112-2024

Fit for purpose: Teachers' own learning experiences and lessons about standardisation from the health sector

- **New Zealand's education sector is in crisis, with over twenty years of increasing concerns about students' performance on international assessments as well as claims of dropping standards in national assessments.**
- **Education is key to New Zealand's future productivity, and a major focus area of previous governments has been maths and science. Delivering high quality education depends on the quality of the workforce.**
- **Our Integrated Data Infrastructure (IDI) research suggests that when it comes to primary school teachers, the education sector could learn some lessons from the health sector to address potential quality gaps and reduce unwarranted variation.**

In 2022, the government funded schools to the tune of nearly $8 billion (Education Counts 2023b). This high level of public spending justifies an in-depth investigation into the value that our education system provides and what can be done to improve it.

Serious concerns about low quality and the need for improvements in the education sector to lift worker productivity and incomes have been common for at least 20 years (see, for example, Carlaw (2002)). However, despite the well-accepted relationship with productivity, any efforts made to address the problem have not paid off:

Major international assessments of maths and science learning (the PISA, the TIMSS, and the PIRLS)[1] have shown that New Zealand's school students have been floundering.

Looking at PISA data alone, it is clear that between 2000 and 2022, the average maths and science scores of New Zealand 15-year-olds have declined (OECD 2023).

While the OECD average has also declined, New Zealand students' performance has declined at a faster rate, closing the gap between our performance and the average performance across the OECD.

"I would honestly say a generation of New Zealanders has been failed"

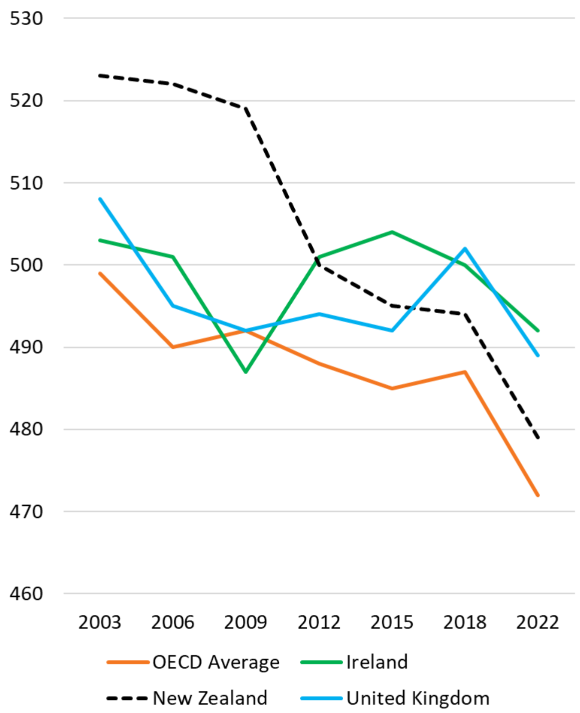
Distinguished Professor Gaven Martin, Royal Society Te Apārangi Expert Advisory Panel on Mathematics and Statistics 2021

New Zealand has also lost its enviable position, significantly above comparator countries Ireland and the UK, and now places below both countries (see Figure 1).

1 PISA is the OECD's Programme for International Student Assessment. PISA measures 15-year-olds' ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges. TIMSS and PIRLS are international assessments that monitor trends in student achievement in mathematics, science, and reading.

Figure 1 PISA mathematics results

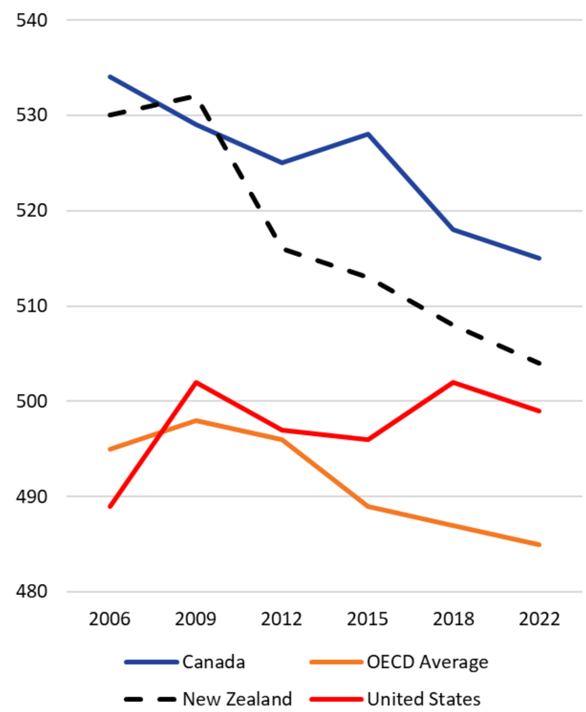
New Zealand, Ireland, the UK, and the OECD average



Source: NZIER, data from PISA data explorer.oecd.org

Figure 2 PISA science results

New Zealand, Canada, the US and the OECD average



Source: NZIER, data from PISA data explorer.oecd.org

In science (see Figure 2), we see a similar story:

- a significant decline in New Zealand students' scores
- a faster decline in New Zealand than the OECD average
- a significant decline in the performance of New Zealand students relative to comparator countries Canada and the US, which either experienced a slower rate of decline or improved performance over the same time period.

In addition to these and other international assessments pointing to declining performance, a stream of recent reports have pointed to a crisis at a system level: high rates of truancy, the worst classroom behaviour in the OECD, the second highest rate of school bullying, and chronic teacher shortages.

The Royal Society Te Apārangi Expert Advisory Panel on Mathematics and Statistics was brought together in 2021 to advise the Ministry of Education on the English-medium Mathematics and Statistics curriculum. The Panel's review of the evidence showed long term decline or low levels of maths achievement across a wide range of measures, expressed concerns about "slippage" in learning away from the intended trajectory of the national curriculum and the lack of teachers' disciplinary and pedagogical knowledge, and called for change at virtually all levels of the system (Royal Society Te Apārangi Expert Advisory Panel 2021).

The new government has put forward some solutions

The new National-led government is concerned about our slipping performance in education. With a focus on 'the basics' of maths, reading and writing, the government has proposed some solutions, including:

- introducing a new national curriculum with much more detail on specific knowledge and skills that must be covered at each year level, along with materials to support teachers in delivering it
- banning the use of mobile phones in classrooms to reduce distractions
- requiring all primary (including intermediate) students to receive one hour of maths, reading and writing per day.

The 'aspirational' target set by the government is for 80 percent of students to be at the expected curriculum level by the time they are ready to move on to secondary school (from the current 50 percent (Education Review Office 2024)).

But are primary school teachers ready and able to deliver more and better maths learning?

Effective implementation of education improvements depends on teachers' ability and willingness to support them. If primary teachers do more maths with their students, and if students are to achieve at higher levels, teachers' own knowledge and skills need to support higher level learning. Additionally, teachers' attitudes towards maths must support students to succeed at higher levels.

