Measuring student progress: A state-by-state report card – Technical Report

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Overview

This Technical Report accompanies the Grattan Institute report *Measuring student progress: A state-by-state report card*, which seeks to measure and compare relative student progress on the NAPLAN (National Assessment Program – Literacy and Numeracy) test in a robust, easy to interpret way. That report analyses school-level data to identify some of the school characteristics associated with higher or lower rates of progress, and to quantify the degree of these associations. The analysis does not attempt to quantify the causal impact of these factors, and should not be interpreted as such.

This Technical Report seeks to explain the key concepts and techniques of the methodology used in the main report.

Chapter 1 provides a brief summary of the methodology.

Chapter 2 describes the rationale behind creating a new frame of reference to interpret NAPLAN results, as per Grattan Institute's 2016 report *Widening Gaps*.

Chapter 3 outlines the technical detail behind the updated methodology used to convert NAPLAN scale scores to Equivalent Year Levels (EYL).

Chapter 4 outlines the treatment of the school-level data used in the analysis, in particular the use of the Index of Community Socio-Educational Advantage (ICSEA), and necessary data exclusions.

Finally, Chapter 5 outlines some additional checks conducted to confirm the robustness of the methodology of our new analysis.

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1 Summary of methodology

The Grattan Institute report *Measuring student progress: A state-by-state report card* compares student progress in each Australian state and territory.[1] To do this we use measures of progress first developed in our 2016 report, *Widening Gaps*,[2] which enable more accurate relative comparisons in NAPLAN data. Our measures help to adjust for the non-linear rate at which students typically gain NAPLAN scale scores as they move through school.

The analysis involves three main steps.

We start by translating student NAPLAN scores into an 'Equivalent Year Level' (EYL) metric which shows the year level in which the typical student would be expected to achieve a given NAPLAN score.

Next, student progress for a given cohort is compared by estimating the difference in EYL over a given time-frame, which we call 'Years of Progress'.

Finally, we compare student progress across groups of schools on a like-for-like basis, controlling for socio-educational advantage.

1.1 Updating the Equivalent Year Level reference curves

To compare student progress across schools for students with different starting points, it is necessary to convert NAPLAN scale scores to an 'Equivalent Year Level' (EYL) measure.

The data source used to update the EYL reference curves was NAPLAN mean scale scores for Metropolitan non-Indigenous students for years 2010 to 2017, published on the NAPLAN website.[3]

1. Goss et al. (2018).
2. Goss and Sonnemann (2016).
3. ACARA (2017a).

The philosophy and methodology used to update the EYL reference curves is described in detail in Chapter 2 and Chapter 3.

1.2 Calculating average student progress at a school level

The next step is to calculate average student progress at a school level.

The data source used to calculate student progress was provided by ACARA and consisted of NAPLAN school-level mean scores from 2010 to 2016 for every school, including all students who sat two successive NAPLAN tests at the same school. That is, it contains the results of five student cohorts for each school (2010-12, 2011-13, 2012-14, 2013-15 and 2014-16), including the mean NAPLAN score for the relevant student cohort at the start and end of the period.

The methodology used to calculate student progress at a school level is described in detail in Chapter 2.

1.3 Comparing student progress across groups of schools

To compare schools on a like-for-like basis, it is necessary to make allowance for different levels of relative advantage. Our approach uses a type of value-added modelling to better isolate the contribution of the school to student progress. The Index of Community Socio-Educational Advantage (ICSEA) is used to estimate school advantage.

The methodology used to calculate student progress at a school level is described in detail in Chapter 4 and Chapter 5.

2 Why our new measures are useful

2.1 NAPLAN scale scores enable comparisons between students

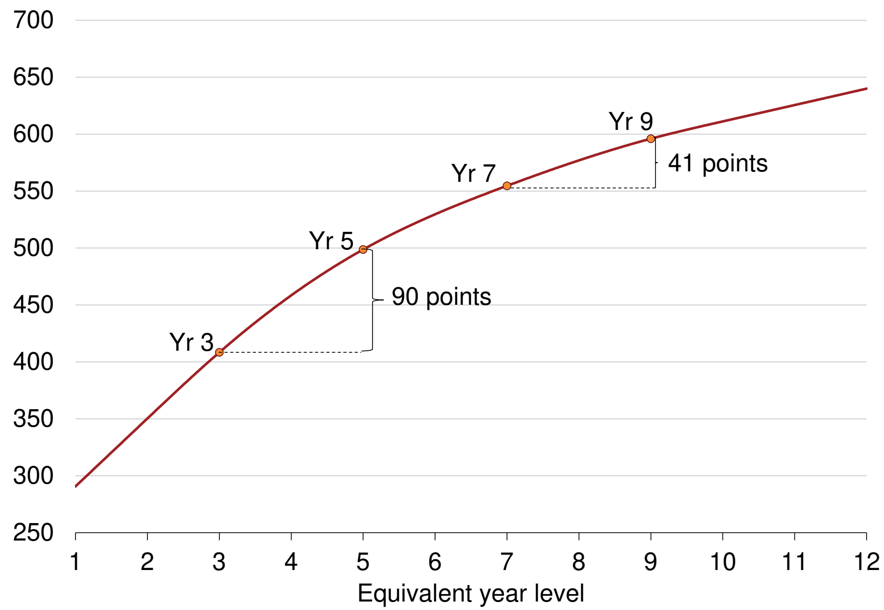
Students who take the NAPLAN test receive a score for each assessment domain: reading, writing, language conventions (which includes spelling, grammar and punctuation), and numeracy. This score, called the NAPLAN scale score, is typically between 0 and 1000. While the scores are used to indicate whether a student is above NAPLAN national minimum standards for each year level, they have no other direct interpretation – the numbers themselves have no particular meaning.

The NAPLAN test is designed so that results in each domain can be compared between students in different year levels and students taking the test in different years. This means, for example, that a student who took the Year 5 NAPLAN reading test in 2012 and received a scale score of 500 is estimated to be at the equivalent level of a student who took the Year 7 reading test in 2013 and received the same score. That is, they are demonstrating comparable reading skills in the elements being tested by NAPLAN.

NAPLAN scale scores are developed from the Rasch model, an advanced psychometric model for estimating a student's skill level.

Figure 2.1: The typical student progresses in NAPLAN at different rates at different stages of school

Average NAPLAN score by year level, numeracy, 2010-2017



Notes: Curve fitted to NAPLAN mean scores for metropolitan non-Indigenous students. Dots represent mean scores.

Source: Grattan analysis of ACARA (2017a).

2.2 But existing NAPLAN measures make it difficult to compare progress

It would be easy to measure student progress using NAPLAN if students gained NAPLAN scores at a steady pace as they moved through school. But they do not. Figure 2.1 shows that the typical gain in NAPLAN scores decreases at higher achievement levels.[4]

NAPLAN is a very sophisticated testing system, but this non-linear growth curve makes it hard to compare progress between different groups of students. It is especially difficult to compare students of different backgrounds, who are likely to be at very different scores on the curve (in other words, at different stages of their learning), even though they are the same age and in the same year level.[5]

NAPLAN's non-linear growth curve makes it complicated to interpret simple gains in NAPLAN scores, or to compare the relative progress of students with different prior scores. For example, a student who gained 40 points in NAPLAN numeracy between Year 3 and Year 5 might be progressing poorly compared to their peers, while another student who gained 30 points from a higher starting point might be progressing as expected.[6]

This non-linearity over time of NAPLAN scale scores is discussed in greater depth in the *Widening Gaps* Technical Report.[7] A potential reason students at higher starting points make lower gain scores is that students increase their skill level faster from a lower base, and slow down over time. But regardless of the explanation, the pattern of higher gain scores from lower starting scores should be taken into account when comparing the relative progress of different groups of students.

