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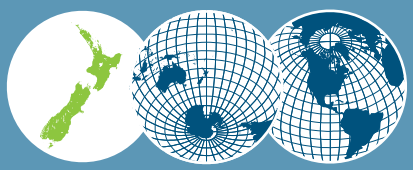
OECD

PISA2012

Series on the Learning Environment, Volume I

Opportunities to learn maths



MINISTRY OF EDUCATION
Te Tāhuhu o te Mātauranga

New Zealand Government

Foreword

The PISA survey measures the abilities of 15-year-olds in mathematics, science and reading. The survey is undertaken every three years by the OECD. In 2012, 65 countries participated.

In 2012 results for New Zealand showed a decline in mathematics, reading and science ability since 2009. The proportion of students at the lowest levels of achievement has increased. New Zealand's results are still above the OECD average in mathematics, reading and science.

The 15 year-olds assessed in this survey started school in 2002. Since that time there have been a number of initiatives put in place to address inequity of achievement among students and to lift the quality of learning and teaching overall.

There have been some successes and there are pockets of excellence in achievement, including in schools in disadvantaged areas. But these successes do not spread easily to other schools. The New Zealand system does not easily support the spread of good practices between schools, and direct interventions in schools that struggle with student achievement have not always been as effective as expected.

Considered together, the information in the Learning Environment series reinforces how important it is for students to get support from their parents, whānau, peers, and those working in their school and the community if they are to reach their potential. The New Zealand PISA data – as well as the data from other countries – clearly establishes a relationship between some of the factors operating in the home and community, in the classroom and school, and student achievement in maths. The data show that support for a student's learning needs to be available in all the contexts in which they acquire their skills and knowledge.

It is unlikely that a student's learning will be better supported or hindered by changing one thing alone – particularly for those students who do not reach the levels of proficiency in the PISA assessment that are associated with supporting a student to participate fully in modern society. But ensuring that students are supported to attend school and classes; are in classrooms where the environment is conducive to learning; are able to enjoy positive relationships with their teachers; are supported by quality teaching – including opportunities to become familiar with all aspects of the curriculum – can make a real difference to what they achieve.

An overview of PISA

The Programme for International Student Assessment (PISA) is an international study that assesses and compares how well countries are preparing their 15-year-old students to meet real-life opportunities and challenges after completing around 10 years of compulsory schooling.

PISA is an initiative of the Organisation for Economic Co-operation and Development (OECD) and a collaborative effort of participating countries. In New Zealand, the Ministry of Education is responsible for implementing and analysing PISA results.

PISA provides countries with information on student achievement and how this relates to student and family factors, school-level factors affecting teaching and learning, and system-related factors.

PISA uses a broad approach to "determine the extent to which young people have acquired the wider knowledge and skills in reading, mathematics and science that they will need in adult life".[1] It is not restricted to assessing how well students have mastered the content of a national school curriculum.

PISA has been administered every three years since it began in 2000. Each time PISA is administered, three key areas of knowledge and skills are assessed: reading literacy, mathematical literacy and scientific literacy. Rotating the main focus for each cycle of PISA provides detailed information on one main literacy area, along with an ongoing source of data on two minor areas.

The focus of PISA 2012 was mathematical literacy, as it was in 2003.

In each country, students complete a two-hour test booklet in their language of instruction.[2] Background information was gathered from students and school principal questionnaires.

Approximately half a million 15-year-old students from 65 countries[3] participated in PISA 2012, including the 34 OECD member countries. In New Zealand, over 5,000 students from 177 schools took part.[4] The majority of these students started school in 2001, the rest in 2002.

Schools and students are randomly selected to ensure the sample is representative of the New Zealand 15-year-old population. Schools that are selected by the PISA consortium are organised by the following characteristics: size, decile, location (urban or rural), authority (state or independent) and type (co-educational or single-sex). Students are selected randomly in the sampled schools from students within the specified age group (between 15 years 3 months and 16 years 2 months).

Further details on PISA study design and quality assurance procedures will be provided in the OECD's forthcoming *PISA 2012 Technical Report*.

1 OECD (2013), *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy,* OECD Publishing – p 14.

2 In New Zealand, PISA was administered only in English.

3 PISA participants include countries and economies, such as Shanghai-China. For brevity the word 'countries' in this report will refer to both countries and economies.

4 This includes nearly 1,000 students who took part in the additional financial literacy component.

Contents

Introduction

The Series on the Learning Environment presents findings from PISA 2012 on the student experience of learning maths in New Zealand classrooms compared with classrooms overseas.[5]

The three volumes in this series focus on how opportunities for New Zealand students to learn maths, school resources, the delivery of maths in classrooms and student behaviour relate to maths achievement. The analysis draws on information collected from students that reflects their cumulative schooling experience in terms of maths achievement, including their current school experience.

In this first volume, *Opportunities to Learn Maths* (Volume I), factors relating to the opportunities students have to learn different mathematical concepts are brought together to provide a picture of the learning environment and how it relates to maths achievement in the PISA 2012 assessment. First of all, student contact with maths is examined through factors such as time spent learning maths and whether additional maths classes and extra-curricular maths activities are offered at school. Next, student self-reports of familiarity with 13 mathematical content areas are presented. Finally, information is provided on the relative opportunities New Zealand students have to learn formal maths problems.[6]

New Zealand's standing is presented relative to the OECD and a core group of selected comparison countries. The four comparison countries have been selected for two main reasons: English is a main language of instruction in these countries, and they represent a range in average maths achievement, with scores that are lower than, similar to, and greater than New Zealand. Table 1 lists these countries, together with their mean maths score and distribution.

Table 1: Average maths achievement score and standard deviation for New Zealand and selected countries

	Mean maths score		Standard deviation	
New Zealand	500	(2.2)	100	(1.2)
OECD	**494**	(0.5)	**92**	(0.3)
Australia	504	(1.6)	**96**	(1.2)
United Kingdom	494	(3.3)	**95**	(1.7)
Canada	**518**	(1.8)	**89**	(0.8)
Singapore	**573**	(1.3)	**105**	(0.9)

Note: Average scores and standard deviations of countries significantly different from New Zealand are in bold.

Standard errors are presented in parentheses.

Source: OECD (2013), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I)*, PISA, OECD Publishing.

5 The 15-year-old students from around the world who took part in PISA 2012 are enrolled in different grades and will be exposed to different content and classroom environments.

6 Terms such as 'formal maths' are described and explained in the sections in which they occur, and also in Appendix 4.

New Zealand's average maths achievement (500 points) was higher than the OECD average (494 points). The spread of scores in New Zealand – as shown by the size of the standard deviation – was relatively wide compared with the OECD average. New Zealand's spread of scores was also relatively wide compared with the comparison countries, apart from Singapore, which had a wide spread of scores, particularly for a high-performing country.

Appendix 1 presents a summary of maths achievement and highlights some of the differences in New Zealand compared with those in the OECD.

Appendix 2 presents the data for the figures in the body of this report.

Appendix 3 looks at the relationship between variables presented in this report and achievement.

Appendix 4 contains the definitions of technical terms and concepts analysed in this report.