Teacher knowledge is critical to quality education. This has been shown in a broad range of studies (for example, Pournara et al. 2015; Anthony and Walshaw 2009; Loewenberg Ball, Thames, and Phelps 2008).

Currently, most of a primary school teacher's subject area knowledge and skills (as opposed to pedagogical knowledge) comes from their own primary and secondary education, which – if experiences have been less than ideal – may leave them with low subject knowledge, low enthusiasm for the subject (e.g. a belief that the subject is boring, not useful, or difficult), and low confidence to teach it. These outcomes impact on the quality of teaching through reduced pedagogical effectiveness and low expectations of students.

Previous research indicates that maths is an area of weakness for primary teachers

Previous research has already shown that many pre-service primary teachers have weak knowledge of mathematics (see, for example, Young-Loveridge, Bicknell, and Mills (2012) and Whyte (2022)).

But does this weakness just reflect a need for a quick refresher due to pre-service teachers having forgotten what they had learned a few years earlier? Or does it reflect a significant knowledge gap from never having learned the material in the first place and the negative experiences of facing learning challenges that may not be easily overcome?

The answer to these questions is critical to designing a solution. For example, it may be possible to integrate a refresher course into teacher training programmes, but overcoming significant gaps in their earlier learning may be more than can be achieved within a three-year degree programme.

We analysed IDI data to understand the engagement and achievement of aspiring primary teachers

One way to better understand teachers' skills, capabilities and attitudes in specific subject areas is to examine their own learning experiences and achievements.

Stats NZ's IDI allows us to do exactly that – linking anonymised data on employment to education records for people who become primary school teachers.

While looking at teachers' experiences of maths, we also explored their experiences of science.

While this is not a focus area of the new government at this stage, the benefits of investment in STEM education depend on the pipeline of school students with a solid foundation in sciences as well as maths.

Our key research questions were:

- How much did recently trained primary school teachers engage with maths and sciences at secondary school? We take this as an indicator of enthusiasm and confidence in the subject matter. If you love maths and science, surely you continue to study them when they become optional subjects (at NCEA Levels 2 and 3)
- What level of achievement did primary school teachers have in maths and sciences when they did study them in secondary school? A low level of achievement raises questions about teaching competence, confidence, and enthusiasm, which may also be confirmed by a lack of engagement with maths and science when those subjects become optional.
- If there is wide variation in indicators of teacher quality, are there related patterns in the types of schools where primary teachers gain their first employment? Do these patterns have implications for equity and efficiency?

To interpret results, we compare achievement and engagement in NCEA maths and science to NCEA English.

We focused on the recent cohort of primary teachers who followed the most common pathway to becoming primary teachers.

New Zealand's secondary education system has changed over time, with the introduction of NCEA in the early 2000s being a notable milestone. This means that teachers who completed their secondary education before NCEA cannot be readily compared with those who went through NCEA.

Our focus on NCEA means that we exclude older teachers. According to Education Counts, in 2022, 83 percent of first-time domestic primary ITE students were aged under 35, so new primary teachers who were too old to have had any contact with NCEA are a minority of all teachers (Education Counts 2023a).

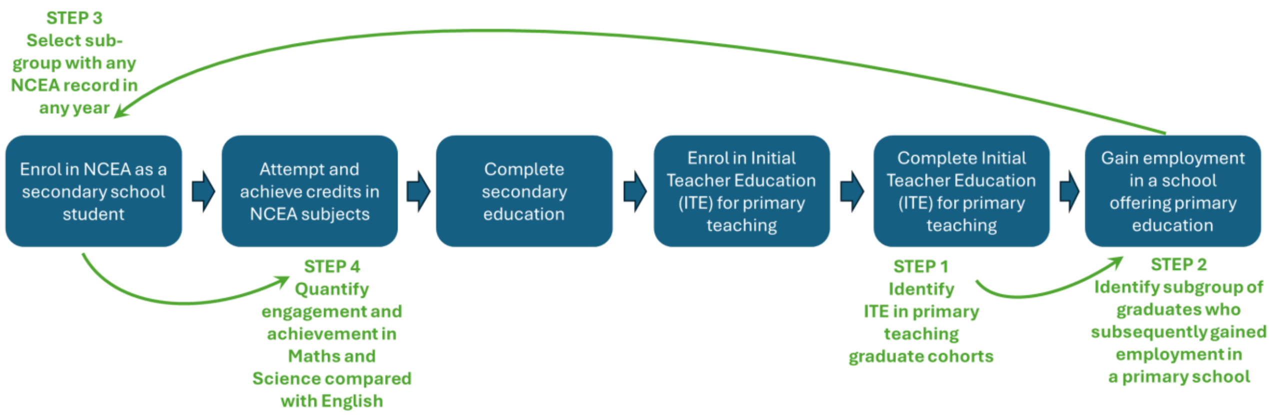
Restricting our analysis to NCEA also means that we excluded teachers who completed secondary school overseas or who studied through an alternative system offered in New Zealand, such as the International Baccalaureate or Cambridge.

However, despite these exclusions, NCEA has been the primary system for assessing secondary students' (and, therefore, most of the recent cohort of teachers') achievements since it was introduced.

We restricted our sample to teachers who gained employment after completing ITE primary, the most common route to primary school teaching. According to Education Counts, in 2022, 90 percent of primary ITE graduates graduated from universities. However, we also included in our sample primary ITE qualifications offered by Te Pukenga, Colleges of Education, Wānanga and private training establishments (Education Counts 2023a).

As shown in Figure 3 below, our method involved tracing forwards and backwards through the data.

Figure 3 Tracing methodology



Source: NZIER

Table 1 School types used to define a sample of primary school teachers

School type	Years	Included
Contributing	1-6	Yes
Full primary	1-8	Yes
Intermediate	7-8	Yes
Composite	1-10	Yes
	1-15	Yes
Restricted composite	7-10	Yes
Secondary	7-10	Yes
	7-15	Yes
	11-15	No
Correspondence		No
Special school		No
Teen parent unit		No
Activity Centre		No

Source: Education Counts, n.d.

We found that teachers show a high rate of disengagement from maths and sciences across NCEA levels

Overall, the level of engagement, as measured by attempts to gain credits in any of the subjects we analysed, shows very little difference at Level 1: Approximately three-quarters of new teachers with any NCEA record had attempted to gain credits in maths (we counted any credits in a maths or statistics achievement standard) and English at Level 1 and slightly fewer had attempted credits in science (either general science or specific science).[2]

Both maths and science[3] see a drop in engagement at Levels 2 and 3 that is not matched by a drop in engagement in English. Continued engagement with English may be due to most schools making English compulsory at Level 2, but schools typically do not restrict students from engaging with maths and science at Level 2, so the absolute level of disengagement with maths and science is likely student choice. By Level 3, while more than half of primary teachers continued to engage with English as a subject, less than 40 percent continued to engage with

2 Because of our methods, we would expect engagement to be less than 100 percent even for compulsory subjects in any given year as some students may not have a full 3 years of NCEA records. For this reason, it is the differences in engagement between subjects and the change in engagement over time that provide the valuable insights.