Using the EYL approach to analyse student progress automatically takes into account a student's prior score, allowing direct comparisons of students, schools or systems with different starting points. The EYL approach has the additional benefit of making achievement and progress on NAPLAN much more intuitive.

2.3 The EYL measure

The philosophy and general methodology used in this report to translate NAPLAN scores to an 'Equivalent Year Level' (EYL) measure are similar to those employed in *Widening Gaps*. They have since been updated for robustness.

Our methodology uses two new measures which take into account the shape of the non-linear NAPLAN growth curve, enabling more accurate comparisons of students at different stages in their learning.

First, NAPLAN scores for students are translated to an EYL. EYL shows the year level in which the average student would be expected to achieve a given NAPLAN score. Second, student progress for a given cohort is then compared by calculating the difference in average EYL over a given time-frame. We call this measure 'Years of Progress'.

2.4 Using the EYL measure makes it easy to see the widening gaps

The EYL metric makes it clear that the learning gaps widen as students move through school. Throughout the *Measuring student progress* report, we measure relative advantage at a school level using the Index of Community Socio-Educational Advantage (ICSEA). ICSEA is defined as having a mean of 1000 and a standard deviation of 100. Further details regarding ICSEA are found in Chapter 4.

Figure 2.2 on the following page shows the achievement gap in low- and high-ICSEA schools by year level, using both NAPLAN scale scores (left-hand panel) and EYL (right-hand panel).

4. The Australian Curriculum, Assessment and Reporting Authority (ACARA) notes that: "students generally show greater gains in literacy and numeracy in the earlier years than in the later years of schooling, and that students who start with lower NAPLAN scores tend to make greater gains over time than those who start with higher NAPLAN scores." ACARA (2016, p. 5).
5. Goss and Sonnemann (2016).
6. VCAA (2012, pp. 6–7).
7. Goss and Chisholm (2016).

Using NAPLAN scale scores (LHS), it appears that the gap between the two groups narrows between Year 3 and Year 9, giving the impression that low-ICSEA students are catching up to high-ICSEA students over time.

But, using EYL (RHS), it can be seen that the gap between low-ICSEA and high-ICSEA students is actually widening.

Looking at gaps through the lens of time, and using EYL, makes it clear that equity gaps grow as students move through school. The next section explores the growth in equity gaps more directly.

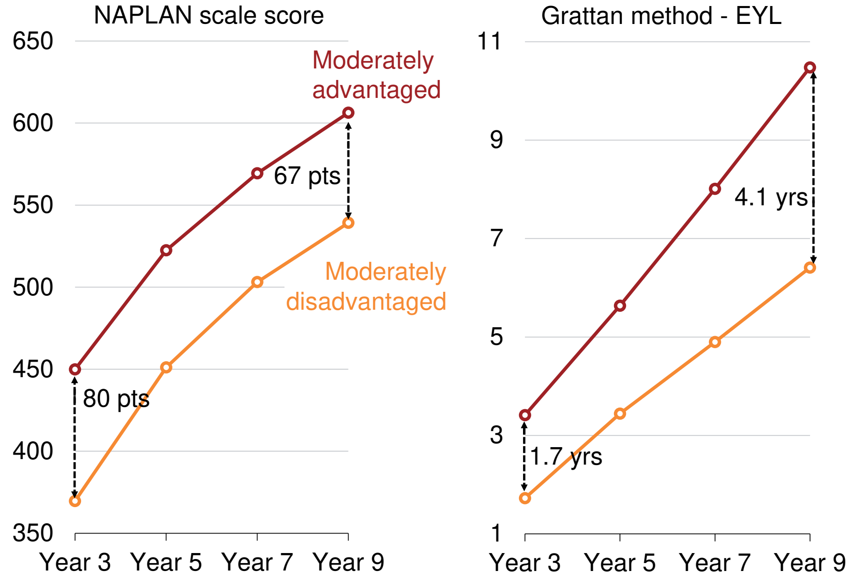
2.5 The EYL measure is especially helpful when analysing progress

While the EYL measure makes it easier to understand the link between ICSEA and achievement, it is particularly helpful to use EYL when analysing progress. Analysing the link using NAPLAN gain scores – the difference in NAPLAN scores between successive tests – can lead to incorrect conclusions.

The left-hand panel of Figure 2.3 on the next page shows that there is a clear relationship between ICSEA scores and Years of Progress.[8] Students learn faster if they attend more advantaged schools. This pattern is highly consistent across time.

The right-hand panel shows that there is no consistent relationship between school advantage and gain points.[9] In effect, the faster rate of learning in higher-ICSEA schools is cancelled out by the fact (see

Figure 2.2: NAPLAN scale scores suggest student learning gaps are narrowing; but Grattan's EYL measure shows they are widening
Average achievement in NAPLAN scale score (LHS) or Equivalent Year Level (RHS), by year level, reading, 2010-2016



Notes: 'Moderately advantaged' refers to schools with ICSEA between 1075-1124; around one standard deviation above the mean. 'Moderately disadvantaged' refers to schools with ICSEA between 875-924; around one standard deviation below the mean. ICSEA is the Index of Community Socio-Educational Advantage.

Source: Grattan analysis of ACARA (2017b).

8. Years of Progress is defined as the difference between the average NAPLAN score in EYL in successive NAPLAN tests.
9. Where there is a relationship, the direction varies. For example, high-ICSEA schools make more gain than low-ICSEA schools in secondary-level writing, but less gain than low-ICSEA schools in primary-level reading.

Figure 2.1 on page 7) that students tend to gain fewer NAPLAN points if they start from a higher base.

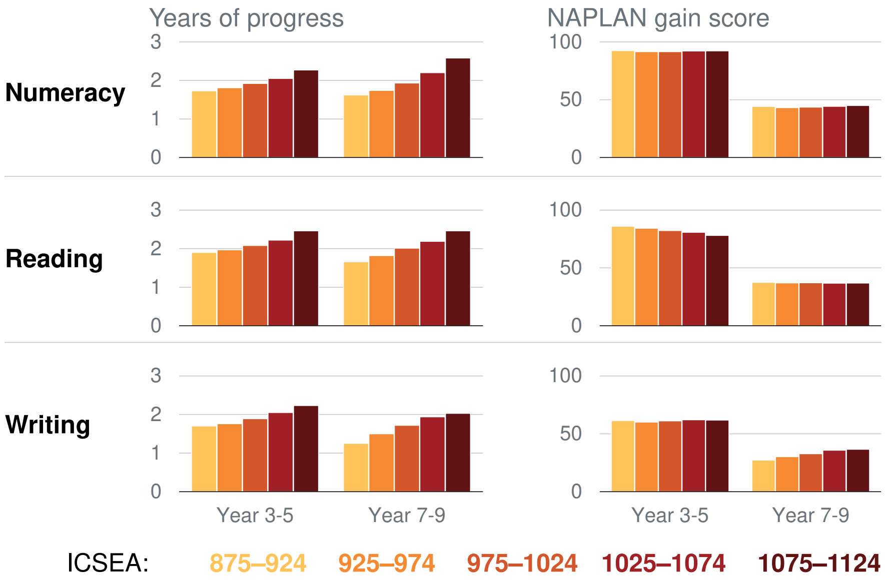
Further analysis shows increasing difficulty in the use of gain scores to compare students from different socio-economic backgrounds.[10] For example, very remote Indigenous students make the highest gain scores in the country in numeracy from Year 7 to Year 9. Unfortunately, this is not because they are learning the most, but because they started at the lowest level in Year 7.