When interpreting data presented in this report, it is important to note the following points

- → 'Maths achievement' refers to the PISA measure of mathematical literacy[7] (see Appendix 4 for a more detailed definition).
- → Information is presented from student and principal questionnaires only. Data relating to teachers, such as teaching practices, were provided by students and principals.
- → Any relationship between factors described in this report should not be interpreted as causal.
- → A difference of 35 points in the New Zealand results is regarded by the OECD as equivalent to the difference of one year of formal schooling.

7 The *PISA 2012 Assessment and Analytical Framework* provides a full description of what mathematical literacy is and how it is measured [OECD (2013), *PISA 2012 Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy*, OECD Publishing].

Key findings

Opportunities to learn

Student contact with maths

- → Students in New Zealand, Australia and the United Kingdom spent considerably less time learning maths per week than their counterparts in Canada and Singapore. The average in New Zealand was just over four hours per week.
- → There was no significant relationship between time spent learning maths per week and achievement in New Zealand and the OECD overall.
- → High proportions of New Zealand students attend schools that offer maths competitions (96%) and enrichment and remedial maths lessons (76%), but fewer students attend schools with maths clubs (25%).
- → In New Zealand, students who attend schools offering a range of extra-curricular maths activities scored higher on average than students whose schools do not offer as many activities.

Covering different areas of maths

- → New Zealand students were most familiar with the mathematical concepts of probability, polygons and linear equations.
- → Up to 60 percent of students indicated they had never heard of mathematical concepts such as congruent figures, radicals and divisors.
- → New Zealand students were less exposed to formal maths (topics such as algebra and geometry) than students in Australia, Canada, the United Kingdom and particularly, Singapore.
- → A student's exposure to formal maths was strongly linked to their maths achievement. Greater exposure was associated with higher maths achievement.
- → New Zealand stood out among PISA participants for having one of the largest differences in achievement related to the level of exposure to formal maths.
- → The higher a students' socio-economic status, the higher their exposure to formal maths.
- → Exposure to formal maths was highest for students from socio-economically advantaged schools and students in urban schools.

Opportunities to learn maths

Volume I of the Series on the Learning Environment focuses on the opportunity that 15-year-old students have to learn maths. It looks at student contact with maths (learning time, availability of additional maths classes and extra-curricular maths activities), student familiarity with 13 mathematical content areas, and exposure to formal maths problems and how they are linked to maths achievement.

Student contact with maths

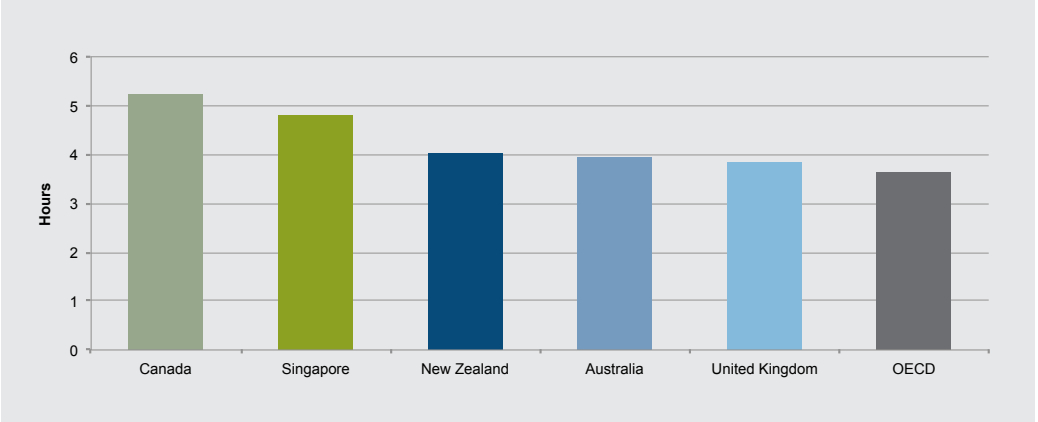
This section looks at how much time students spend learning maths in class and the opportunities they have to take part in extra-curricular lessons and activities offered at school.

How much time do students spend learning maths per week in the classroom?

Students in New Zealand spend, on average, four hours per week learning maths.

Figure 1 shows that New Zealand students spend more time learning maths in class than the OECD average, but students in Canada and Singapore spend more time learning maths than New Zealand students.

Figure 1: Average time spent learning maths per week



Has time spent learning maths changed since 2003?

Although the time spent learning maths in New Zealand has not changed since 2003, a relatively small increase of 13 minutes per week has occurred in the OECD average.

Is time spent learning maths linked to maths achievement?

Average time spent learning maths in the classroom per week is not strongly correlated with achievement in New Zealand, the OECD overall, or in any of the comparison countries, except for Singapore. This may suggest that improving maths achievement in New Zealand cannot be accomplished simply by scheduling more maths lessons.

Do students have the opportunity to engage in maths through additional classes and extra-curricular activities at school?

Principals indicated whether their school offers additional maths lessons (outside of normal class time, and for remedial or enhancement purposes, or both) and extra-curricular activities such as a maths club, a chess club, a club with a focus on computers and ICT, and maths competitions (see Appendix 4 for more information).

Figure 2 shows that over 70% of students in New Zealand attend schools where both remedial and enrichment maths lessons are offered.

Almost all students attend schools where they have the opportunity to participate in maths competitions. Close to 70 percent of students can belong to a chess club at school, and over 50 percent can take part in a computer/ICT club. A smaller percentage of students (25%) have the opportunity to attend a maths club at their school.

Figure 2: Proportion of New Zealand students who attend schools that offer additional maths lessons and extra-curricular maths activities

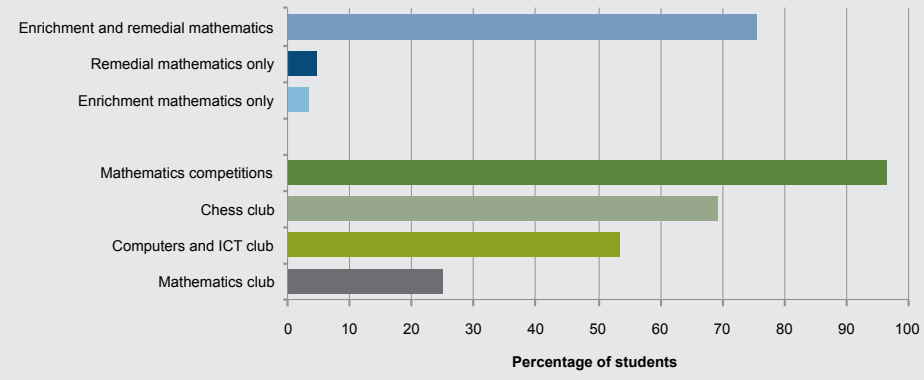
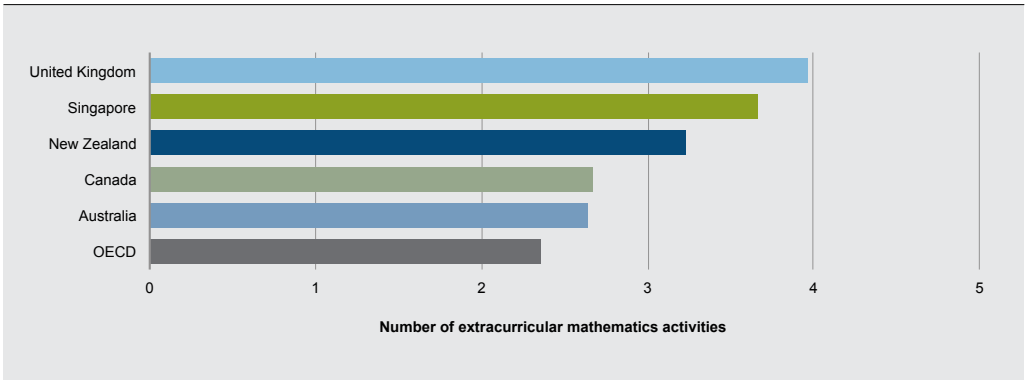


Figure 3 shows the index of extra-curricular maths activities, ranging from no activities to five activities. Schools in different countries tend to offer a different number of extra-curricular activities to their students. Students in New Zealand have more opportunities to participate in extra-curricular maths activities than students in the OECD, Australia and Canada. However, students in the United Kingdom and Singapore have more opportunities than New Zealand students.