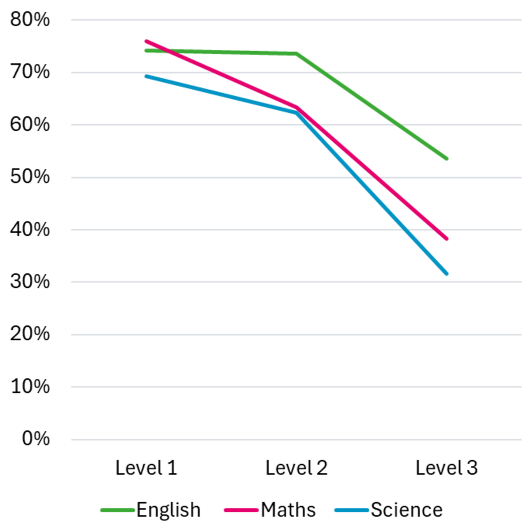
3 We combined general science and the three core sciences (biology, chemistry and physics) to calculate results for science.

maths, and less than a third continued with science.

The engagement gap between English (clearly the most popular of the three subjects) and science (the least popular) grows from five percentage points at Level 1 to 12 percentage points at Level 2 to 22 percentage points at Level 3.

Looking only at the Level 2 to Level 3 engagement rates (removing any effect of school requirements to undertake certain subjects), the rate of disengagement in English between Level 2 and Level 3 remains lower than the rate of disengagement from maths and science.

Figure 4 Engagement with English, maths and science across NCEA Levels 1–3



Note: Maths includes mathematics and statistics achievement standards. Science includes general science and the core sciences (biology, chemistry and physics).

Source: NZIER, IDI data

Engagement with maths and science through NCEA may not be an accurate indicator of *absolute* interest and enthusiasm. Some students may drop maths and science not out of any dislike for these subjects but simply to be able to pursue other subjects instead, although this does say something about *relative* interest and enthusiasm. In other cases, students may drop maths and science due to a perception that they have 'done enough' of these subjects for the career they wish to pursue. In those cases, we can at least still be reasonably certain that a love for the subjects was not there.

Extending the analysis to actual results broadens the picture and helps to provide some understanding of why these students disengaged from maths and science at such a high rate.

Achievement rates at Level 1 reveal that while maths has proved more challenging than English for primary teachers, science is the weakest subject

At Level 1, among teachers who at least had attempted to gain credits in any of English, maths or science, significant percentages failed to gain an Achieved level endorsement (the NCEA equivalent of a subject pass)[4].

The failure rate in English is the lowest, averaging 14 percent for teachers employed between 2017 and 2022; however, this still means that nearly 1 in 6 beginning primary school teachers had not passed Level 1 English.

In maths, an average of 25 percent of new teachers employed between 2017 and 2022 had failed to gain an Achieved level endorsement at Level 1. This means, on average, a quarter of all new primary school teachers who attempted could not pass at a basic level, the compulsory maths required of 15-year-olds in New Zealand.

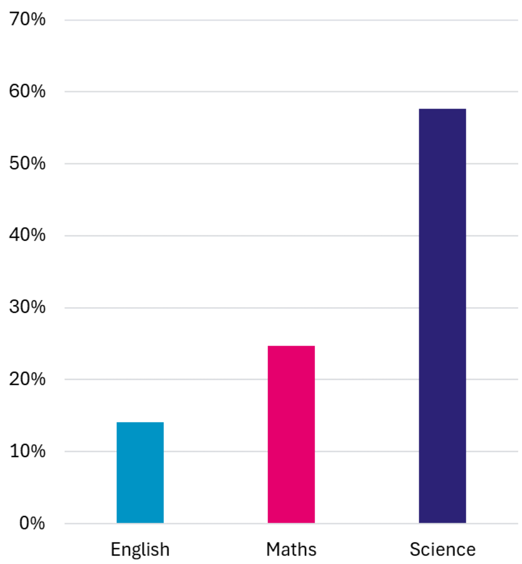
If that result is concerning, then the science results are alarming indeed: people who were new primary school teachers between 2017 and 2022 had failure rates in Level 1 science, averaging 58 percent. That is, most new

4 Students can gain Level 1 NCEA if they have enough credits overall and enough numeracy and literacy credits, but a subject level Achieved endorsement is the closest to a subject "pass" under the current NCEA system. It is also a low standard that most New Zealanders would want to know primary school teachers have reached.

primary school teachers who attempted failed to pass at a basic level the compulsory science required of 15-year-olds.

Figure 5 Percentage of new primary school teachers who attempted credits in English, maths and science at Level 1 but failed to get Achieved level endorsement

Average rate based on teacher cohort employed between 2017 and 2022



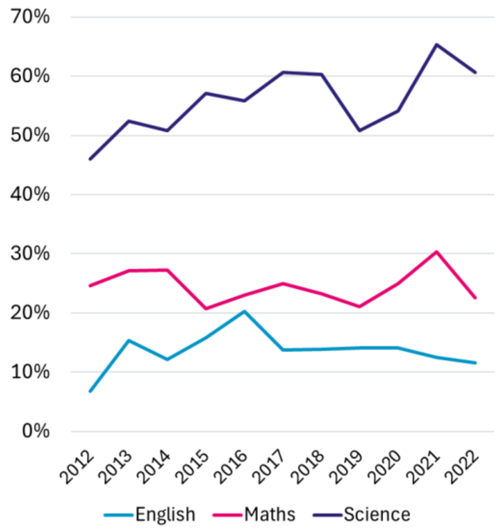
Note: Maths includes mathematics and statistics achievement standards.

Source: NZIER, IDI Data

Looking at this data as a time series and extending the time period back to 2012 suggests that while maths and English achievement has remained relatively constant, science skills have been deteriorating over time, with failure rates of teachers employed in the last five years significantly higher than those of teachers employed in the previous five years.

Figure 6 Percentage of new primary school teachers who attempted credits in English, maths and science at Level 1 but failed to get Achieved level endorsement

By year of teachers' first employment (2012-2022)



Note: Maths includes mathematics and statistics achievement standards. Science includes general science and the core sciences (biology, chemistry and physics).

Source: NZIER, IDI data

Level 2 results widen the achievement gap between English and maths and reveal physics as the most challenging science subject for aspiring primary teachers.

Focusing only on those who continued to engage with these subjects at Level 2, the percentages of students who failed at this level to gain an Achieved level endorsement rises for both English and maths, with around 30 percent failing to achieve Level 2 English and over half failing to achieve Level 2 maths.

At Level 2, general science splits into specific science subjects. We focus on the three core sciences: Biology, chemistry and physics.