Researchers and policy makers often try to identify schools whose students are under- or out-performing. It is better to do this by looking at student progress than student achievement.[11]

But it is risky to do this analysis using gain scores as the measure of student progress, because the starting point of the students has such an impact.

By contrast, using Years of Progress as the measure of student progress takes account of student starting point. This enables comparisons of different groups of schools.

Figure 2.3: Translating NAPLAN scores into EYL shows a clear link between increasing school advantage and higher student progress
Progress, in Years of Progress (LHS) or NAPLAN gain score (RHS), by ICSEA band, multiple cohorts



Notes: Numeracy and reading include the 2010-12 to 2014-16 cohorts. Writing includes the 2011-13 to 2014-16 cohorts. ICSEA is the Index of Community Socio-Educational Advantage. ICSEA band 975-1024 is the average level of advantage. ICSEA band 1075-1124 is moderately advantaged; around one standard deviation above the mean. ICSEA band 875-924 is moderately disadvantaged; around one standard deviation below the mean.

Source: Grattan analysis of ACARA (2017b).

10. It is much less problematic to compare gain scores for students from similar backgrounds, or similar schools, as is done on the My School website. That is because they will typically have similar starting points on the NAPLAN curve.
11. Jensen et al. (2010); OECD (2008); and CESE (2015).

3 Update to the Equivalent Year Level reference curve

In this report we translate NAPLAN scores to an Equivalent Year Level (EYL) measure, which shows the year level in which the average student would be expected to achieve a given NAPLAN score. The methodology was first proposed in *Widening Gaps*.

However the EYL methodology introduced in *Widening Gaps* has two significant limitations that have been addressed in this report. First, the original methodology relied on the use of median student performance. This has some conceptual advantages, as described in the *Widening Gaps* Technical Report,[12] but relies on having access to individual unit record data for all students. This data is held by ACARA but is not always easily accessible, particularly in combination with school data.

Second, the original methodology created a specific reference curve to translate NAPLAN points into EYL for a specific year, 2014. The curve would be slightly different for 2013, or 2015, or any other calendar year. This approach has the benefit of internal consistency within each year; for example, the median student in Year 3 in 2014 is by definition working at EYL 3.0. However, the use of a different curve for each year prohibits analysis of whether the performance of a school (or a state, or a particular subset of students, *etc.*) has changed over time.

For this report, and for our future analysis of NAPLAN results using EYL, we wanted a more generalised way of estimating EYL. In particular, we wanted to explore whether rates of student progress are static or changing over time. There are three main methodological differences between the approach used in this report to generate the EYL curve,[13] and the original approach described in detail in the *Widening Gaps* Technical Report:

- The reference curve now uses multiple years of data;
- The benchmark levels of achievement are now based on a restricted subset of data, the national mean achievement levels of metropolitan non-Indigenous students; and
- The method used to estimate EYL below EYL3 and above EYL9 has been updated.

Our internal analysis indicates that these methodological differences make the approach more robust, and more useful, than the approach described in *Widening Gaps*, while not changing the overall findings of that report. The revised EYL curves (one curve per NAPLAN domain) are available from the authors of this report and can be freely used by anyone who wishes to apply the EYL methodology.[14]

The remainder of this chapter describes the key details of the methodological updates.

3.1 Use of multiple years of data

For our *Measuring student progress* report, we have developed a single EYL reference curve for each NAPLAN domain, based on national results across multiple years of NAPLAN data, rather than a different curve for each calendar year. This gives a more reliable curve and also enables us to observe changes in overall achievement over time.

12. Goss and Chisholm (2016, p. 17).
13. This new approach has also been used in other recent analysis, specifically the Grattan Institute submission to the Closing the Gap Refresh process. Goss (2018).
14. Available on our website at https://grattan.edu.au/report/measuring-student-progress/. Please cite "Goss, P. and Emslie, O. (2018). Equivalent Year Level mapping of NAPLAN scale scores. Grattan Institute." when you use the curves.

We propose to use these reference curves at least until NAPLAN Online is fully established.

Data from 2010 to 2017 is used to develop reference curves for four of the five NAPLAN test domains: reading, numeracy, spelling, and grammar and punctuation. The writing curve uses data from 2011 to 2017. The inclusion of 2017 data maximises the amount of reliable data used to create the reference curve, while earlier data is excluded for three reasons, even though NAPLAN tests were administered annually from 2008.

First, mean scores from 2008 and 2009 for some domains and year levels are significantly different to those from years following. This observation is consistent with the NAPLAN test being refined over its first two years, and the first two years of data are ignored for all domains in all our analysis in this report.

Second, the ICSEA measure of school socio-economic advantage was updated in 2010. Given that our analysis in this report takes ICSEA into account, we look at results only from 2010 onwards. It is therefore consistent to define the reference curve from 2010.

Third, the NAPLAN writing test used a different scale before 2011. From 2008 to 2010, the NAPLAN writing test used a narrative prompt. The 2011 to 2015 tests used a persuasive prompt, and the 2016 and 2017 tests returned to using a narrative prompt. From 2016, new analytical methods were used to put the writing results onto the existing persuasive writing scale, creating a NAPLAN writing scale comparable for both genres. This means that 2016 and 2017 results can be compared with writing results from 2011 onwards, but results before 2011 are not directly comparable with later results.[15]

We note that the treatment of writing is consistent with ACARA's guidance on comparing writing results, which uses a base year of 2011, but not for other domains where ACARA uses a base year of 2008.[16] The key findings of our report are unchanged if the reference curves incorporate the earlier data, but given that we do not report data before 2010 anyway (because of the ICSEA change), it is prudent to define the reference curve from 2010.

3.2 Comparing against metropolitan non-Indigenous students

The first step in fitting the curve involves determining NAPLAN scores representing a reference level of achievement at Years 3, 5, 7 and 9.

We use the national mean NAPLAN scores for metropolitan non-Indigenous students, averaged over at least the past six years of NAPLAN tests.[17] This covers approximately 70 per cent of all students.[18] Mean scores are used rather than median scores because the mean score data is readily available.[19]

Indigenous and non-metropolitan students are two groups with known lower-than-average performance on NAPLAN, and therefore a different distribution of NAPLAN performance than metropolitan non-Indigenous students. In particular, Indigenous students are

15. ACARA (2017c, p. iv).

16. Ibid. (p. iv).
17. The ABS geolocation categories changed in 2016. Before 2016, we use the mean score for Metropolitan non-Indigenous students. For 2016 and 2017, we use the mean score for Major Cities non-Indigenous students. Some cities changed category, including capital cities such as Hobart and larger regional cities such as Cairns and Townsville, which are counted as Metropolitan but not Major Cities. Mandurah was not defined as Metropolitan before 2016, but is now included in Major Cities. The changes are sufficiently small that they are ignored.
18. These reported national means include results for absent and withdrawn students that have been statistically imputed by ACARA, while exempt students are excluded from the calculation. This means that the reported data should reflect the unbiased mean of all students within a given population, except for those who are exempt because of significant disabilities or because they recently arrived from overseas and have a language background other than English. ACARA (2017c, pp. vii-viii).
19. ACARA (2017a).

strongly over-represented at the low end of the curve. Excluding these students in the reference group used to fit the curve reduces statistical distortions in estimating the EYL curve. Of course, once the reference curve has been generated then it can be used to estimate the EYL of any student or group of students, with limitations only for very high and very low scores (see below for further explanation).

