 under the National Administration Guidelines,[68] with programmes such as 'Pathfinder' instigated to support this.[69] Policy is currently under review with the Government seeking to improve the support offered to students in making choices about qualifications.[70]

There is a long-standing concern in New Zealand over standards.[71] Nevertheless, the Ministry of Education adopted a consensual approach to the development of curriculum policy – this approach appears to have been relatively successful in achieving a consensus[72].

9. What policies and practices are there for transition and retention?

- → What policies or practices are there to support students' transition from lower secondary to upper secondary mathematics options?
- → More generally, what policies or practices are directed at students struggling with upper secondary mathematics?

It is a national education goal of New Zealand that all students, regardless of background, have access to a qualifications system which encourages participation in post-compulsory schooling.[73]

There are no mandatory mathematics courses in New Zealand in Years 11-13, but most secondary schools would typically offer two or three different mathematics courses in Years 11 and 12. These courses are tailored to the needs of particular groups of students. In year 11, for example, one course could be focussed on foundation mathematics with an emphasis on numeracy. This course could be based on outcomes from curriculum levels 5 and 6 and would lead onto a course in year 12 that could be based on outcomes from curriculum levels 6 and 7.

In terms of qualifications this would be a two year programme aimed at gaining NCEA Level 1, and also some credits towards a Level 2 qualification. Another course for year 11 students may well be based on curriculum outcomes from levels 6 and 7, and students in this course would gain an NCEA Level 1 in year 11 and also gain some credits towards an NCEA Level 2. It is this flexibility in course design that allows mathematics courses that are tailored to particular needs, and this type of support enables high participation rates in mathematics.

[68] http://www.minedu.govt.nz/NZEducation/EducationPolicies/Schools/PolicyAndStrategy/PlanningReportingRelevantLegislationNEGSAndNAGS/TheNationalAdministrationGuidelinesNAGs.aspx
[69] http://www.kiwicareers.govt.nz/
[70] Ministry of Education. (2012). *Review of Career, Information, Advice, Guidance and Education (CIAGE): Discussion Paper.* Wellington: Ministry of Education.
[71] Openshaw, R., & Walshaw, M. (2010). *Are our standards slipping? Debates over literacy and numeracy standards in New Zealand since 1945*. Wellington: NZCER Press; Nuthall, G. (1985). Standards of achievement in schools. *Economic Bulletin, 702*.
[72] Anthony, G., & Walshaw, M. (2007). *Effective pedagogy in mathematics/Pàngarau: Best evidence synthesis iteration*. Wellington, New Zealand: Ministry of Education.; Ruthven, K. (2011). Using international study series and meta-analytic research syntheses to scope pedagogical development aimed at improving student attitude and achievement in school mathematics and science. *International Journal of Science and Mathematics Education, 9*(2), 419-458.
[73] http://www.inca.org.uk/new-zealand-system-mainstream.html

10. What information is available on (other) factors affecting recruitment and retention?

→ What factors would you attribute to the upper secondary mathematics recruitment levels in your education system?
→ Please give details of any supporting information or sources

See section 6 above.