NZIER INSIGHT

98-2021

The big subtract: Why do we care about maths and our declining maths skills?

School maths performance is declining

New Zealand's school maths scores are, by international standards, bad. Bad enough for the Ministry of Education to commission an investigation by a Panel at the Royal Society Te Apārangi, who recently published their findings. The Panel cite New Zealand's National Monitoring Study of Student Achievement (NMSSA), as well as two main international studies on student performance; Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). While the TIMSS focuses on how well students grasp topics of pure maths (like algebra and geometry), PISA focuses on mathematical *literacy*, which is how well students can apply mathematical thinking to understanding and solving problems in a real-world context. Figure 1 explains some of the key differences between the TIMSS and PISA. While both are measured on a scale where 500 is the international average, the scales are based on a different group of participating countries, so they cannot be directly compared.

Figure 2 shows how our PISA maths scores have declined dramatically since 2003, compared to a relatively stable OECD average, while Figure 3 is a snapshot of the TIMSS maths score in 2019 and our international positioning. People tend to compare New Zealand's performance to other OECD countries, as they have similar economic structures, so we highlight the OECD members in the TIMSS results. By TIMSS benchmarks, our top 75th percentile averages at "intermediate" level (475–550) and our bottom 25th at the "low" level (400–475).

In this Insight, we explore why it matters that our top 75th percentile and bottom 25th percentile are under-performing internationally and the consequences for both the people left behind and the New Zealand economy as a whole.

Figure 1 Comparing PISA and TIMSS

PISA asks 15-year-olds how well they can apply understandings and skills to everyday situations. For example, are they able to:

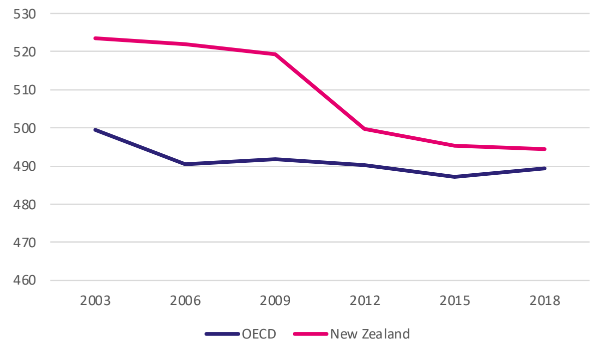
- Read tables and graphs in newspapers?
- Perform currency conversions?

TIMSS looks at how well Year 5 and Year 9 students have mastered the factual and procedural knowledge taught in school curricula. For example, do students know:

- What the angles of a triangle sum to?
- How to convert 7/10 to a decimal?
- What congruent triangles are?

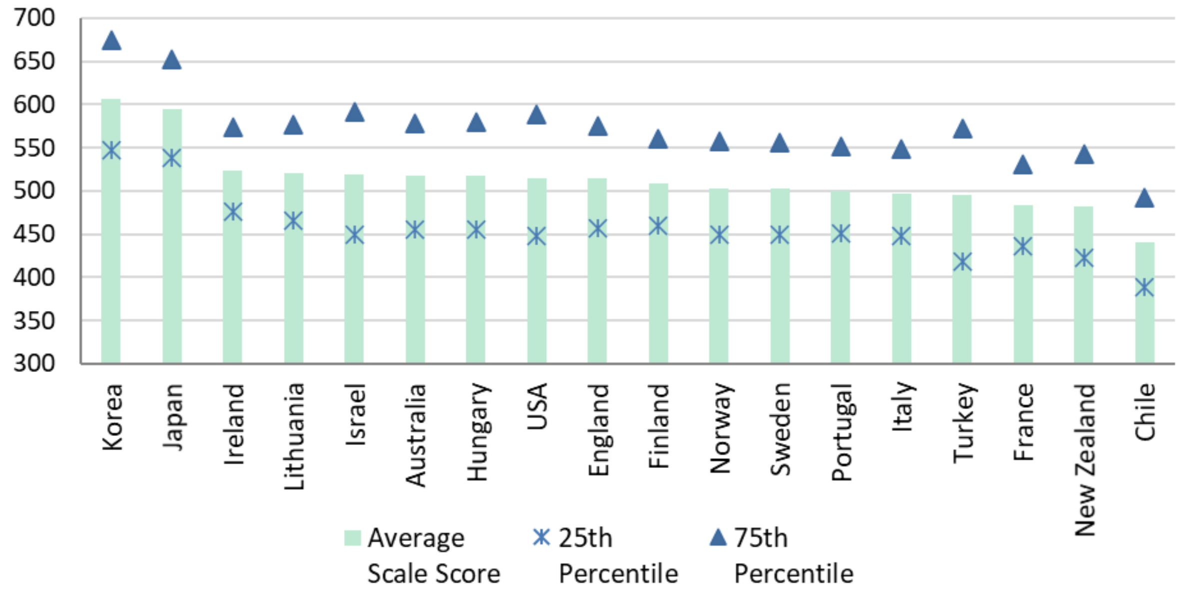
Source: NZIER, adapted from ACER (2015)

Figure 2 Average PISA maths scores



Source: PISA Data Explorer

Figure 3 TIMSS 2019: Average Year 9 maths performance



Source: TIMSS Data Explorer

Why do we care about maths?