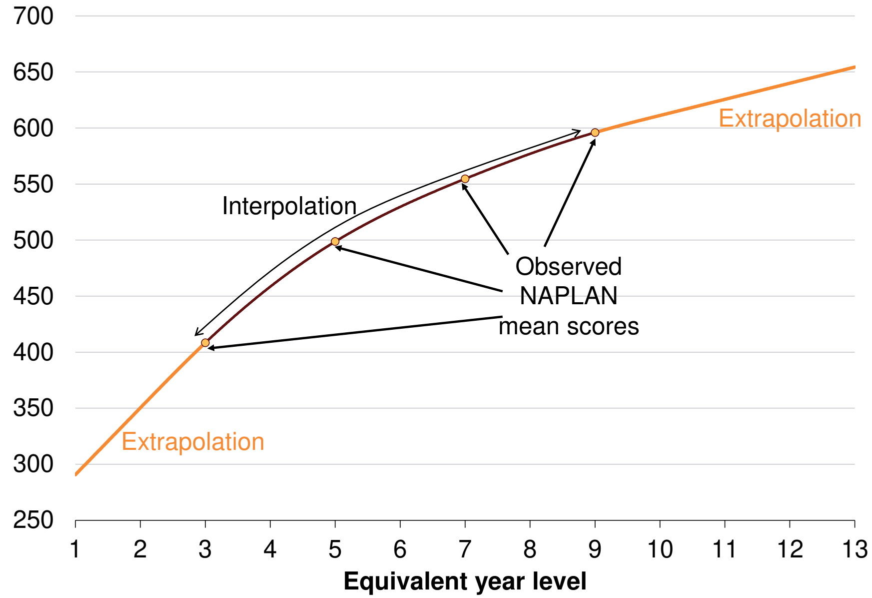
There is also a practical benefit to referencing the EYL curve against the achievement levels of metropolitan non-Indigenous students: it provides a more meaningful measure for many of the higher-achieving metropolitan schools. Using a curve based on national means including all students, many high-achieving schools will have mean EYL greater than Year 13. This makes analysis difficult, and, particularly for a progress measure, these high-achieving schools must be excluded from analysis. Using a curve excluding students with known disadvantage enables more schools to be included in the analysis, giving the analysis more credibility.[20]

Conceptually, it would be possible to use an even more targeted benchmark, such as the mean NAPLAN score of the middle 80 per cent of metropolitan non-Indigenous students by socio-economic status. This would remove the potential outlier groups at both the very advantaged and very disadvantaged ends of the socio-economic distribution. However, this data is not readily available, whereas ACARA publishes the national mean for metropolitan non-Indigenous students online.[21]

20. Referencing a higher-achieving group for the EYL curve also means more schools will be excluded from the analysis due to having a mean EYL below Year 1 level. But there are far fewer students attending schools with mean EYL around Year 1 than students attending schools with mean EYL around Year 13. Thus, the net effect of a higher-achieving reference group is to enable more students to be included in the analysis.
21. ACARA (2017a).

Figure 3.1: Estimating the Equivalent Year Level reference curve involves interpolation and extrapolation

Mapping of NAPLAN score to EYL, numeracy



Notes: Curve fitted to NAPLAN mean scores for metropolitan non-Indigenous students. Dots represent mean scores.

Source: Grattan analysis of ACARA (2017a).

3.3 The method used to estimate EYL below Year 3 and above Year 9

To fit the EYL curve between Year 3 and Year 9, we interpolate between the selected mean NAPLAN scores at Year 3, 5, 7 and 9 (see Figure 3.1). There is little scope for the EYL curve to vary between Year 3 and Year 9. However, fitting the curve below Year 3 and above Year 9 is far more open to different methods. To fit the EYL curve below Year 3, we:

- Fitted a quadratic curve that passes through the data means at Year 3, 5 and 7
- Extrapolated this quadratic to provide a value at Year 2. This answers "What does the curvature over the range [3,7] imply for where the value for Year 2 might lie?"
- Fitted a cubic spline through data points at Year 3, 5, 7 and 9, and the extrapolated point at Year 2
- Extrapolated this curve linearly over range [1,2]

We applied a similar method to fit the EYL curve above Year 9. Specifically, we:

- Fitted a quadratic curve that passes through the data means at Year 5, 7 and 9
- Extrapolated this quadratic to provide a value at Year 10. This answers "What does the curvature over the range [5,9] imply for where the value for Year 10 might lie?"
- Fitted a cubic spline through data points at Year 3, 5, 7 and 9, and the extrapolated point at Year 10
- Extrapolated this curve linearly over range [10,13]

Our analysis is that this approach gives better internal consistency than linear extrapolation below Year 3 or above Year 9.[22] We acknowledge that there is significant uncertainty involved in fitting the curve below Year 3 and above Year 9. As such, the true achievement level of schools is more uncertain at the extremes. We have included data in our analysis only between EYL 1 and EYL 13.

This gives more allowance at the high-achieving end, with the highest valid EYL point being four years beyond the highest measured point, the mean NAPLAN score in Year 9. Given the volume of schools achieving at the high end, we have sufficient confidence in the curve up to EYL 13.

EYL 13 cannot be thought of as representing the average for any given student cohort, because secondary school finishes at Year 12. However, when calculating student progress, we can think of EYL 13 as being the expected achievement level for a Year 9 student who achieved at EYL 11 in Year 7 if they progressed at the average rate for all students from Year 7 to Year 9.

22. Internal consistency can be tested by examining the curve that would be generated by school-level achievement and progress data, and comparing this to the curve generated using national means. This is because some schools achieve two years higher or lower than average, for example with a mean score of EYL 9 in Year 7 or a mean score of EYL 3 in Year 5. Examining the mean Year 9 score of the high-performing schools, and the Year 3 scores of the low-performing schools, gives an indication of how the EYL curve changes below EYL 3 or above EYL 9. The implications of this analysis on the best way to extrapolate the EYL curve can be cross-checked by the examining the counterfactual, the Year 9 achievement levels of schools that are low performers in Year 7, and the Year 5 performance of schools that are high performers in Year 3. By definition, these achievement levels are likely to be within the standard range of EYL 3 to EYL 9.

4 ICSEA adjustment and data exclusions in our analysis

This chapter provides additional detail regarding adjustments made in the analysis for relative advantage of schools. It also explains several data exclusions which were necessary to maintain the robustness of our findings.

4.1 Relative advantage of schools

The main report spells out the need to adjust for differences in relative advantage between groups of schools.

In our analysis, relative advantage of schools is measured by the Index of Community Socio-Educational Advantage (ICSEA), a scale that was developed by ACARA to enable NAPLAN scores to be compared fairly across schools.[23] Each school on the My School website has an ICSEA value. This value gives an indication of the level of the school's educational advantage.

ICSEA is the only measure that is available for all schools, calculated consistently nationwide, and specifically designed to measure school advantage.

The ICSEA formula takes account of four factors:

- Parents' education levels;
- Parents' occupations;
- The school's geographical location; and
- The proportion of Indigenous students.