Figure 3: Extra-curricular maths activities available at school



Note: The index of extra-curricular activities is calculated as the sum of the number of different maths activities and additional lessons schools offer out of normal class time, ranging from 0 (no activities) to 5 (five activities).

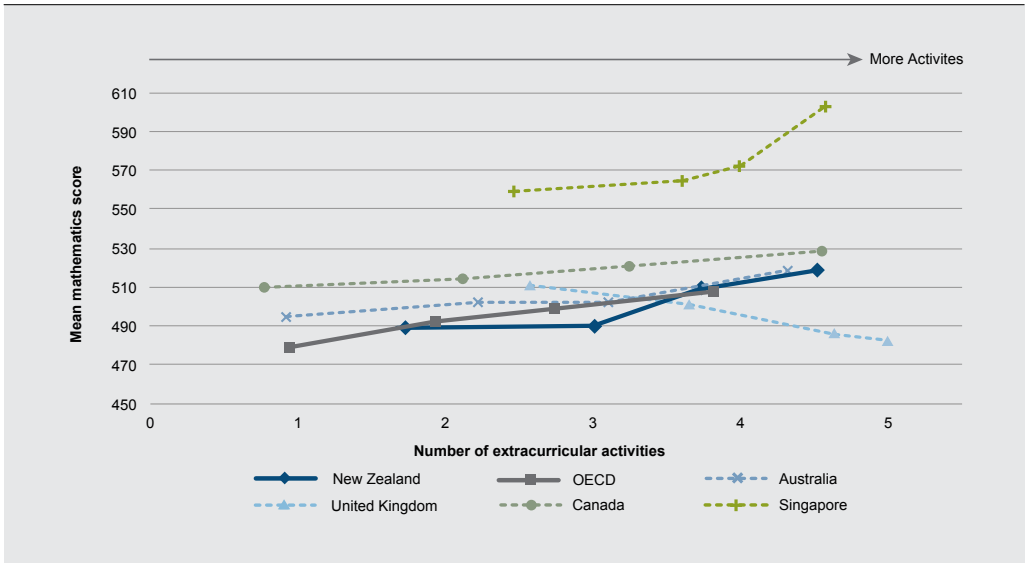
Is availability of extra-curricular maths activities at school linked to maths achievement?

Figure 4 shows that maths achievement tends to increase with the number of opportunities available to students.

An increase in student achievement is evident as schools offer more extra-curricular maths activities in New Zealand, the OECD, Australia, Canada and Singapore. This pattern is not observed in the United Kingdom, where the balance of activities offered may be driven by different student needs.

On average, New Zealand students with the most extra-curricular maths activities available achieve higher maths scores, with a 30-point difference between students in the top quarter of the index of extra-curricular activities and those in the bottom quarter of the index.

Figure 4: The link between availability of extra-curricular maths activities and maths achievement



Note: The index of extra-curricular activities is calculated as the sum of the number of different maths activities and additional lessons schools offer out of normal class time, ranging from 0 (no activities) to 5 (five activities). Maths achievement is plotted against national quarters of this index.

Covering different areas of maths

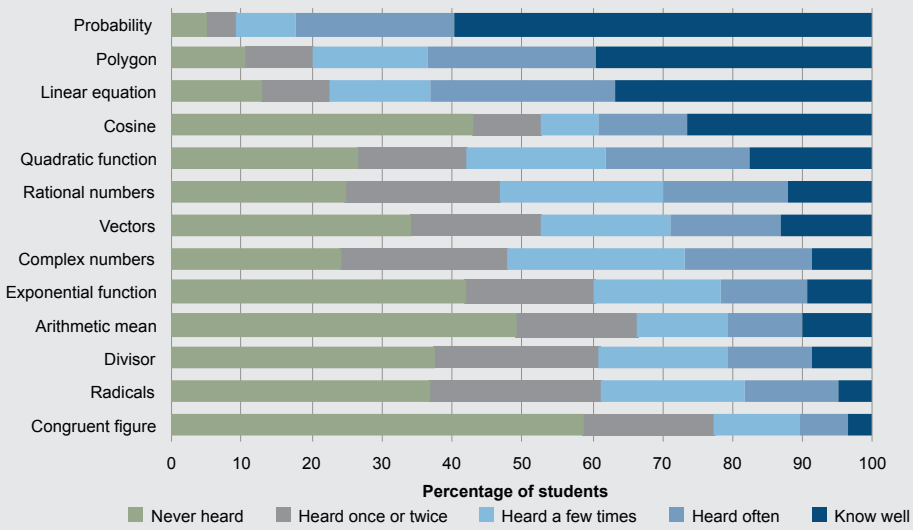
Within PISA, opportunities that students have to cover different areas of maths were measured through familiarity with mathematical concepts and exposure to formal maths problems.

How familiar are New Zealand students with different mathematical concepts?

Students were presented with a list of mathematical concepts and asked to indicate how familiar they are with each term. Responses represented a continuum of familiarity, beginning with 'never heard of it', through 'heard of it once or twice', 'heard of it a few times', 'heard of it often', and 'know it well, understand the concept'.

Figure 5 illustrates how familiar New Zealand students are with each mathematical concept.[8] Concepts such as probability, polygons and linear equations are among those a high percentage of New Zealand students are familiar with. In contrast, fewer students are familiar with divisors, radicals and congruent figures.

Figure 5: Familiarity of students with mathematical concepts



8 This measure is based on the specific terminology used for each concept. Students may actually be familiar with the concept but not be familiar with the terminology used in this question. For example, nearly 50 percent of students had never heard of the arithmetic mean, yet this concept is covered in Level 4 of the New Zealand maths curriculum.

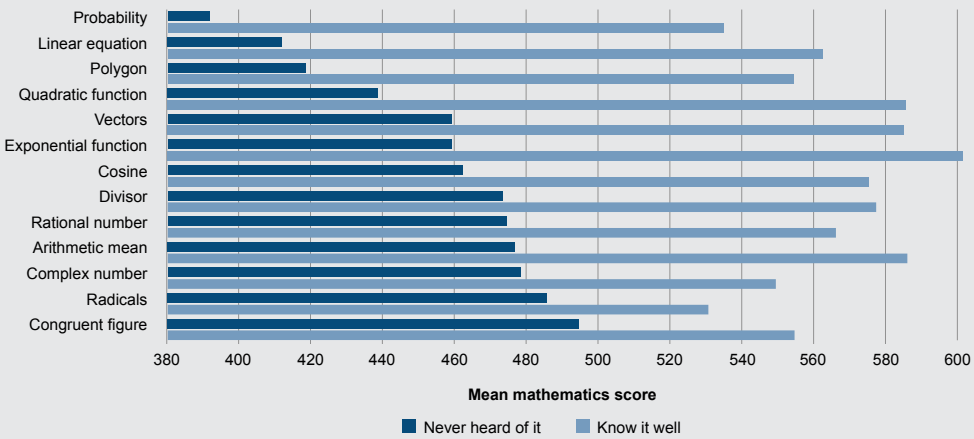
Is familiarity with mathematical concepts linked to maths achievement?