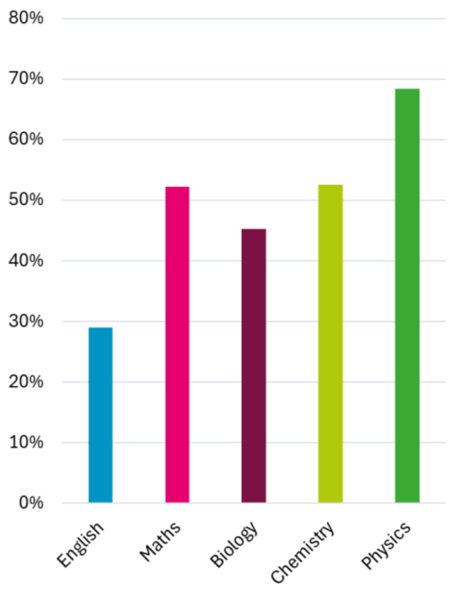
Results in these science subjects reveal interesting differences:

- All sciences have a significantly lower pass rate than English, but only one has a significantly lower pass rate (in most years) than maths.

- The percentage of students failing to get at least an Achieved level endorsement ranges from an average of 45 percent in biology to 68 percent in physics.
- The lowest pass rate is in the science subject most reliant on mathematics skills (physics), and the highest pass rate is in the science subject that requires more language-based work (e.g. writing verbal explanations) (biology).[5]

Figure 7 Percentage of new primary school teachers who attempted credits in English, maths and science at Level 2 but failed to get Achieved level endorsement

Average rate based on teacher cohort employed between 2017 and 2022



Note: Maths includes mathematics and statistics achievement standards. Science includes general science and the core sciences (biology, chemistry and physics).

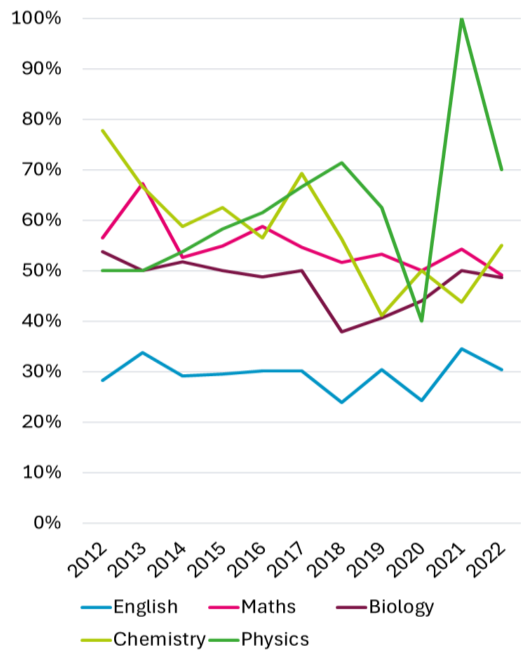
Source: NZIER, IDI data

Looking at results over ten years, no obvious trends exist, but the consistent gap between English achievement and achievement in maths and sciences indicates this is a persistent issue.

These results are made all the more striking when considered against the continued engagement with Level 2 English for aspiring primary teachers due to English being a compulsory subject for most students at Level 2. One might expect that compulsory subjects would have higher failure rates due to students who struggle with those subjects being required to continue with them, but the opposite is true here: Even though large numbers of aspiring primary teachers had disengaged from maths and science between Level 1 and Level 2, the select few remaining still had a lower success rate than was achieved in English.

Figure 8 Percentage of new primary school teachers who attempted credits in English, maths and science at Level 2 but failed to get Achieved level endorsement

By year of teachers' first employment (2012–2022)



Note: Maths includes mathematics and statistics achievement standards. Science includes general science and the core sciences (biology, chemistry and physics)

Source: NZIER, IDI data

5 These are features of the NCEA assessments rather than being features of these branches of science.

Our results indicate not only knowledge gaps but also significant potential for impacts on attitudes

Overall, our results suggest the recent cohort of primary teachers arrived at ITE with significant knowledge gaps in maths and science.

The high rates of disengagement with maths and science may indicate not only a lack of knowledge and skills but a lack of interest in these subjects or a fixed mindset (a belief that it is not possible to master the subject due to inherent shortcomings, i.e. the belief that being bad a maths runs in the family).

Additionally, the high failure rate, not only when subjects are compulsory but after they become optional, is indicative of many students entering ITE having had negative experiences that may result in anxiety related to teaching maths and science.

Our results are consistent with previous research. For example, Young-Loveridge, Bicknell, and Mills (2012) described the mathematics knowledge of the 319 pre-service primary teachers as "weak" and noted that many could not use knowledge of number properties to find common factors, were unable to use calculation strategies based on number sense to add common fractions, or could not convert a fraction to a percentage. Over one-third added both numerators and denominators for the addition of common fractions. Only around half of pre-service teachers liked mathematics.

The impact of negative learning experiences has also been well-documented:

- Di Martino et al. (2013) found that more than three-quarters of pre-service primary teachers associated mathematics with negative emotions, such as fear, anxiety, anger, panic or unease.
- Whyte (2022) found that some New Zealand teachers experience maths anxiety related to their own learning experiences and that they often adopt maths avoidance strategies such as teaching only at lower levels, avoiding certain topics, reducing time spent on maths, cancelling maths rather than other subjects to make room for special events or activities, or they spend a large amount of time preparing for maths teaching.

While many teachers struggled with maths and science, some demonstrated a high level of proficiency

Within our sample of aspiring primary teachers, there were also some who displayed strengths, not only in teacher-preferred English but also in maths and, to a lesser extent, in science.

Students who achieve significantly above the level required to 'pass' an NCEA subject may receive a Merit or Excellence endorsement, indicating that they not only achieved enough credits to pass but that a majority of those credits were from assessments where the student demonstrated a high level of proficiency.

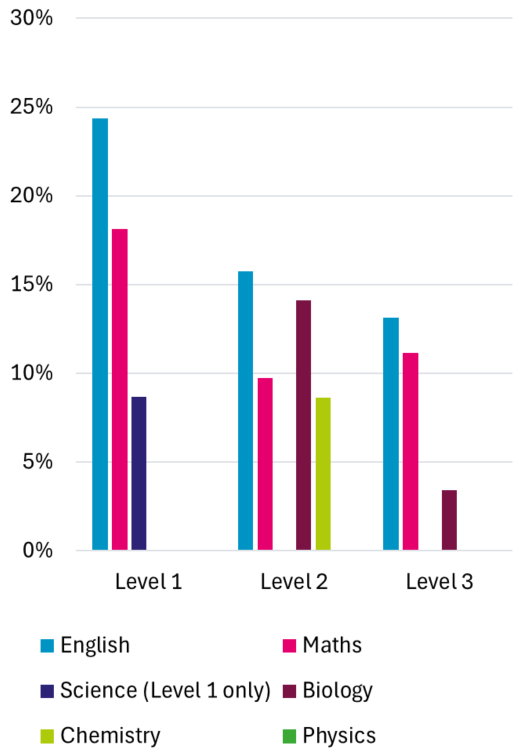
Over the period 2017 to 2022, at Level 1, some aspiring primary teachers got a Merit or Excellence endorsement:

- Nearly a quarter achieved this in English
- Nearly one in five achieved this in maths
- Nearly one in ten achieved this in science.