Schools with students who have similar levels of educational advantage will have similar ICSEA values, even though they may be located in different parts of Australia and may have different facilities and resources. These schools can then be meaningfully compared, to see how their students perform relative to each other, or to identify schools that perform particularly well in NAPLAN. Indeed, the weightings of the four factors listed above are chosen to maximise the predictive power of ICSEA.[24]

4.1.1 Schools with ICSEA between 875 and 1124 included in analysis

ICSEA is defined as having a mean of 1000 and a standard deviation of 100. Our analysis has been limited to schools with ICSEA between 875 and 1124, because we are unable to reliably calculate a progress measure for many of the schools with ICSEA outside this range.

The EYL measure is considered reliable over the range from Year 1 to Year 13, as discussed in Section 3.3.

Schools with very low or very high ICSEA scores can have very low or very high scores in NAPLAN. These are hard to translate into EYL. For example, schools with an ICSEA score of 800 or below have an average Year 3 reading score of 288, which is below EYL 1. Meanwhile, schools with an ICSEA score of above 1200 have an average Year 9 reading score of 662, which is above EYL 13.

We cannot accurately calculate average student progress for schools which achieve an EYL lower than Year 1 level or higher than Year 13

23. ACARA (n.d.).

24. ACARA (2014).

level, and they must be excluded from our analysis.[25] At primary school level, around 0.4 per cent of schools have average annual achievement below Year 1 level in Year 3 NAPLAN, and are thus excluded from the analysis.[26] At secondary level, around 9 per cent of schools have average achievement above Year 13 level in Year 9 NAPLAN, and are thus excluded.[27]

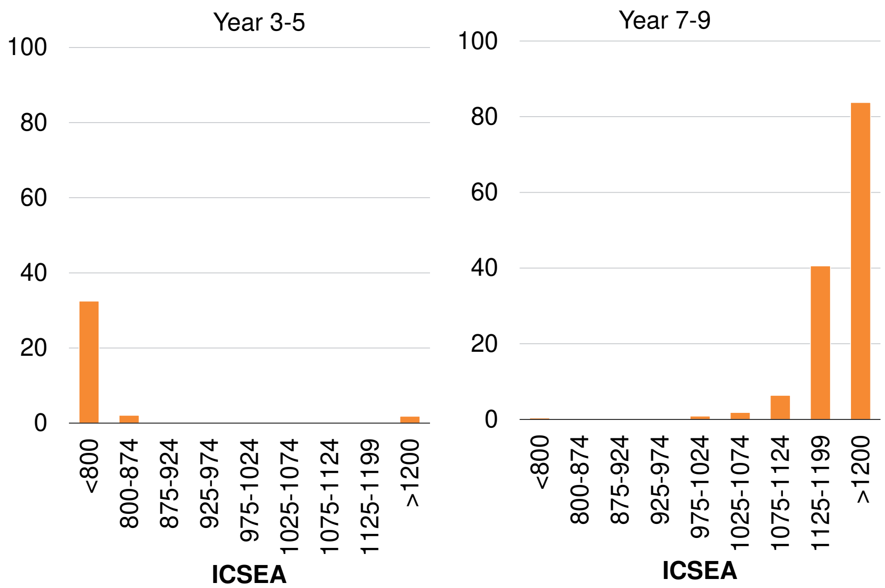
Excluding schools with very high or very low achievement creates a secondary issue. Since these schools are concentrated in very high and very low ICSEA bands, there is a risk that the remaining schools in these ICSEA bands will be unrepresentative of the ICSEA bands as a whole. The left-hand side of Figure 4.1 shows that 32 per cent of schools with ICSEA less than 800 would be excluded from Year 3-5 progress analysis due to very low achievement. The right-hand side shows that 41 per cent of schools with ICSEA between 1125 and 1199, and 84 per cent of schools with ICSEA 1200 or greater, would be excluded from Year 7-9 progress analysis due to very high achievement.

The exclusion of a significant proportion of schools is likely to cause significant distortion in the results within ICSEA bands above 1124 and below 875. Thus, our analysis has been limited to schools with ICSEA between 875 and 1124.[28]

25. Where a school achieved higher than Year 13 (or lower than Year 1) for a given student cohort, only that cohort is excluded. Other student cohorts from the same school are included.
26. There is also a very small number of schools with average achievement above Year 13 level at Year 5.
27. There is also a very small number of schools with average achievement below Year 1 level at Year 7.
28. For an average progress measure for a given student cohort at a school, we consider the ICSEA of the school in the initial year of the relevant two-year progress period. If a school had an ICSEA over 1124 or under 875 in a given calendar year, the cohort beginning in that year would be excluded from the analysis. So, for example, if a school had an ICSEA of 1126 in 2010, but less than 1125 in subsequent years, our analysis would exclude the 2010-12 cohort

Figure 4.1: At primary level, a significant proportion of low-ICSEA schools are excluded. At secondary level, a significant proportion of high-ICSEA schools are excluded

Proportion of students at schools with achievement higher than EYL 13 or lower than EYL 1, numeracy, 2010-12 to 2014-16 cohorts



Notes: Exclusion is due to one or both of the year levels of the matched student cohort achieving an EYL below Year 1 level or above Year 13 level. At primary level, this will typically be schools whose average achievement in Year 3 is below Year 1 EYL. At secondary level, this will typically be schools whose average achievement in Year 9 is above Year 13 EYL.

Source: Grattan analysis of ACARA (2017b).

ICSEA is defined as having a mean of 1000 and a standard deviation of 100, thus the ICSEA range we have included represents 1.25 standard deviations either side of the mean. Around 84 per cent of students are included in this ICSEA range.

Inclusion of ICSEA between 875 and 1124 means the conclusions of our analysis are generally applicable to schools with moderate advantage and disadvantage, but not necessarily applicable to schools which are extremely advantaged or extremely disadvantaged.

Schools with ICSEA less than 875 are likely to be remote, many with high Indigenous populations. These schools face unique challenges. To assess student progress at the most disadvantaged schools, a more detailed analysis of small data on student learning would be most appropriate, linked to specific factors affecting these schools.

Schools with ICSEA higher than 1124 are mostly high-fee independent schools, and very advantaged government schools, including selective schools in New South Wales. To assess student progress at the most advantaged schools, the NAPLAN test may not be the most relevant measure. With 40 standard questions, it does not clearly separate the top-performing students from each other.[29]

4.1.2 We consider ICSEA bands 50 points wide

To compare student progress on a like-for-like basis among states, we need to allow for differences in ICSEA distribution among states. One way to do this is to separate data into ICSEA bands, and compare schools in different states within the same ICSEA band.

Our analysis considers data separated into five ICSEA bands, 50 points wide. This band width corresponds to half a standard deviation.

Using these ICSEA bands, we have calculated ICSEA-adjusted differences in student progress from a national average, for each state, using the formula:

$$D_j = \sum_{i=1}^{5} d_{ij} w_{ij}$$

where:

D_j is the weighted difference from the average student progress for state j

i represents an ICSEA band (875-924, 925-974, 975-1024, 1025-1074 or 1075-1124)

d_{ij} represents the difference in student progress between state j in ICSEA band i and the average student progress for ICSEA band i

w_{ij} represents the proportion of students in state j who attend schools in ICSEA band i[30]

A similar method can be used for any group of schools, by replacing 'state' with, for example, 'sector', or 'region'.