Maths improves outcomes for people

First, maths is linked to money. People with good high school maths education are likely to earn more ten years later, with students who take more advanced courses seeing bigger wage premiums (Rose and Betts 2004). An Australian study shows that people with higher literacy and numeracy skills have a higher likelihood of employment and higher wages (Shomos and Forbes 2014).

Maths is effective at increasing wages because it opens doors to a wider range of high-paid career options, like engineering, computer science, medicine (and economics). We can call these STEM disciplines.[1] Kohen and Nitzan (2021) look at the decision to study high school maths as a predictor for Israeli student outcomes. The authors find that choosing a more advanced mathematics level in high school is the best predictor for completing and succeeding in a STEM bachelor's degree and making a STEM career choice. In a way, school maths education is like a gatekeeper for a broad range of further education and professional options – many of which are among those well rewarded in New Zealand.[2]

On the other side, unequal access to maths education can worsen inequality. Schmidt et al. (2015) use PISA results to investigate how maths performance depends on opportunities to learn, which includes curriculum quality, time spent learning, and academic standards. The authors find that opportunities to learn are a key driver in explaining the relationship between socioeconomic status and student outcomes. This is why we care about the bottom 25th percentile of students because averaging at the "low" benchmark puts those students at risk of missing out on the life-long earnings and career benefits of maths.

People who are not directly using maths in the workplace also benefit from a good grasp of

[1] STEM stands for science, technology, engineering and mathematics. Attracting students into these subjects is a priority for governments worldwide, given their importance for driving innovation, productivity and wellbeing.

[2] New Zealand research shows that three years after degree graduation, relative wages more than double for STEM graduates and rise by about 50% for non-STEM graduates (Maré et al. 2017).

maths. Maths makes us better critical thinkers (Aizikovitsh-Udi and Cheng 2015) no matter what career we choose. Maths can help us apply frameworks to how we think, recognise patterns, and make better sense of the world. When people have a poor grasp of maths, they are more likely to be fooled by probability traps (like gambling) or be persuaded by misinformation, as we are now seeing in the context of COVID-19 (Surowiecki 2021). Being able to speak the 'universal language' of maths has benefits for everyone.

Maths improves outcomes for New Zealand

There is a gap in the public narrative about the value of mathematics to the economy. While the economic contribution of maths has not been measured in New Zealand, research from the UK suggests large benefits (Deloitte 2013). At the national level, a mathematically minded workforce is crucial for driving technological innovation. Maths education helps us stay on top of the cutting edge and increase New Zealand's productivity (producing more outputs with fewer inputs). Greater productivity can mean fewer work hours, higher wages, and higher wellbeing – so overall, maths can make us happier.

One of the reasons we care about STEM subjects, in particular, is that they drive innovation. Innovation is the improvement of existing products or services, or the creation of entirely new ones, and is key to long-run economic growth, competitiveness, and quality of life improvements. The benefits of innovation are experienced by all of us, not just those working in the sector. Research in the United States finds that the innovative use of information technologies accounted for half the nationwide productivity growth over fifteen years (Atkinson and McKay 2007).

Innovation also leads to higher overall employment, higher paid jobs, and improved healthcare. Innovation in science and technology relies on a workforce educated in STEM, and each STEM subject has a component of maths (Atkinson and Mayo 2010). This is why we care about the top 75th percentile scores as the group most likely to pursue STEM careers. If this group is averaging at the "intermediate" level, we may not be developing the top skills we need for an innovative future workforce.

Maths education can also affect the skills we need to import. Prominent on the long-term skills shortage list are scientists, engineers, and health professionals, all typically requiring high school maths as a first step. If we had more New Zealanders developing a passion for maths in their school years, we might eventually be able to cross some professions off the shortage list.

These reasons are amongst the many that led the government to commission a Royal Society Te Apārangi expert panel investigation. While the scope focused on New Zealand's maths curriculum, the Panel quickly discovered there are many complex factors at play and made more comprehensive recommendations.

Who is in the top and bottom of the distribution?

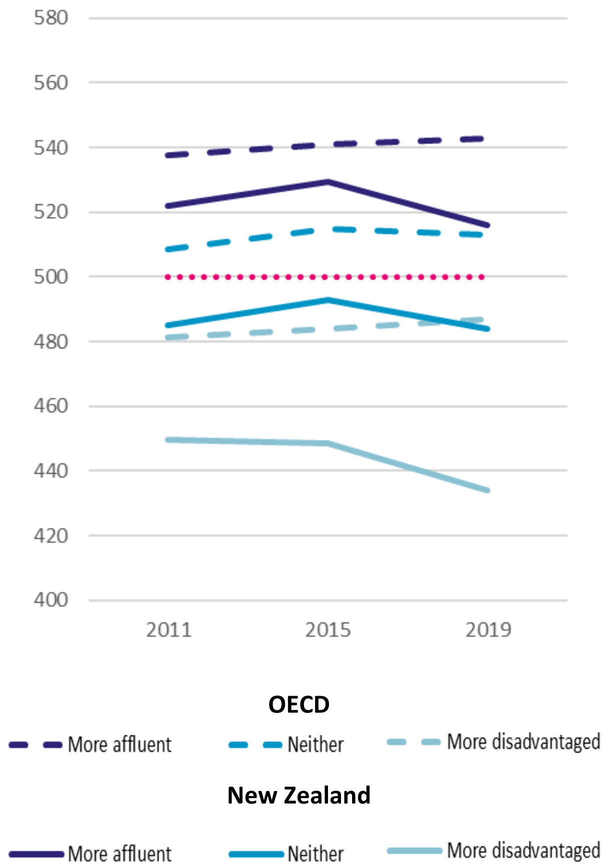
We know that the maths performance for the top and bottom of the distribution are important, but the policy implications will depend on who falls into these groups. The TIMSS data lets us compare maths scores by school 'affluence'. This groups students into three categories:

- 'More affluent': schools where more than 25% of students came from economically affluent homes, and not more than 25% from disadvantaged homes.
- 'More disadvantaged': schools where more than 25% of students came from disadvantaged homes, and not more than 25% from economically affluent homes.
- 'Neither': everything else.

In 2019, 38% of students attended more affluent schools, 19% more disadvantaged, and 43% neither. OECD countries have the same percentage at affluent schools, but 29% at more disadvantaged schools. This data on school affluence is reported by school principals, who may not all have had access to good quality data on household affluence. Figure 4 shows performance for these three groups for the past three TIMSS, for OECD countries (dashed lines) and New Zealand (solid lines).

OECD performance has stayed relatively consistent over time, with only the more disadvantaged schools below the baseline. However, New Zealand has lower scores for all groups and declines across the board between 2015 and 2019. The drops are similar across the more affluent (13 points) and the more disadvantaged (15 points), but the decline in scores for the more disadvantaged schools is proportionally greater, and they were further from their OECD peers, to begin with.

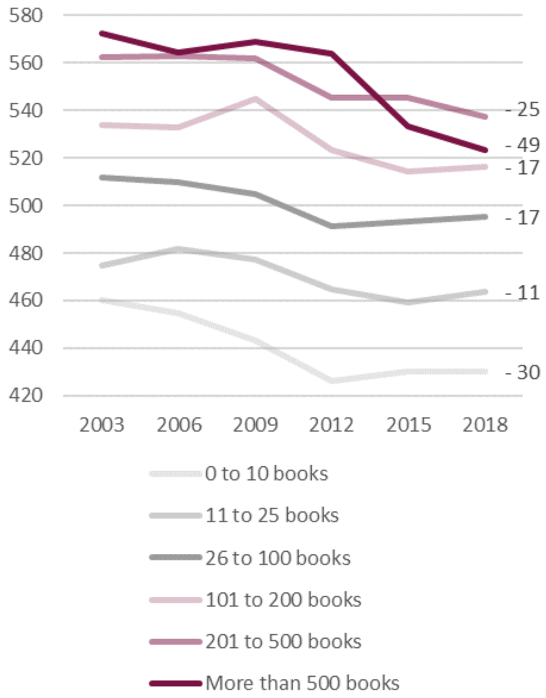
Figure 4 TIMSS Year 9 maths score by school affluence – NZ vs OECD



Source: TIMSS Data Explorer

We can also use the PISA data to understand how students differently experience declining scores. Figure 5 shows maths scores over time by one of PISA's socioeconomic indicators; number of books in the home. The numbers on the right of the graph show average score change between 2003 and 2018. While all groups experience falling scores, the declines are most acutely seen at the top and bottom of the distribution, with students in households with over 500 books falling by 49 points (or 8.6%) and those with ten and under books falling by 30 points (or 6.5%).

Figure 5 PISA maths score in New Zealand by number of books in the home



Source: PISA Data Explorer

What to make of all this?

By international standards, New Zealand is clearly performing poorly. Only those attending the most affluent schools are close to the OECD mean, and even for them, there is a clear downward trend.

School affluence data indicates that while similarly declining scores are seen across all types of schools in New Zealand, the size of the decline is proportionally bigger for students from the least affluent schools, making the gap between the least affluent schools here and their equivalents across the OECD increasingly alarming. This is particularly relevant in light of the COVID pandemic, in which schools were forced to rely on digital devices for continued learning, excluding those without access. But the steep decline for students with the most books in the home is also a problem, reducing the skills of the high performers we need to drive innovation and technological change.

Overall, the data shows us that maths performance is a problem across the board, with many of our students not accessing the benefits to be gleaned from a good maths education, and the country as a whole is on a trajectory to miss out on the innovation benefits that come with a skilled STEM workforce. In NZIER Insight 99,[3] we will look at the potential for policy response and how we might reverse the decline.

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This Insight was written by Olivia Wills and Sarah Hogan at NZIER, September 2021
For further information please contact
Olivia.Wills@nzier.org.nz or 027 288 6623
NZIER | (04) 472 1880 | econ@nzier.org.nz | PO Box 3479 Wellington

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[3] The big subtract: Can we improve our maths performance?