Figure 6 shows how the maths achievement of New Zealand students changes according to different levels of familiarity with mathematical concepts.[9]

Maths achievement in PISA was lowest for New Zealand students who never heard of concepts such as probability, linear equations and polygons. Maths achievement was highest among New Zealand students familiar with concepts such as exponential functions, arithmetic mean and quadratic functions.

Four different maths content categories were used in PISA 2012. Use of these four categories began in PISA 2003, when maths was first the major domain.[10] Among the four different maths content categories, New Zealand's highest average was for the uncertainty and data domain (506 points).[11] This is consistent with the finding that students are most familiar with probability – a concept key to uncertainty and data. Weaker achievement is evident in areas they are less familiar with, such as geometry (eg, polygons), assessed in the space and shape domain (491 points).

Figure 6: The link between familiarity with mathematical concepts and maths achievement among New Zealand students



Note: Average maths achievement in New Zealand was 500 points and in the OECD it was 494 points.

New Zealand students' maths scores were lower when they had never heard of probability. Students' maths achievement was highest when they knew exponential functions well.

9 For more information, see data presented in Table 6 (Appendix II), where increasing familiarity with mathematical concepts is linked to higher maths achievement.

10 The four maths content categories are uncertainty and data; quantity; change and relationships; and space and shape. A short description of these categories can be found in Appendix IV.

11 See the Ministry of Education's forthcoming *Spotlight on maths achievement* .

What is the level of student exposure to formal maths?

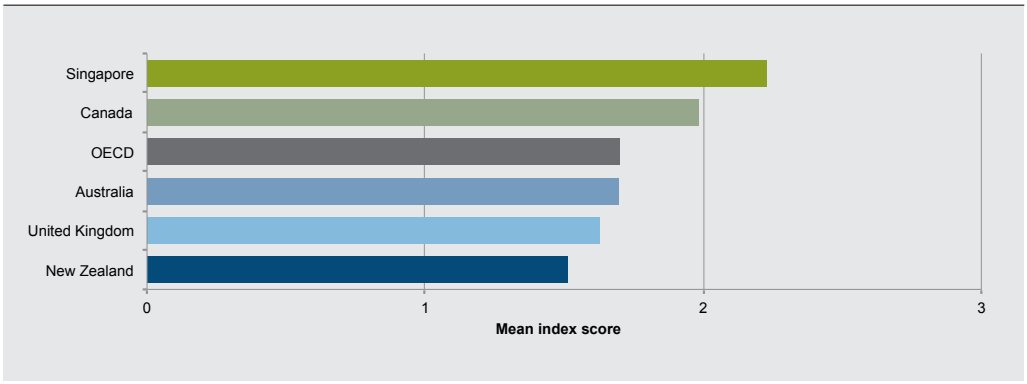
The index of exposure to formal maths, ranging from no exposure to frequent exposure, combines student responses about their familiarity with algebra and geometry concepts, and whether they had encountered specific formal maths problems at school (see Appendix 4 for more information).

Figure 7 shows that the average exposure of New Zealand students to formal maths is lower than that of the OECD average and all other comparison countries.

There is greater variability in exposure to formal maths within New Zealand than within the OECD overall. In other words, the opportunity to learn formal maths in New Zealand is more variable among students than in the OECD generally.

Most of the differences in exposure to formal maths are *within* schools. This means that students attending the same school report different levels of exposure to formal maths.

Figure 7: Students' average exposure to formal maths



Note: The formal maths index ranges from 0 (never encountered formal maths problems) to 3 (frequently encountered).

What factors contribute to explaining the differences in students' exposure to formal maths?

PISA created an index of economic, social and cultural status (ESCS), which is used as a measure of socio-economic status for students.[12] This index also compares the average ESCS of students in each school to the average ESCS of students in the system as a whole to distinguish between socio-economically advantaged, average and disadvantaged schools (see Appendix 4 for more information). As well as being able to compare schools within a country, this makes it possible to look at the performance of schools from an international perspective.

12 Low ESCS students are those in the bottom quarter of the PISA ESCS index within a country; high ESCS students are those in the top quarter of the index.

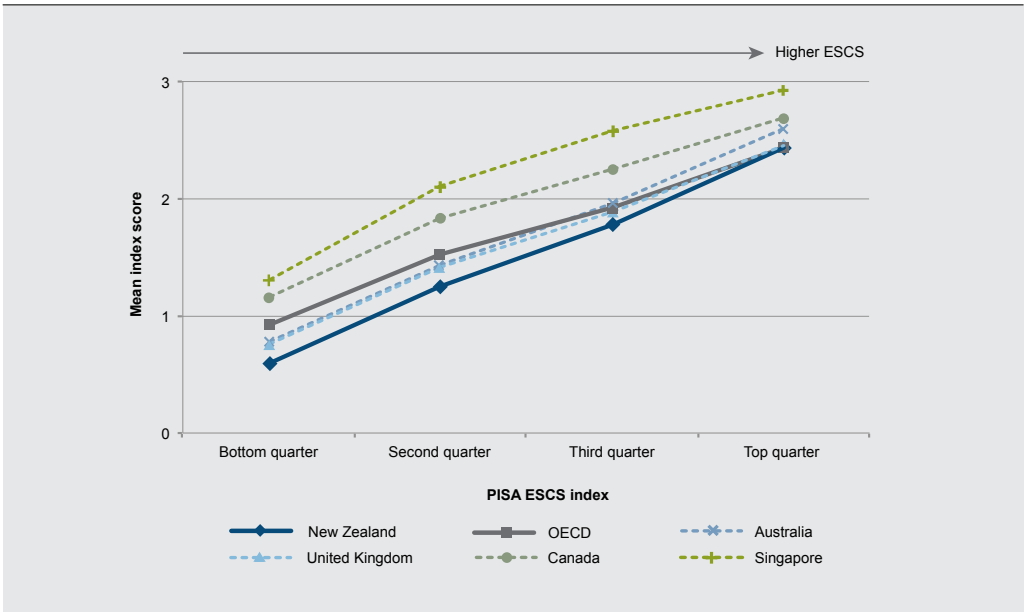
Both student ESCS and school socio-economic background can contribute to understanding student exposure to formal maths in New Zealand.[13]

Figure 8 maps student socio-economic status against the level of exposure those students have had to formal maths. In general, the level of exposure a student has to formal maths is strongly related to their socio-economic status. The higher a student's ESCS, the more likely they are to have a high level of exposure to formal maths. This relationship holds for all the comparison countries and the OECD overall. However, New Zealand has one of the largest differences in exposure to formal maths between low and high ESCS students: 1.85 index points, compared with the OECD average of 1.51 points.