Using five ICSEA bands rather than individual ICSEA scores gives stability to the calculated averages, and allows us to meaningfully understand whether differences in student progress are consistent across a range of ICSEAs. Using ICSEA bands also enable us to see trends which differ for different levels of relative advantage.

from that school, but include all later cohorts. Where it is necessary to calculate an ICSEA for an individual school across multiple cohorts, an average of the ICSEA across cohorts is used.

29. The NAPLAN Online test may better separate students at the extremes, because initial answers will determine the difficulty of later questions a given student is asked.

30. As a proportion of students in state j who attend schools with ICSEA between 875 and 1124.

There is a risk that analysis comparing data in ICSEA bands will be distorted, because we are considering some schools with ICSEA almost 50 points apart to be directly comparable. However, such distortions are likely to be slight.[31] Also, the risk is alleviated because our key findings relate to differences in student progress which are consistent across ICSEA bands and across years.

4.2 Other data exclusions

This section details segments of data which have been excluded from certain parts of our analysis, for reasons of segment size, or distortions introduced by heavy biases in particular ICSEA bands.

4.2.1 States with Year 7 in primary school are excluded from secondary school analysis

The data used for our analysis captures student progress only for students who attended the same school for two consecutive NAPLAN tests two years apart.

For Year 3-5 progress, this captures a majority of students, because most students attend the same school for the period from Year 3 to Year 5. For schools with ICSEA between 875 and 1124 (as per our analysis), between 70 and 80 per cent of students sitting the NAPLAN test are included in our student progress analysis, in all states and territories except the NT, where the proportion is around 65 per cent.

In most states, around 80 per cent of students attend the same school in Year 7 and Year 9. However, in Queensland, Western Australia and South Australia, over the period of our analysis, Year 7 was generally part of primary school rather than secondary school.[32] While some students in these states attend the same school in Year 7 and Year 9 (for example, some students attending K-12 schools), this is a clear minority in the three affected states. Around one-in-three WA students are included in the Year 7-9 progress data, one-in-five SA students, and one-in-seven Queensland students.

The students for which progress data is available in Queensland, Western Australia and South Australia are not a representative sample; for one thing, they are weighted heavily towards non-government schools. This means any findings from the included data would not necessarily be applicable to the state's students on the whole. Thus, we have excluded these three states from all analysis of Year 7-9 progress.

4.2.2 Schools with less than 13 students per year level are excluded from school size analysis

Our analysis of school size excludes schools with less than 13 students in each year level.

For schools with smaller numbers of students, the average NAPLAN score has a higher standard error; that is, there is more volatility in the annual average score recorded.

When small schools are spread between groups being analysed, this volatility of small-school averages will not have a significant impact. Results for small schools are weighted less, so will not greatly impact on results for, say, a particular state or school sector.

31. In most cases, schools are distributed fairly uniformly across each ICSEA band, in part because we have excluded schools with very low or very high ICSEA.

32. In 2015, Queensland and Western Australia began including Year 7 in secondary school. The first Year 7-9 cohort affected by this change would be the 2015-2017 cohort, after the period of this analysis.

However, for the analysis of student progress by school size, a group consisting of the smallest schools will have results that are highly volatile.

To avoid findings being exposed to too much volatility, we have excluded schools with less than 13 students per year level from the school size analysis.[33] These schools are included in all other analysis.

4.2.3 Sector analysis considers only three ICSEA bands

Our analysis compares student progress across school sectors only for schools with middle to high levels of relative advantage.

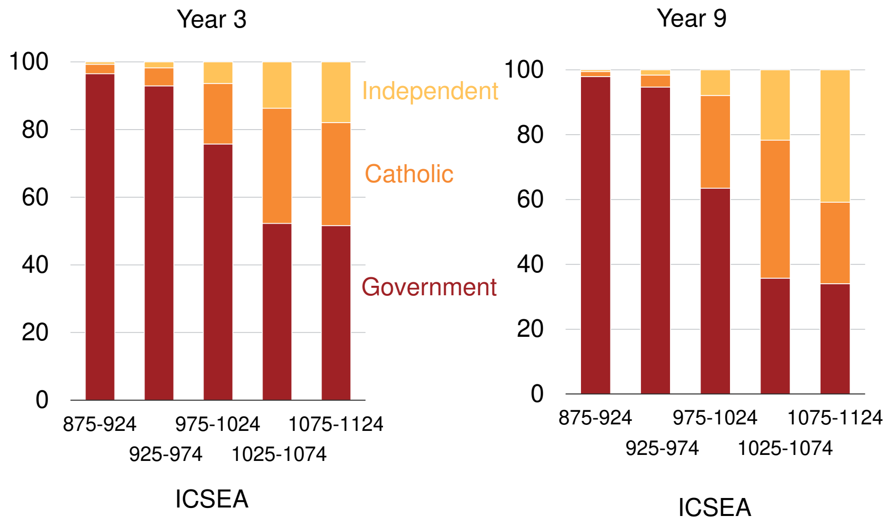
Non-government schools typically have higher ICSEA than government schools. Figure 4.2 shows that, of the five ICSEA bands we consider in our analysis, the lower two bands are dominated by government schools (97 per cent of students attending schools with ICSEA 875-924 are at government schools, as are 93 per cent of students attending schools with ICSEA 925-974).

Comparisons of student progress across school sectors within these ICSEA bands will be highly volatile due to the small proportion of independent and Catholic schools.

Due to the small number of non-government schools with low ICSEA, our comparisons of student progress by school sector include only three ICSEA bands: 975-1024, 1025-1074 and 1075-1124. That is, our analysis compares student progress across school sectors only for schools with middle to high levels of relative advantage. This is reasonable, because these are the only levels of advantage in which there are significant numbers of government, Catholic and independent schools.

Figure 4.2: Less-advantaged schools are more likely to be government schools

Proportion of students sitting numeracy NAPLAN test, by sector and school ICSEA band, average from 2010 to 2016, per cent



Note: ICSEA is the Index of Community Socio-Educational Advantage. ICSEA band 975-1024 is the average level of advantage; ICSEA band 1075-1124 is moderately advantaged; ICSEA band 875-924 is moderately disadvantaged.

Source: Grattan analysis of ACARA (2017b).

33. This is roughly one class per two grade levels.

4.2.4 Very remote schools are excluded from remoteness analysis

Our analysis of remoteness excludes schools classified as 'Very Remote'.

Our analysis of remoteness uses the Australian Statistical Geography Standard (ASGS) Remoteness Structure: Major Cities, Inner Regional, Outer Regional, Remote, and Very Remote.[34]

The very remote category contains less than 1 per cent of students. Of students attending schools with ICSEA in the range included in our analysis, less than 0.4 per cent are very remote.