Out of those who continue to engage with English, maths and science, over 10 percent achieved a merit or excellence endorsement in English and/or maths at Level 3. However, very few made an attempt at this level. However, very few made an attempt at this level.

Figure 9 NCEA Merit and Excellence endorsements amongst aspiring primary teachers

Average percent of merit and excellence endorsements achieved amongst students who attempted any credits in the subject, based on teacher cohort employed between 2017 and 2022



Note: Maths includes mathematics and statistics achievement standards.

Source: NZIER, IDI data

Quality variation in education should be a concern

Clearly, there is a wide range of pre-training experience with maths and science amongst primary teachers, which may translate into a wide range of impacts on the quality of teaching, with some teachers likely experiencing very low confidence and negative attitudes towards maths and science, while others are likely to enter the profession with the necessary confidence and enthusiasm to effectively support children's learning.

OECD (2023) research using PISA data shows that relative to the OECD average, New Zealand students are more likely to be either top performers in at least one subject or to be low performers across all subjects assessed. In other words, there is more variation in outcomes from New Zealand's education system than on average across the OECD.

High variation in outcomes can be the product of both high variation in inputs (greater differences between students in characteristics not related to their in-school education, e.g. socioeconomic conditions) and high variation in the education received.

Other sectors with high levels of quality variation, such as the health sector, have a history of investigating both the potential causes of quality variation and the specific areas where quality variation is leading to low quality processes and outcomes and implementing measures to reduce quality variation where there are aspects that are within their control. This is something that the education sector may also benefit from.

Does quality variation between teachers translate into quality variation between schools?

Having investigated a potential source of quality variation (teachers own experiences with maths and science learning), we turn our attention to investigating the potential impacts of quality variation across schools with a focus on risks of inequities and inefficiencies:

- Inequities arise when lower quality teaching is concentrated in some places (e.g. in some types of schools, some geographical areas), with additional concerns related to the potential for this to exacerbate existing inequities (e.g. if lower quality teaching is concentrated in low income areas).
- Inefficiencies arise where there is a mismatch between teacher skills and the requirements of their job (e.g. where those who do have higher level maths and science skills are not employed where those skills are most needed).

Inequity related to quality variation

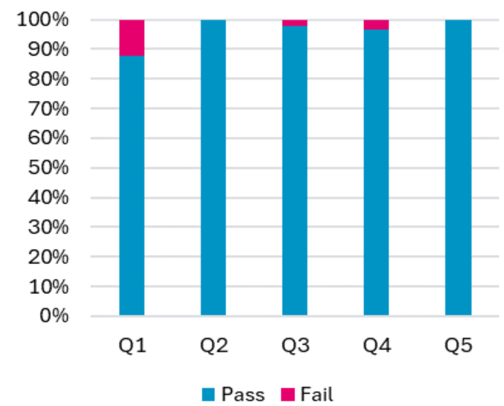
OECD (2023) research using PISA data shows that the socioeconomic status of a students' family is a predictor of performance in mathematics. But the OECD also found that family socioeconomic status only accounts for 16 percent of the variation in New Zealand students' mathematics performance in PISA 2022.

Using our sample of aspiring primary teachers, we investigated whether there is a relationship between the school decile (grouped into quintiles for our analysis[6]) and the pre-training maths and science results of the teachers recently employed there. In other words, do schools with students from more disadvantaged areas employ teachers with characteristics that may result in lower quality teaching?

As shown in Figure 10, teachers employed in Quintile 1 schools (those with more students from disadvantaged areas) had a 12 percent failure rate in Level 1 English (compared with failure rates between 0 percent and 3 percent for schools in other quintile schools).

Figure 10 NCEA English Level 1 pass rates by school quintile

Based on teacher cohort employed between 2017 and 2022



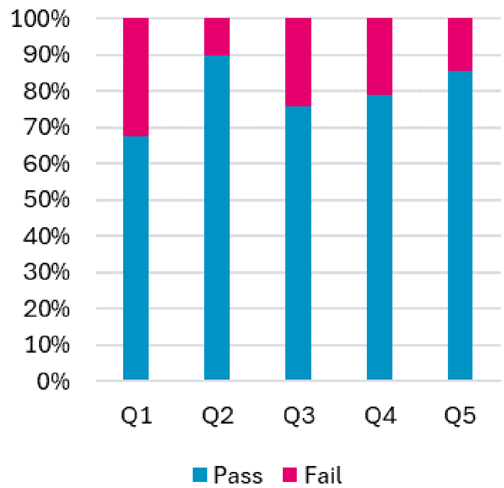
Source: NZIER, IDI data

In comparison to English, failure rates in maths are considerably higher for all quintiles, but again, failure rates are highest in new teachers employed in the lowest quintile schools. (32 percent failure rate compared with 10 to 24 percent failure rates for teachers employed by schools in more affluent areas.)

Interestingly, when looking at both maths and English, teachers employed by Quintile 2 schools (representing deciles 3 and 4) appear to have been the most academically successful, with a 100 percent pass rate in English and a 90 percent pass rate in mathematics. The data cannot tell us why this might be the case.

Figure 11 NCEA Maths Level 1 pass rates by school quintile

Based on teacher cohort employed between 2017 and 2022



Note: Maths includes mathematics and statistics achievement standards.

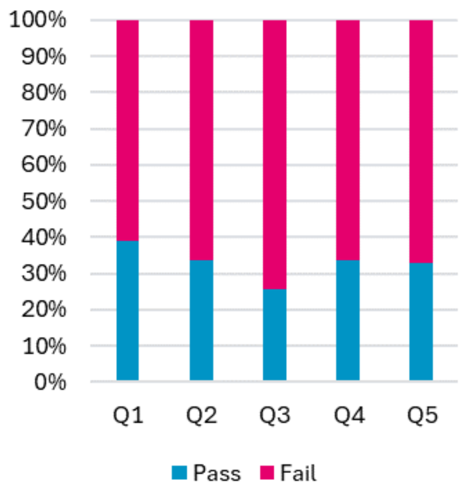
Source: NZIER, IDI data

Science also has significantly higher failure rates across all quintiles – even higher than maths – but no clear relationship to school quintile is observable.

[6] Q1 schools are decile 1 and 2 schools (those whose students live in the most socioeconomically disadvantaged communities), whereas Q5 schools are decile 9 and 10 schools (those whose students live in the least socioeconomically disadvantaged communities).

Figure 12 NCEA Science Level 1 pass rates by school quintile

Based on teacher cohort employed between 2017 and 2022



Source: NZIER, IDI data

While the differences are not large, our research shows that primary school teachers working in the schools where more students come from disadvantages areas (low decile schools) may need more support to deliver the same quality of maths and English teaching, but teachers in all schools require similar support to deliver science education.

Inefficiency related to quality variation

The Royal Society's (2021) review of published studies led to their assertion that "*teacher knowledge 'well beyond the student level' is essential to be able to answer questions meaningfully, make connections, make the most of the teachable moments, and plan how to implement the curriculum*".