Looking at the socio-economic status information for schools (as opposed to students), the same patterns are apparent. Students in socio-economically advantaged schools tend to have more exposure to formal maths than students in average schools, and students in these schools in turn have higher exposure to formal maths than students in disadvantaged schools. The difference between students in socio-economically advantaged and average schools (0.40 index points) is greater than the difference between students in average and disadvantaged schools (0.18 index points).

With regard to differences relating to school location (see Appendix 4 for definitions), students in town schools have higher exposure to formal maths than students in rural schools (a difference of 0.27 index points), and students in city schools have higher exposure than students in town schools and rural schools (differences of 0.27 and 0.53 index points, respectively). The difference between students in city and rural schools is notable.

Figure 8: The link between student economic, social and cultural status and exposure to formal maths



Note: The formal maths index ranges from 0 (never encountered formal maths problems) to 3 (frequently encountered).

13 Thirteen percent of the variance is explained.

Is exposure to formal maths linked to maths achievement?

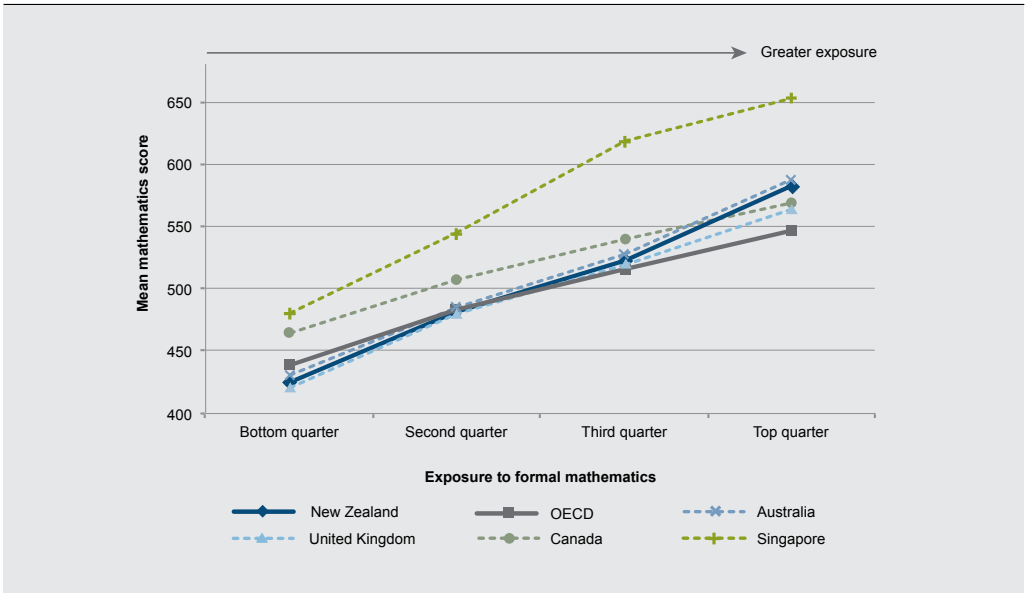
Figure 9 shows how maths achievement changes according to levels of exposure to formal maths. On average, New Zealand students with higher levels of exposure to formal maths achieved higher maths scores, with a 158-point difference between students in the highest quarter of the index of exposure to formal maths and those in the bottom quarter of the index.

New Zealand stood out among PISA participants for having one of the largest differences in achievement related to the level of exposure to formal maths.

A one-unit increase in the index of exposure to formal maths is related to an increase in maths achievement of 73 points among New Zealand students. The link between exposure to formal maths and achievement among students in the comparison countries is similar.

In New Zealand, student exposure to formal maths has a particularly strong relationship to maths achievement, more so than in the OECD overall (see Appendix 3).[14]

Figure 9: The link between exposure to formal maths and maths achievement



Note: The formal maths index ranges from 0 (never encountered formal maths problems) to 3 (frequently encountered). Maths achievement is plotted against national quarters of this index.

14 PISA 2012 examined opportunities to learn through two additional indices: exposure to word problems (formal maths calculations couched in a setting using words that fill out the problem) and exposure to applied maths. For PISA participants, both of these indices had a much weaker relationship with maths achievement than the index of formal maths [see OECD (2013), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I)*, PISA, OECD Publishing].

Summary

What can we say about opportunities to learn maths?

Student contact with maths

New Zealand students spend, on average, four hours per week learning maths. The time spent learning maths in New Zealand has not changed since 2003, though an increase of 13 minutes had occurred across the OECD by 2012. Students in Canada and Singapore spend more time learning maths than New Zealand students.

No significant relationship was found between the average time spent learning maths per week and maths achievement in New Zealand. The data suggest that simply scheduling more maths lessons will not by itself improve maths achievement, and that more attention needs to be given to other aspects of maths lessons, such as the exposure students are getting to different areas of maths.

Over two-thirds of students in New Zealand attend schools where both remedial and enrichment mathematical classes are offered; almost all students attend schools where they have the opportunity to participate in maths competitions; over two-thirds can be a part of a chess club at school; over half can be a part of a computer/ICT club; and fewer than one-quarter can attend a maths club at their school.

The opportunity for more student contact with maths in terms of the availability of additional maths lessons and extra-curricular maths activities is related to higher maths achievement among New Zealand students.

Covering different areas of maths

Opportunities to learn maths in the classroom, measured by student familiarity with mathematical concepts such as probability, and student exposure to formal maths problems are strongly linked to the maths achievement of New Zealand students.

Greater familiarity with mathematical concepts is linked to higher maths achievement, with a difference in achievement greater than 140 points between students who know concepts such as exponential functions and probability well and those who have never heard of these concepts.

New Zealand students are most familiar with probability, which is consistent with the finding that uncertainty and data had the highest average score (506 points) among the four maths content domains.

The range of exposure to formal maths problems is greater among students in New Zealand than in the OECD overall.

The higher a students' socio-economic status, the higher their exposure to formal maths. New Zealand stood out as having one of the largest differences in exposure to formal maths between students with low and high socio-economic status. Exposure to formal maths in New Zealand is highest among students from socio-economically advantaged schools and students in city schools.

Appendix 1: Maths achievement

Table A1.1: Mean maths achievement

	New Zealand		OECD	
Overall mean	500	(2.2)	494	(0.5)
Gender				
Boys	507	(3.2)	493	(1.3)
Girls	492	(2.9)	481	(1.2)
Student economic, social and cultural status (ESCS)				
Bottom quarter of ESCS index	445	(3.2)	452	(0.7)
Second quarter of ESCS index	493	(4.0)	482	(0.6)
Third quarter of ESCS index	514	(4.0)	506	(0.7)
Top quarter of ESCS index	559	(3.6)	542	(0.8)
School average socio-economic background				
Socio-economically disadvantaged schools	443	(4.9)	444	(0.9)
Socio-economically average schools	497	(4.4)	492	(0.7)
Socio-economically advantaged schools	558	(4.1)	548	(0.9)
School authority				
Public schools	496	(2.5)	489	(0.7)
Private schools	584	(6.1)	522	(1.7)
School location				
Rural schools	458	(6.1)	467	(2.5)
Town schools	492	(5.3)	492	(0.9)
City schools	513	(3.2)	502	(1.2)

Note: Standard errors are presented in parentheses. Results may appear inconsistent due to rounding.