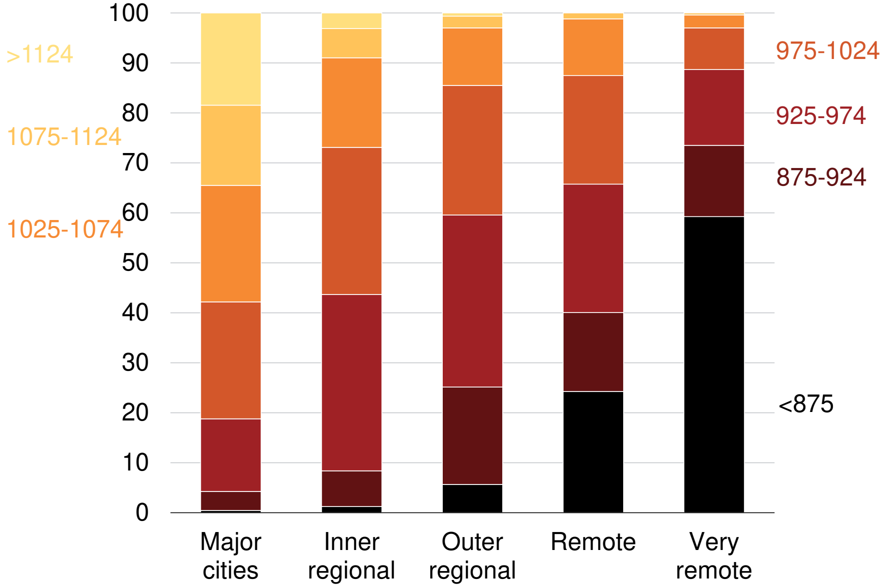
Figure 4.3 shows that around two-in-three of the students in very remote areas are at schools with ICSEA less than 875, and will thus be excluded from our analysis. Student progress for the remaining very remote schools will be very volatile, being such a small number of students, and may not be representative of very remote schools as a whole.

For this reason, we have excluded very remote schools from the analysis of remoteness. These schools are included in all other analysis.

There is a risk of over-correcting for rurality in the remoteness analysis, because rurality appears in both the ICSEA measure and our remoteness grouping. However the risk is small given remoteness makes only a small contribution in the ICSEA calculation, adding less than 0.1 per cent to the power of ICSEA to explain student achievement.[35]

Figure 4.3: Very remote schools typically have low ICSEAs

Proportion of students sitting Year 9 numeracy NAPLAN test, by remoteness and school ICSEA band, average from 2010 to 2016, per cent



Note: ICSEA is the Index of Community Socio-Educational Advantage. ICSEA band 975-1024 is the average level of advantage; ICSEA band 1075-1124 is moderately advantaged; ICSEA band 875-924 is moderately disadvantaged.

Source: Grattan analysis of ACARA (2017b).

34. The current version of the ASGS Remoteness Structure came into use in 2016. Our analysis of student progress uses the current structure for all historical data. ABS (2016).
35. Barnes (2010, p. 18).

5 Additional considerations in our analysis

The main measure compared across groups of schools is average student progress over a two-year period, either between Year 3 and Year 5, or between Year 7 and Year 9. The student progress measure is calculated as the average EYL NAPLAN score achieved at the end of the two-year period, less the EYL NAPLAN score at the start of the period for a matched cohort of students. In each case the matched cohort of students represents students who sat successive NAPLAN tests at the same school.

5.1 Converting mean NAPLAN scores to EYL

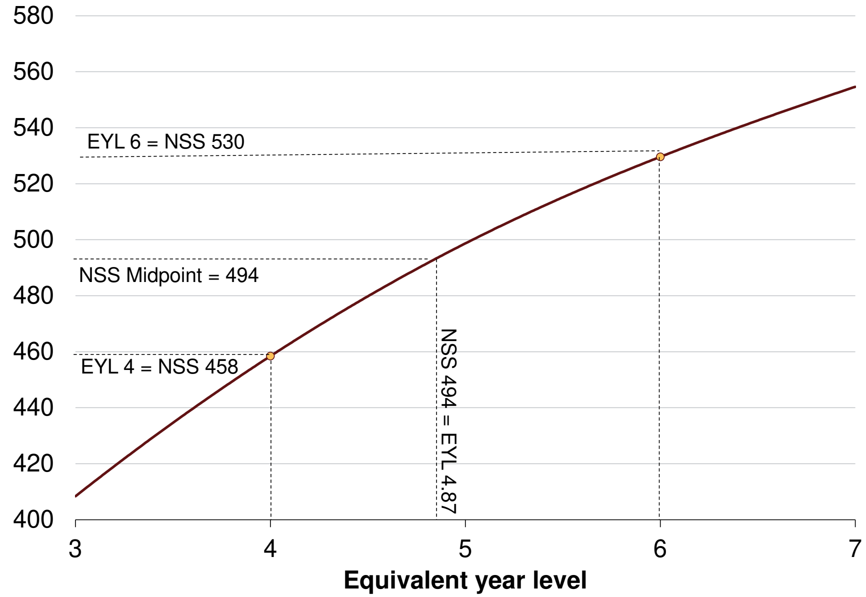
When calculating the average EYL achievement for a group of students (either for input into the progress calculation above, or to compare student achievement at a point in time), the ideal method would involve calculating the EYL achievement for each student, and taking the average of these EYL measures.

However, the data used for this analysis does not include student-level results, only mean NAPLAN scores at a school level. This makes the ideal method impossible, and we instead used a second-best methodology. The methodology we used is to calculate the mean NAPLAN score across all students attending a given group of schools (for example, across a state), then convert this mean NAPLAN score to an EYL.

In calculating average EYL achievement for a group of students, our second-best methodology will generally understate the average EYL achievement, due to the convex shape of the EYL curve. We can illustrate this with a simple example of two students, one achieving at Year 4 level in numeracy, and the other achieving at Year 6 level, illustrated in Figure 5.1. In this case, the 'true' average EYL achievement across the two students is Year 5 level. But using the second-best method, the

Figure 5.1: Using the second-best method will generally understate the mean EYL

Mapping of NAPLAN score to EYL, numeracy



Source: Grattan analysis of ACARA (2017a).

calculated average EYL is lower. EYL 4 represents a NAPLAN score 41 points lower than EYL 5, while EYL 6 is only 31 NAPLAN points higher than EYL 5. Thus, the mean NAPLAN score is five points below EYL 5 level. The mean NAPLAN score represents an EYL of 4.87, around one month of learning behind Year 5 level.

The distortion introduced by using the second-best methodology is exacerbated for groups of students with larger variation in achievement. This means we would calculate lower average achievement levels for a more varied group of students than a more homogeneous group, even if both groups had the same 'true' average EYL achievement.

When calculating a *progress* measure by comparing average EYL at the end of a two-year period with average EYL at the start of the period, the distortion from the second-best methodology is reduced, because it generally affects the starting EYL and final EYL to a similar extent. The distortion is thus mostly cancelled out, by taking the difference between two similarly distorted measures.

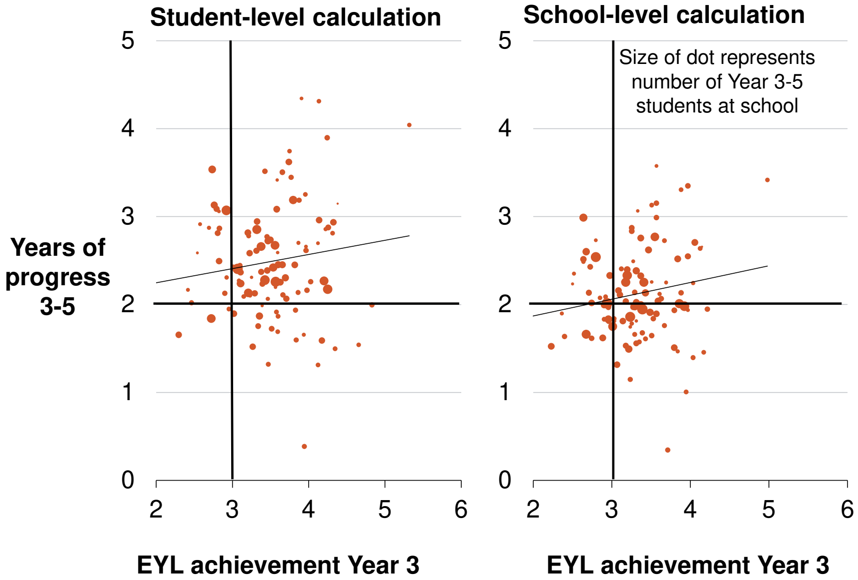
5.1.1 Conclusions are similar using school-level or student-level EYL calculations

We have been able to illustrate the difference between school-level or student-level EYL calculation, because we were able to obtain a small dataset with both student-level and school-level data.