While no specific level of teacher knowledge has been identified as sufficient for teaching children in Year 1 compared with teaching children in Year 8, it would be fair to assume that the need for teacher knowledge "well beyond the student level" translates into an imperative to get those teachers with higher level NCEA achievement into the later primary year levels. With a low supply of high-level maths and science skills in new primary teachers, making efficient use of what skills there are should be a key objective.

Using our sample of aspiring teachers, we identified the average pass and fail rates (based on subject endorsement at the Achieved level) in Level 1 English, maths and science and compared these across those who later gained their first employment in a full primary school (Years 1–8), an intermediate school (years 7–8) and a contributing primary school (years 1–6).

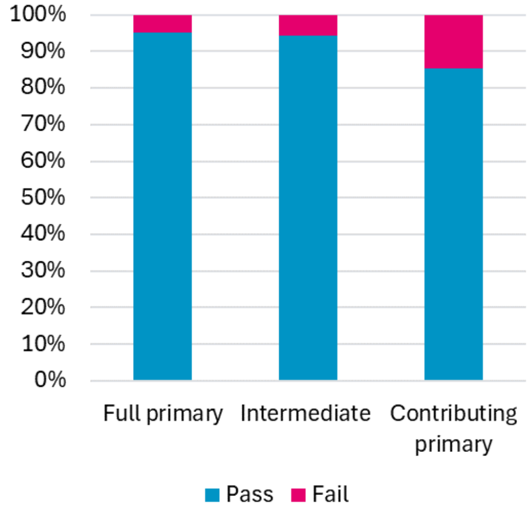
We constrain our sample to these school types, excluding composite, restricted composite, and secondary schools even though they employ primary-trained teachers because they may use secondary-trained teachers to teach maths and science and, even if primary teachers are teaching those subjects in the primary school years, they have access to the specialist subject knowledge of their secondary-trained colleagues.

If teacher knowledge is being efficiently used, we would expect to see higher Level 1 fail rates in the contributing primary schools, where teachers' knowledge may not need to be at such a high level as in intermediate schools. Full primary schools are more difficult to analyse due to the data not revealing which year levels teachers are employed to teach. However, because these schools represent a combination of contributing primary years and intermediate years, we would expect results to fall somewhere in between the other two school types.

Our results (shown in Figures 13, 14 and 15 below) show that across all three subjects, failure rates were lowest for teachers who gained employment in intermediate schools and highest for teachers who gained employment in contributing primary schools.

Figure 13 New primary teachers' Level 1 English pass and fail rates

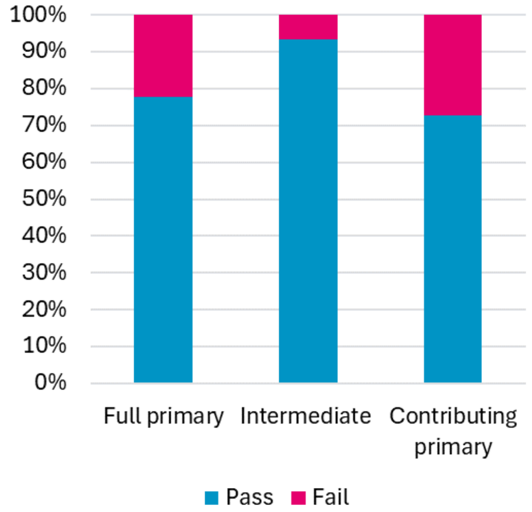
Based on teacher cohort employed between 2017 and 2022



Source: NZIER, IDI data

Figure 14 New primary teachers' Level 1 Maths pass and fail rates

Based on teacher cohort employed between 2017 and 2022

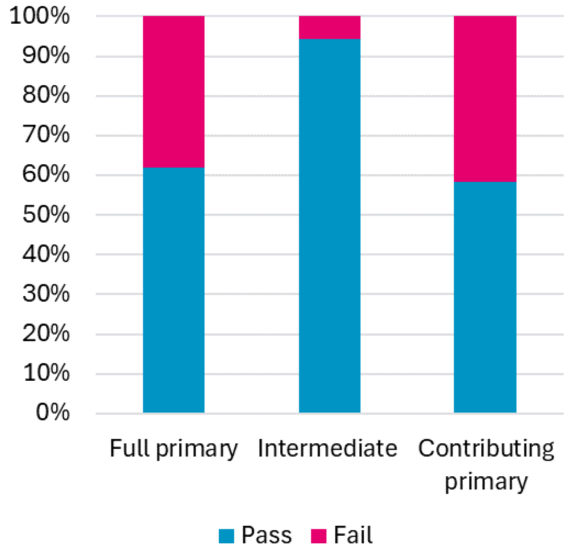


Note: Maths includes mathematics and statistics achievement standards.

Source: NZIER, IDI data

Figure 15 New primary teachers' Level 1 Science pass and fail rates

Based on teacher cohort employed between 2017 and 2022



Source: NZIER, IDI data

The results for full primary schools – in the middle but closer to the contributing primary schools than the intermediate schools – are as expected.

These results are encouraging and may indicate that:

- the level of knowledge of beginning teachers is recognised during the application process, and those with higher levels of knowledge are sought after to teach at the higher levels of primary school
- beginning teachers seek out employment that is most appropriate to their level of knowledge and confidence.

Focusing on solutions rather than finger-pointing

Primary school teachers are hard-working, trained professionals who juggle large numbers of demands and difficult situations. Overall, they do a great job providing a safe environment and quality learning experiences that set our children up for further learning.

Teachers employed in New Zealand have met all the requirements of their training, registration and certification and engage in ongoing professional development to maintain and extend their skills. So, while teachers cannot be held accountable for the current system-wide problems, it is essential that solutions are based on a realistic understanding of the existing workforce.

It is well-recognised that the teaching profession is not highly remunerated, and this no doubt contributes to many students who may have higher levels of maths and science knowledge being attracted to other opportunities. At the same time, it is unclear whether those who achieve higher levels of maths and science knowledge would be attracted to teaching even if substantially higher remuneration were offered[7] or whether they would be able to acquire the same levels of the many other required skills and attitudes that our current teaching workforce bring to their professional practice.

At any rate, significantly increasing teacher remuneration in order to attract students with higher maths and science knowledge to the profession is costly and, at best, a long-term solution that might even result in inefficient allocation of those skills which are needed in other sectors.

So, what are the solutions? To identify the most efficient and practical solutions that can be implemented in the short term, we propose that the education sector should look to the health sector for solutions appropriate to making the best use of its workforce and addressing quality variation.

What the education sector can learn from the health sector

We propose that there are two key, related lessons for the health sector that indicate practical solutions for the education sector:

- the efficient use of generalists and specialists
- how to improve quality and reduce unwarranted variation with a generalist workforce.

Lessons about the efficient use of generalists and specialists in the health sector

The health sector provides an example of a workforce comprising various clinical professions with different levels and types of specialisations. In primary care, patients see nurses and general practitioners (GPs) who, while being highly skilled, are trained to provide treatment for common ailments and to recognise a broad range of signs and symptoms, including those that warrant referral to a specialist for a more in-depth investigation that requires a higher level of knowledge in a more specific branch of medicine.