See Appendix 4 for definitions of ESCS, school socio-economic background, school authority and school location.

Table A1.2: Distribution of students

	Percentage	
Gender	**New Zealand**	**OECD**
Boys	51	50
Girls	49	50
School average socio-economic background		
Socio-economically disadvantaged schools	22	26
Socio-economically average schools	55	47
Socio-economically advantaged schools	23	27
School authority		
Public schools	94	81
Private schools	6	19
School location		
Rural schools	6	11
Town schools	38	56
City schools	56	36

The following points summarise some of the differences in maths achievement occurring within New Zealand.

- → New Zealand's maths achievement is higher than the OECD average, but the spread in achievement is wider.
- → The variation in maths achievement evident within schools in New Zealand is more than the variation occurring between schools. This means that most New Zealand schools have both low- and high-achieving students. A similar pattern is evident in the OECD overall, but to a lesser extent.
- → In New Zealand, as in the OECD overall, the maths achievement of boys is higher than that of girls.
- → Student economic, social and cultural status (ESCS) is linked to maths achievement, as evidenced by students in the bottom, second, third and top quarters of the PISA ESCS index having progressively higher achievement scores. The same pattern is evident among students attending socio-economically disadvantaged, average and advantaged schools, and public and private schools.
- → The overall variance in student achievement accounted for by differences in student ESCS in New Zealand is 18%, compared to 15% in the OECD on average.
- → Socio-economic background contributes to explaining much of the difference in maths achievement between schools, but it contributes little in explaining the differences in maths achievement among students in the same school.
- → The achievement of students in town schools and city schools is higher than the achievement of students in rural schools in both New Zealand and the OECD overall, although differences are smaller once socio-economic background is taken into account.

Appendix 2: Tables for figures

Table A2.1: Average time spent learning maths per week

	Mean time (minutes)
Canada	**314** (2.8)
Singapore	**288** (1.3)
New Zealand	241 (2.0)
Australia	**236** (0.9)
United Kingdom	**230** (2.2)
OECD	**218** (0.4)

Note: Values significantly different from New Zealand are indicated in bold. Standard errors are presented in parentheses.

Source: OECD (2013), *PISA 2012 Results: What Makes Schools Successful? Resources, Policies and Practices (Volume IV)*, PISA, OECD Publishing.

Table A2.2a: New Zealand students who attend schools that offer additional maths lessons

Percentage of students		
Enrichment maths	**Remedial maths**	**Enrichment and remedial maths**
4 (1.9)	5 (1.6)	76 (3.9)

Note: Standard errors are presented in parentheses.

Source: OECD (2013), *PISA 2012 Results: What Makes Schools Successful? Resources, Policies and Practices (Volume IV)*, PISA, OECD Publishing.

Table A2.2b: New Zealand students who attend schools that offer extra-curricular maths activities

Percentage of students			
Maths club	**Computers and ICT club**	**Chess club**	**Maths competitions**
25 (3.8)	53 (4.0)	69 (4.0)	97 (1.2)

Note: Standard errors are presented in parentheses.

Source: OECD (2013), *PISA 2012 Results: What Makes Schools Successful? Resources, Policies and Practices (Volume IV)*, PISA, OECD Publishing.

Table A2.3: Extra-curricular maths activities available at school

	Mean index score	
United Kingdom	**3.96**	(0.07)
Singapore	**3.66**	(0.01)
New Zealand	3.23	(0.09)
Canada	**2.67**	(0.07)
Australia	**2.64**	(0.06)
OECD	**2.36**	(0.01)

Note: The index of extra-curricular activities is the sum of whether schools offer different maths activities and additional lessons out of normal class time, ranging from 0 (no activities) to 5 (five activities). Values significantly different from New Zealand are indicated in bold. Standard errors are presented in parentheses. Results may appear inconsistent due to rounding.

Source: OECD (2013), *PISA 2012 Results: What Makes Schools Successful? Resources, Policies and Practices (Volume IV)*, PISA, OECD Publishing.

Table A2.4: The link between availability of extra-curricular maths activities and maths achievement

	Mean index scores							
	Bottom quarter		**Second quarter**		**Third quarter**		**Top quarter**	
New Zealand	1.68	(0.17)	3.00	(0.02)	3.71	(0.16)	4.52	(0.14)
OECD	0.94	(0.02)	1.94	(0.02)	2.73	(0.02)	3.82	(0.02)
Australia	0.92	(0.06)	2.23	(0.11)	3.11	(0.08)	4.31	(0.04)
United Kingdom	2.57	(0.09)	3.65	(0.13)	4.63	(0.14)	5.00	(0.00)
Canada	0.77	(0.09)	2.11	(0.10)	3.25	(0.09)	4.55	(0.07)
Singapore	2.46	(0.03)	3.61	(0.02)	4.00	(0.00)	4.58	(0.01)
	Mean maths scores							
New Zealand	**489**	(5.6)	490	(7.1)	509	(6.9)	**519**	(7.7)
OECD	**479**	(1.2)	492	(1.1)	499	(1.0)	**507**	(1.1)
Australia	**495**	(3.4)	502	(3.5)	502	(3.5)	**519**	(4.1)
United Kingdom	**510**	(6.7)	501	(6.0)	486	(6.1)	**483**	(6.8)
Canada	**510**	(3.2)	514	(3.5)	521	(4.2)	**528**	(4.3)
Singapore	**559**	(3.3)	564	(3.9)	572	(3.6)	**603**	(2.8)

Note: The index of extra-curricular activities is the sum of whether schools offer different maths activities and additional lessons out of normal class time, ranging from 0 (no activities) to 5 (five activities). Maths achievement is presented for national quarters of this index. Top and bottom quarter values significantly different from each other are indicated in bold. Standard errors are presented in parentheses. Results may appear inconsistent due to rounding.

Source: OECD (2013), *PISA 2012 Results: What Makes Schools Successful? Resources, Policies and Practices (Volume IV)*, PISA, OECD Publishing.

Table A2.5: Familiarity of students with mathematical concepts

	Percentage of students									
	Never heard of it		Heard of it once or twice		Heard of it a few times		Heard of it often		Know it well	
Congruent figure	59	(1.1)	19	(0.8)	12	(0.7)	7	(0.5)	4	(0.4)
Radicals	37	(1.1)	24	(1.0)	21	(0.8)	13	(0.7)	5	(0.4)
Divisor	37	(1.1)	23	(0.8)	19	(0.8)	12	(0.7)	9	(0.6)
Arithmetic mean	49	(1.0)	17	(0.6)	13	(0.6)	11	(0.6)	10	(0.7)
Exponential function	42	(1.2)	18	(0.7)	18	(0.7)	12	(0.8)	10	(0.7)
Complex numbers	24	(0.9)	24	(1.1)	25	(0.9)	18	(0.8)	9	(0.6)
Vectors	34	(1.4)	19	(0.6)	19	(0.7)	16	(0.7)	13	(0.8)
Rational numbers	25	(0.9)	22	(0.8)	23	(0.9)	18	(0.7)	12	(0.8)
Quadratic function	27	(1.1)	15	(0.7)	20	(0.8)	21	(0.7)	18	(0.9)
Cosine	43	(1.1)	10	(0.6)	8	(0.5)	13	(0.7)	26	(1.2)
Linear equation	13	(0.9)	10	(0.6)	14	(0.7)	26	(0.8)	37	(1.2)
Polygon	10	(0.8)	10	(0.6)	16	(0.7)	24	(0.7)	39	(1.1)
Probability	5	(0.5)	4	(0.4)	8	(0.5)	23	(0.8)	60	(1.1)

Note: Standard errors are presented in parentheses. Results may appear inconsistent due to rounding.