A common efficiency-related feature of publicly funded health care systems is the use of general practice as the first point of contact and as a gatekeeper to specialist services to reduce costs overall and ensure limited specialist services are available to those who really need them. This system is so effective that even in many private insurance-based health systems where people can self-refer to specialists (e.g. Germany), insurers offer a financial incentive to use GPs first.

These design features make sense because most of the population will have most of its health needs met most of the time within general practice. Most patients only

[7] Teachers' responsibilities include a broad range of requirements that may not appeal to people with advanced maths and science skills. For example, a recent ERO report identifies that classroom behaviour is a daily challenge for most teachers, and half report that this impacts on their decision to remain in the profession, and with the problem being reported as worst in maths classes (ERO 2024).

occasionally require a referral to specialist services, and only a minority of patients need specialist services consistently. In many cases, GPs may also contact specialists for advice, which may reduce pressure on specialists.

The key takeaway is that the success of this system is not based on denying specialist services. In fact, the system relies on *timely access* to specialist services for those who need them, with gatekeeping being a supporting mechanism for this.

Adapting the health model to education

Regarding subject matter expertise, the education sector also has generalists and specialists. Primary school teachers are typically generalists. Secondary school teachers, in contrast, are more likely to be specialists: People who have studied their subject area at the tertiary level and whose teacher training focuses on the pedagogy specific to their speciality subject(s).[8] Some primary school teachers may upskill and train to attain a degree in maths specialisation. However, this is a relative rarity.

If you have had a child in a state primary school in New Zealand, you are likely to have been aware of a range of specialist primary teachers, including ones specialising in music, Te Reo or foreign languages, reading recovery, and technology. Primary schools also have access to resource teachers of learning and behaviour (RTLBs) who may be called in to support children with learning difficulties or behavioural issues. But, specialist maths and science teachers typically do not feature.

If the education sector adopted the health sector approach, using the first point of contact and gatekeeper design features, this would mean:

- All students start with a generalist teacher because a generalist teacher will be sufficient for most students most of the time.
- When students fail to keep up with the expected level of learning or far exceed the expected level of learning, a referral to a specialist teacher may be made.
- When teachers are planning to teach topics, they are less confident in, they should be able to get specialist support and advice to improve the quality of their teaching and reduce the risk that students will require specialist support later due to low quality teaching.
- At a certain level of complexity (e.g. higher levels of maths and science), all of the teaching should be provided by specialist teachers – the optimal level may in fact, be lower than the current setting (typically Year 9), given the knowledge level of many primary teachers.

But where would the specialist teachers come from?

The Royal Society (2021) concluded that *"building and maintaining high levels of teacher content knowledge for teaching mathematics and statistics in Aotearoa New Zealand schools is a long-term challenge"*.

Our research shows clearly that many primary teachers are unlikely to have the knowledge and attitudes required to easily become specialists in teaching maths and science.

That means incorporating more content instruction in ITE to fill pre-service teachers' own knowledge gaps and help them overcome challenges like maths anxiety would be a heavy requirement, possibly requiring a significant extension to the duration of programmes (e.g. from three years to four or more), and would likely reduce enrolments, exacerbating teacher shortages.

[8] This is at least the assumption behind the design of secondary teacher training programmes. The actual level of subject matter knowledge and the extent to which secondary subjects are in fact taught by subject specialists warrant further investigation.

However, a small number of pre-service teachers who have had more positive experiences and achieved higher levels of knowledge should be given options to become specialist maths and science teachers.

In addition to a small number of primary teachers upskilling to be specialist maths and science teachers, there are at least three other options that might be easier to achieve:

- Secondary trained teachers could be employed by primary schools to provide specialist maths and science support for primary teachers (e.g. one specialist per primary school).
- Secondary trained teachers could teach maths and science in primary schools (e.g. at least in Years 7 and 8[9]).
- New roles for maths and science specialists could be created with their own ITE pathway and higher remuneration to attract students with stronger maths and science skills.

A key condition for these solutions is that the reliance on specialist teachers is minimised for efficiency and financial sustainability, so generalist teachers would still do the lion's share of the teaching at the primary level.

Again, the health sector offers lessons from experience in getting the balance right; the key is in standardisation.

Standardisation to improve quality and achieve the optimal balance of generalists and specialists

The use of standardisation is often associated with the manufacturing sector, which has demonstrated that standardised processes allow firms to employ low-skilled labour and still produce high quality and highly sophisticated outputs. MacDonald's is another great example of successful standardisation, resulting in low-skilled workers producing consistent products at tens of thousands of locations around the world.

But many people may not realise that the health sector also makes extensive use of standardisation, not to be able to use low-skilled workers, but to improve quality and reduce unwarranted variation with a workforce characterised by a mix of specialist and generalist skills. By and large, the health sector has been highly successful, improving efficiency by minimising the use of specialists and improving the quality of care at every level.

The secret to the health sector's success has been the adaptation of standardisation to an industry that is different from manufacturing in two key ways:

- Whereas the manufacturing sector can standardise not just processes, but also inputs, the health sector cannot standardise inputs because in the health sector, the customer is also the main input into the production process, and people (particularly in regard to their health) cannot be standardised.
- Whereas the manufacturing sector can employ low-skilled labour to operate standardised processes, the health sector requires high-skilled labour, with even generalists (GPs, nurses) requiring speciality skills in a key area: the ability to recognise and exercise good professional judgement with regards to the sometimes subtle but potentially critical differences between patients and in patients over time. The speciality of even generalist health sector workers is as much related to interpersonal skills as they are related to their understanding of disease.

The health sector's adaptation of standardisation began in the 1980s, motivated by increased awareness of the extent of unwarranted variation in clinical practice and

[9] Most secondary teacher training prepares teachers to teach years 7 to 13.

health outcomes. The high degree of customisation that prevailed at all levels of care was recognised as resulting in outputs and outcomes that are difficult to measure, compare, and replicate. Every situation being treated as unique meant that while highly skilled clinicians were exercising their professional judgement, errors were common and good outcomes were not always achieved. Wide variation in practice also made data collection challenging.

Focusing on tasks rather than processes

The health sector's approach to standardisation required a focus on specific tasks rather than the entire process of care. In general practice, these were typically areas where:

- GPs lacked deep and specific knowledge about diseases and conditions
- tasks that were routine or repeatable.

This led to the development and proliferation of clinical practice guidelines based on systematic reviews of evidence. These directed clinicians (including GPs), who may lack in-depth knowledge in specific areas or occasionally make errors in judgement, to consistently deliver high-quality care informed by the expertise of those with specialist knowledge and a deep understanding of the evidence base.

More recently, additional tools have been developed and implemented to support greater standardisation and reduce quality variation in primary care. A great example of this is HealthPathways, a digital tool that integrates locally agreed information, such as what specialists require from GPs to be able to consider a referral, with clinical guidelines, such as the appropriate diagnostic tests to order for patients with certain symptoms or conditions. HealthPathways facilitates GP decision-making, uses GP and specialist capacity more efficiently, and frees up time spent on administrative tasks so more time can be spent caring for patients.