Source: OECD (2013), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I)*, PISA, OECD Publishing.

Table A2.6: The link between familiarity with mathematical concepts and maths achievement among New Zealand students

	Mean maths scores									
	Never heard of it		Heard of it once or twice		Heard of it a few times		Heard of it often		Know it well	
Exponential function	**459**	(3.0)	503	(4.0)	525	(4.6)	548	(4.8)	**601**	(8.0)
Divisor	**473**	(3.3)	496	(4.0)	520	(5.6)	533	(5.1)	**577**	(9.3)
Quadratic function	**439**	(3.7)	477	(5.5)	509	(4.5)	533	(3.8)	**586**	(6.1)
Linear equation	**412**	(3.8)	439	(6.0)	469	(5.9)	510	(3.6)	**562**	(3.9)
Vectors	**459**	(3.5)	490	(4.6)	515	(4.6)	538	(5.2)	**585**	(8.8)
Complex numbers	**479**	(4.6)	492	(4.3)	513	(4.4)	517	(5.2)	**549**	(10.4)
Rational numbers	**475**	(4.5)	489	(4.0)	506	(3.6)	516	(4.9)	**566**	(8.8)
Radicals	**486**	(3.2)	502	(4.0)	519	(5.0)	521	(6.7)	**531**	(11.1)
Polygon	**419**	(4.8)	452	(6.4)	470	(4.6)	501	(3.7)	**555**	(3.8)
Congruent figure	**495**	(3.0)	508	(4.0)	521	(5.5)	513	(9.0)	**555**	(17.1)
Cosine	**462**	(3.2)	471	(4.9)	483	(8.0)	533	(5.4)	**575**	(5.4)
Arithmetic mean	**477**	(2.8)	504	(4.4)	514	(5.8)	537	(7.0)	**586**	(8.7)
Probability	**392**	(7.7)	419	(7.9)	440	(5.7)	485	(3.2)	**535**	(3.2)

Note: Significantly different maths achievement scores between students with weaker and stronger levels of familiarity are indicated in bold. Standard errors are presented in parentheses. Results may appear inconsistent due to rounding.

Source: OECD (2013), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I)*, PISA, OECD Publishing.

Table A2.7: Students' average exposure to formal maths

	Mean index score	
New Zealand	1.51	(0.02)
United Kingdom	**1.63**	(0.02)
Australia	**1.69**	(0.01)
OECD	**1.70**	(0.00)
Canada	**1.98**	(0.01)
Singapore	**2.23**	(0.01)

Note: The formal maths index ranges from 0 (never encountered formal maths problems) to 3 (frequently encountered).
Values significantly different from New Zealand are indicated in bold. Standard errors are presented in parentheses.
Results may appear inconsistent due to rounding.

Source: OECD (2013), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I)*, PISA, OECD Publishing.

Table A2.8: The link between student economic, social and cultural status and exposure to formal maths

	Mean index scores			
	Bottom quarter ESCS	**Second quarter ESCS**	**Third quarter ESCS**	**Top quarter ESCS**
New Zealand	**0.59** (0.02)	1.25 (0.02)	1.78 (0.02)	**2.44** (0.02)
OECD	**0.92** (0.00)	1.52 (0.00)	1.92 (0.00)	**2.43** (0.00)
Australia	**0.78** (0.01)	1.44 (0.02)	1.97 (0.02)	**2.59** (0.01)
United Kingdom	**0.76** (0.02)	1.41 (0.03)	1.90 (0.02)	**2.45** (0.02)
Canada	**1.16** (0.02)	1.83 (0.01)	2.25 (0.01)	**2.70** (0.01)
Singapore	**1.31** (0.02)	2.10 (0.02)	2.57 (0.01)	**2.92** (0.01)

Note: The formal maths index ranges from 0 (never encountered formal maths problems) to 3 (frequently encountered). Significant differences in exposure among students in the bottom and top ESCS quarters are indicated in bold.

Standard errors are presented in parentheses. Results may appear inconsistent due to rounding.

Source: OECD (2013), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I)*, PISA, OECD Publishing.

Table A2.9: The link between exposure to formal maths and maths achievement

	Mean index scores			
	Bottom quarter	**Second quarter**	**Third quarter**	**Top quarter**
New Zealand	**425** (3.3)	482 (4.2)	522 (4.0)	**583** (5.1)
OECD	**439** (0.7)	484 (0.8)	515 (0.7)	**547** (0.8)
Australia	**431** (1.9)	485 (2.6)	528 (2.7)	**587** (3.2)
United Kingdom	**421** (4.5)	479 (4.9)	519 (5.1)	**564** (4.1)
Canada	**464** (2.6)	507 (2.6)	540 (2.8)	**570** (2.8)
Singapore	**480** (3.1)	545 (3.6)	618 (3.4)	**652** (2.9)

Note: Significant differences between maths achievement scores of students in the bottom and top exposure quarters are indicated in bold. Standard errors are presented in parentheses. Results may appear inconsistent due to rounding.

Source: OECD (2013), *PISA 2012 Results: What Students Know and Can Do – Student Performance in Mathematics, Reading and Science (Volume I)*, PISA, OECD Publishing.

Appendix 3: Measuring the association between opportunities to learn and achievement

Table A3.1 gives measures of the association between learning environment factors that are significantly linked to maths achievement.[15] The first column gives the average difference between groups of students. For student familiarity with mathematical concepts this is given as the difference between "never heard" and "know well" and for the other factors the average difference between two students one unit apart on the index for a learning environment factor (change in achievement per unit of index)[16] is reported.

The second column is the percentage of variance in New Zealand maths scores explained by each learning environment factor.[17] This can be compared with the percentage of variance explained in the OECD (column 3) to provide an indication of whether the strength of the association in New Zealand is stronger or weaker than for other countries.

The percentage of variance explained is obtained from the results of a linear regression where maths achievement is the dependent variable. Another way of looking at the percentage explained is as a measure of how close data points are to the regression line – a high percentage means that data points are close to the line whereas a low percentage means that there is a large spread of achievement around the regression line. The slope of the regression line is given by the change in achievement per unit of index.

15 In this volume, time spent learning maths per week was not significantly linked to maths achievement.

16 As each PISA index is set to an OECD mean of 0 and standard deviation of 1, the magnitude of the change in achievement can be compared between two or more factors.

17 It is important to note that variance explained in this context is a measure of association only and does not imply that maths achievement is caused by the learning environment factor.

Table A3.1: Relationship between variables in Volume I and maths achievement

Relationship between variables in Volume I and maths achievement	Difference between groups
Greater student familiarity with mathematical concepts was related to *higher* maths achievement	Over 140-point difference between never heard vs. know well

Relationship between variables in Volume I and maths achievement[1]	Change in achievement per unit of index	Variance explained in New Zealand (%)	Variance explained in OECD (%)
Higher student contact with maths in terms of offering additional maths lessons and extra-curricular maths activities was related to *higher* maths achievement	Increase of 9 points	1.2	2.7
Greater exposure to formal maths problems was related to *higher* maths achievement	Increase of 73 points	36	23

[1] Measures of association from a univariate linear regression with maths achievement as the dependent variable.