Standardisation and its opposite, customisation, are both features of health care that require ongoing attention and fine-tuning to avoid treating frontline services like manufacturing plants:

- Too much customisation can introduce chaos to the system whereby understanding what has happened and how outcomes have been achieved becomes impossible, time is spent unnecessarily on designing solutions with duplication of efforts across the system, and wide variation in outcomes result from wide variation in practice quality.
- Too much standardisation can make a highly trained workforce feel oppressed and disempowered, inhibit personalised approaches where needed, and contribute to poor outcomes where the standard solution is not appropriate for the individual.

  (Sinsky et al. 2021)

Recognising the skills mix of teachers is critical to getting the balance of standardisation and customisation right

Primary teachers may be generalists when it comes to subject area knowledge, but they are specialists in age-relevant pedagogy and may either come with or develop critical interpersonal skills that support positive teacher-student relationships and allow them to create safe and trusting learning environments. Teachers will inevitably need to customise interactions with students according to individual needs, and it's critical that standardisation does not inhibit this.

A key lesson from the health sector is that *all* frontline workers have specialist skills, even if they do not have specialist expertise on specific subject matter. The effective and efficient delivery of education depends upon:

- Standardisation being used to support areas where skills are more generalist and tasks are routine and repeatable (e.g. planning maths lessons, providing opportunities for practice, assessing progress)

- Customised approaches where interpersonal skills and the specialist pedagogical knowledge of teachers are needed to support warranted variation (variation driven by the individual needs of students).

Figure 16 Standardisation and customisation in a workforce with a mix of generalists and specialists

Approach / solutions / products	Skill		
		Generalist	Specialist
	Standardisation	• Standardised approaches to delivery are ideal for a generalist as they do not require both broad and deep knowledge/skill. • Improves quality by standardising to best practice (requires specialist expertise to identify best practice and design standards). • Reduces duplication, error, and unwarranted variation. • Frees up resources for alternative uses (e.g. more teacher time for supporting students) by eliminating time spent designing custom solutions. • Allows for a low-skilled workforce to deliver a quality product/service. • Supports cost reduction/cost minimisation.	• Standardisation of specialist services risks obliviating the value of specialist expertise. • Can improve quality where quality is poor and reduce unwarranted variation. However, opportunities for standardisation must be selected carefully to apply to routine tasks while allowing special or complex situations to be treated with specialist expertise. • Important role for technology in routine tasks performed by specialists. • Standardised design for delivery by non-specialists may require specialist expertise and is warranted where there is high value added.
	Customisation	• Customisation requires skills that generalists may lack: To understand a problem in depth and quickly design and deliver the right solution. • Quality will be lower overall. • Level of unwarranted variation will be high if there are important skill/knowledge gaps. • High resource use to develop custom solutions significantly increases the size of workforce required or constrains a limited workforce's ability to spend time on other tasks. • May result in burnout due to high workload and work stress associated with lacking the skills and knowledge for the work. • Some customisation is needed in frontline services. Critical to focus on where this is needed (likely to be where highly personalised approaches are needed) and ensure skills are adequate.	• When there is a clear and unavoidable need for custom solutions, these are best designed and delivered by specialists who can typically assess, design and deliver more efficiently by drawing on expertise. • Costly due to training required and potentially need to attract workers with other, more lucrative options. • In many sectors, customisation is the exception rather than the rule. Reserving specialist skills for these instances reduces the overall cost of using these high-cost inputs.

Source: NZIER

Getting the balance right in education requires a more specific curriculum

There has been a long-standing debate, not just in New Zealand but internationally, about the degree of flexibility that curricula should allow to enable teachers to adapt their practice to the needs and interests of students.

The New Zealand curriculum's open design was intended to allow local flexibility – opportunities for schools to tailor curricula to their communities and classrooms. There is no mandated national approach to teaching basic maths and science skills; consequently, teachers have little guidance on how to do it or how to know they are doing it well. Additional flexibility is built in through the two-year levels of the curriculum, which means that basic skills that teachers may find challenging to teach can be postponed – possibly on the mistaken assumption that 'next year's teacher' will be able to teach those skills.

Because of the flexibility in the system and the resulting lack of consistency, the degree of customisation is too high for the mix of specialist and generalist skills in primary teachers. Routine repeatable tasks that also require subject matter knowledge, like lesson planning for maths and science, are not standardised and impose a heavy burden on teachers who do not have the required skill set to customise these tasks. This is a recipe for not only unwarranted variation in outcomes but also workforce burnout.

NZIER recommends

Based on our research and previously published research identifying the extent of unwarranted quality variation in education, the new government's proposed tightening of the national curriculum is likely to be a move in the right direction, particularly if this is used to launch the development and dissemination of standardised tools like lesson plans to support teachers to deliver the curriculum consistently and free up time and energy to focus where they have specialist skills.

But other sectors that have increased their use of standardisation have learned that there are always fishhooks, and the government should ensure it goes about this in the right way. It should:

- Ensure standards are aligned with other improvement efforts and the overall vision and goals for the sector
- Engage with teachers to gain buy-in on the design and implementation of standards
- Identify how to ensure teachers are working to the standard, including processes for monitoring/auditing
- Create opportunities and processes for ideas about innovation and improvement to flow up from the frontline to ensure the system remains open to continuous improvement
- Recognise and identify where standardisation may not work (e.g. children with learning disabilities) and plan for an effective customised solution, which may require the use of specialist teachers, to ensure standardisation does not increase inequities (the health sector's gatekeeper model will help ensure costs are minimised, but access to support is critical to achieving good outcomes).

For best results, the government should also seek to address the current balance of generalist and specialist skills, including:

- Investing in the development of mathematics and science specialist roles specifically for primary schools to ensure access to specialist knowledge for teachers facing teaching more complex material than they are comfortable with, and support learning for students who fall behind or far exceed the expected curriculum level

- Ensuring the supply of specialists is adequate and equitable by implementing gatekeeper and standardised referral processes.

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This Insight was written by Sarah Hogan and Tom Dunn at NZIER.

The support and assistance of Sarah Spring and Jason Shoebridge is gratefully acknowledged.

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Access to the data used in this study was provided by Stats NZ under conditions designed to give effect to the security and confidentiality provisions of the Data and Statistics Act 2022. The results presented in this study are the work of the author, not Stats NZ or individual data suppliers.

These results are not official statistics. They have been created for research purposes from the Integrated Data Infrastructure (IDI) which is carefully managed by Stats NZ. For more information about the IDI please visit https://www.stats.govt.nz/integrated-data/.

How to cite this document:

Hogan, S. and Dunn, T. 2024. Fit for purpose: Teachers' own learning experiences and lessons about standardisation from the health sector. NZIER Insight 112-2024 Available at https://www.nzier.org.nz/publications/fit-for-purpose-teachers-own-learning-experiences-and-lessons-about-standardisation-from-the-health-sector

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