Appendix 4: Definitions

Technical definitions

Average

Student performances in PISA are reported using means (a type of average) for groupings of students. In general, the mean of a set of scores is the sum of the scores divided by the number of scores, and it is referred to in this report as 'the average'. For PISA, as with other large-scale studies, the means for a country are adjusted slightly (in technical terms, 'weighted') to reflect the total population of 15-year-olds rather than just the sample.

The OECD average includes only the OECD countries: no non-OECD (partner) countries are included. The OECD average is the average of the means for the OECD countries.

Index points

Index points are values that New Zealand and other participating countries have on a particular index, which, unless otherwise stated, have been standardised to have an average of 0 and a standard deviation of 1 among OECD countries.

Points

The design of PISA allows for a large number of questions to be used in maths, but each student answers only a proportion of these questions. PISA employs techniques to enable population estimates of achievement to be produced for each country, even though a sample of students responded to differing selections of questions. These techniques result in scores that are on a scale with an average value of 500. Scores on this scale are referred to in this report as points. About two-thirds of students across OECD countries achieved between 400 and 600 points.

Standard error

Because of the technical nature of PISA, the calculation of statistics such as averages and proportions has some uncertainty due to (i) generalising from the sample to the total 15-year-old school population, and (ii) inferring each student's proficiency from their performance on a subset of items. The standard errors (usually given in brackets) provide a measure of this uncertainty. In general, we can be 95 percent confident that the true population value lies within an interval 1.96 standard errors either side of the given statistic.

Statistical significance

In order to determine whether there is a real difference between two scores, tests of statistical significance are conducted that take into account the error associated with means. In this report, comparisons are tested using the t statistic, with results reported at the 95 percent confidence level.

Variance

Variance is a measure of spread. A small total variance of the average score (calculated as the square of the standard deviation) highlights equity in outcomes, such that most students are achieving at levels close to the average. Large total variance highlights inequity, such that many students achieve at levels far from the average. It is useful to compare the variance in achievement among New Zealand students with the average OECD variance.

Definitions of variables in Volume I

Content categories in maths

The PISA 2012 maths domain measured four content categories: uncertainty and data (ie, statistics); quantity (ie, number and aspects of measurement); space and shape (ie, geometry and aspects of measurement); and change and relationships (ie, algebra). These content categories have been used in PISA since 2003, the first time maths was the major domain. The forthcoming Ministry of Education publication *Spotlight on maths achievement* examines student achievement in these categories.

Economic, social and cultural status (ESCS)

The PISA index of economic, social and cultural status (ESCS) was derived from the following three indices: highest occupational status of parents, highest educational level of parents in years of education, and home possessions (including books). In this report, low ESCS students are those in the bottom quarter of the PISA ESCS index within a country, and high ESCS students are those in the top quarter of the index.

Exposure to formal maths

The index of exposure to formal maths ranges from 0 to 3 points and is the average of three subscales:

- → familiarity with algebra, developed from students' responses to their level of familiarity with exponential functions, quadratic functions and linear equations (scaled from 0 to 4, beginning with 'never heard of it', 'heard of it once or twice', 'heard of it a few times', 'heard of it often', and 'know it well, understand the concept')
- → familiarity with geometry, encompassing student levels of familiarity with vectors, polygons, congruent figures and cosines (scaled as above)
- → two items measuring how often students had been confronted with problems defined as formal maths (eg, solving an algebraic equation or finding the volume of a box); students' responses ranged from never, coded as 0, progressing through rarely, sometimes and frequently, which were all coded as 1.

Extra-curricular maths activities

School principals were asked to report whether their school offers various extra-curricular activities to students in the grade containing the most 15-year-olds[18]. The index of extra-curricular maths activities at school is the sum of principals' responses to whether schools offer: a maths club, a chess club, maths competitions, a club with a focus on computers and ICT. There is also a separate question regarding the availability of additional maths lessons (for remedial only, for enhancement only, or for both remedial and enhancement).

Familiarity with mathematical concepts

Students were asked to indicate how familiar they were with certain formal maths content, including such topics as quadratic functions, radicals and the cosine of an angle. Having heard of a topic more often was assumed to reflect a greater opportunity to learn maths.

18 In New Zealand this is year 11

Mathematical literacy

This refers to an individual's capacity to formulate, employ and interpret maths in a variety of contexts. It includes reasoning mathematically and using mathematical concepts, procedures, facts and tools to describe, explain and predict phenomena. It assists individuals to recognise the role that maths plays in the world, and to make the well-founded judgements and decisions needed by constructive, engaged and reflective citizens.

Maths learning time in additional classes

Students were asked to report the number of hours they typically spend per week attending after-school lessons in maths. These are lessons that may be given at their school, at their home or at an alternative location.

Maths learning time in regular school lessons

Students reported the average number of minutes per class period and the number of class periods per week for maths.

Opportunity to learn

PISA measures students' opportunity to learn maths by looking at their exposure to certain mathematical problems and their familiarity with mathematical concepts. Opportunities to learn may differ across students and schools for many reasons. If the school system channels students into different schools that distinguish, for example, between academic and vocational pathways, students' exposure to maths may vary correspondingly, depending on the schools they attend.

Exposure to different mathematical concepts and experience with mathematical problems may also differ among students within a particular school, especially when students are grouped by ability and taught different material. Instructional content and delivery may also differ within a school if 15-year-old students are enrolled in different grades within the same school, or if students choose different programme strands.

School authority

Schools are classified as either public or private according to whether a private entity or a public agency has the ultimate power to make decisions concerning its affairs. In New Zealand, public schools are also known as state and state-integrated schools. Private schools are also known as independent schools.

School location

- → Rural schools are those in areas with less than 3,000 inhabitants.
- → Town schools are those in urban areas of 3,000 to about 100,000 inhabitants.
- → City schools are those in major urban areas with over 100,000 inhabitants.

Socio-economically advantaged, average and disadvantaged schools

- → Socio-economically advantaged schools: the average socio-economic status of 15-year-old students is more advantaged than the average socio-economic status of students in the system as a whole.
- → Socio-economically average schools: the average socio-economic status of 15-year-old students is not statistically different from the average socio-economic status of students in the system as a whole.
- → Socio-economically disadvantaged schools: the average socio-economic status of 15-year-old students is more disadvantaged than the average socio-economic status of students in the system as a whole.

List of countries and economies participating in **PISA 2012**


Albania*

Austria

Bulgaria*

Chinese Taipei*

Croatia*

Denmark

France

Hong Kong-China*

Indonesia*

Italy

Kazakhstan*

Liechtenstein*

Macao-China*

Montenegro*

Norway

Portugal

Russian Federation*

Singapore*

Spain

Thailand*

United Arab Emirates*

Uruguay*


Argentina*

Belgium

Canada

Colombia*

Cyprus*

Estonia

Germany

Hungary

Ireland

Japan

Korea

Lithuania*

Malaysia*

Netherlands

Peru*

Qatar*

Serbia*

Slovak Republic

Sweden

Tunisia*

United Kingdom

Viet Nam*

Australia

Brazil*

Chile

Costa Rica*

Czech Republic

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Greece

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