This dataset includes about 100 schools at primary level and about 30 at secondary level. The schools in this dataset are not likely to represent a cross-section of Australian schools. They are all similar in geographical location and socio-educational advantage, and moderately more advantaged than average. However, the dataset can help indicate the impact of calculating measures based on school-level averages, as opposed to more accurate student-level information.

Figure 5.2: Conclusions change very little when using a student-level or school-level calculation of Years of Progress

Progress between Year 3 and Year 5 vs achievement in Year 3, 2011-13 cohort



Notes: This dataset includes about 100 schools at primary level. The schools in this dataset are not likely to represent a cross-section of Australian schools. They are all similar in geographical location and socio-educational advantage, and moderately more advantaged than average. The 'student-level calculation' involves calculating the EYL achievement for each student, and taking the average of these EYL measures. The 'school-level calculation' involves calculating the mean NAPLAN score across a school, then converting this mean NAPLAN score to an EYL.

Source: Grattan analysis of dataset of around 100 schools, provided on condition of anonymity.

Figure 5.2 on the preceding page illustrates the difference between the two calculation methods. Schools can 'shift' in both EYL and Years of Progress when the two different methods are used. However, the relative positioning of schools remains broadly consistent. In this example, we see that the positive relationship between prior achievement and progress holds true when using a student-level or school-level calculation of achievement and progress.

5.1.2 Reporting relative progress data

Another way we reduce distortion is by comparing the student progress measure for a relevant group of schools to that of other comparable groups of schools, rather than reporting an absolute progress measure. This means that any remaining distortion in progress measures is likely to be mostly 'cancelled out', provided the distortion is similar between comparable groups of schools. The size of the distortion is likely to be similar between comparable groups of schools, provided the variation in student achievement is reasonably similar between the groups.

5.2 School-level versus student-level modelling

Our analysis was conducted on school-level data. NAPLAN scores in the data we have used are an average at school level. The ICSEA measure for a school is also essentially based on an average of socio-economic characteristics across the student body at a school. Thus, we are unable to see the spread of results within a school, or any correlation between progress and socio-economic characteristics at a student level.

For example, we can see clearly that schools with a higher socio-economic student cohort have higher average student progress. But within a given school, we cannot see whether students of higher socio-economic status make more progress than students of lower socio-economic status. That is, we observe between-school variation, but not within-school variation.

Were our analysis to be based on student-level data, including student-level results and characteristics, it is likely that our findings would be somewhat different. This analysis would have the potential to more precisely identify differences by establishing more accurately the expected student progress for a school, based on individual characteristics of its student population.

The results shown in the main report could have been more precise had we been able to include student-level data. However, our key findings relate to effects that are visible across different annual student cohorts, *and* across different ICSEA bands.

For example, one of our key findings is that Queensland schools make above-average student progress at primary level for numeracy and reading. Additional uncertainty introduced by modelling at a school level could possibly make Queensland's student progress look better than it really is for schools in one ICSEA band, or for one annual cohort. However, Queensland's above-average student progress is observable across all five ICSEA bands, and across all five annual cohorts.

The fact that this observation of above-average progress is so consistent reduces the likelihood that it is a 'false positive' result created by our need to model student progress at school level rather than student level.

5.3 Multiple regression

Our findings in the main report regarding the differences in student progress between groups of schools are based on two-way comparisons: we adjust for the effect of ICSEA, then consider the differences between schools with different values of one other characteristic (for example, different states, different sectors, different sizes).

A risk with this method is that our findings could be distorted by interactions between measurable characteristics. For example, imagine a scenario where, in every state, students at independent schools make 2.5 years of progress across two years on average, while students at government and Catholic schools make 1.5 years of progress. In this case, there is no real difference between states; the only difference is between sectors. However, if a higher proportion of students in NSW attend independent schools, our analysis would show NSW schools achieving higher student progress on average.

We explored the possibility of strong interactions between different school factors using a series of three-way analyses. For example, we looked at comparative progress of government, Catholic and independent schools within the four large states, as well as for the nation as a whole. These state-level results are not reported because they are broadly similar to the national picture, but with higher uncertainty due to smaller sample sizes.

We are able to test whether our findings are unduly influenced by correlations of this kind by using multiple regression. Multiple regression is a technique that can isolate the effect of a given factor in the absence or presence of other factors.[36] If our key findings are evident under a multiple regression model as well as the two-way analysis we have used, it strongly suggests that our conclusions are not materially distorted by interactions.

Table 5.1 on the next page shows that the key findings contained in this report are supported by multiple-regression analysis.

36. Our regression method also allows for heteroscedasticity by calculating robust standard errors. This reduces the chance that multi-level modelling would generate different results.

Table 5.1: Key findings in this report are supported by multiple-regression analysis

Finding	Support from regression
Queensland makes above-average student progress at primary level for numeracy and reading	The effect is positive and significant for both subjects at primary level
New South Wales stretches more-advantaged schools, Victoria supports less-advantaged schools	Lower ICSEA slope in Victoria, significant at Year 7-9 for all subjects
The ACT makes less progress at primary and secondary level	The effect is negative for all three subjects at primary and secondary level, and significant for all except Year 7-9 reading
South Australia makes less progress in primary school	Significantly below national average in numeracy and reading
Tasmania's results are better than expected	Not significantly worse than the national average in any domain/year level
The NT's results are better than expected	Not significantly worse than the national average in any domain/year level
Sectoral differences aren't big nationally	The biggest variation is around 2.5 months for Year 7-9 writing. The next biggest is around 1.5 months for Year 7-9 numeracy and reading. By comparison, state differences are up to four months at Year 3-5 and seven months at Year 7-9
Regional differences aren't big once ICSEA is taken into account	The variations are all less than two months of progress
Differences among schools of different sizes aren't big, although small secondary schools make the most progress	The variations are mostly less than two months. Secondary schools with fewer than 50 students have a positive and significant effect in all three subjects

Source: Grattan analysis of ACARA (2017b).

5.4 Using school advantage rather than prior achievement for 'like-for-like' comparisons

We have adjusted for relative school advantage, using ICSEA, to compare schools on a like-for-like basis.

An alternative method would be to use prior achievement in place of school advantage, for example adjusting for the average level of achievement in Year 3 when comparing average Year 3-5 progress across schools.

This would acknowledge that there is a strong positive relationship between prior achievement and student progress, known as the 'Matthew Effect'.[37]

In effect, adjusting for ICSEA rather than prior achievement assumes that a school's students should be expected to make similar progress to those at similarly advantaged schools elsewhere, regardless of their starting point. This is a reasonable expectation for a school.

ICSEA is also a more powerful predictor of student progress than prior achievement. At a school level, ICSEA explains more of the variation in student progress than prior achievement for all subject domains and year levels, with the exception of Year 7-9 numeracy (see Figure 5.3). In fact, once ICSEA is included in a regression model, prior achievement adds only minimal additional explanatory power (see Figure 5.4 on the next page).

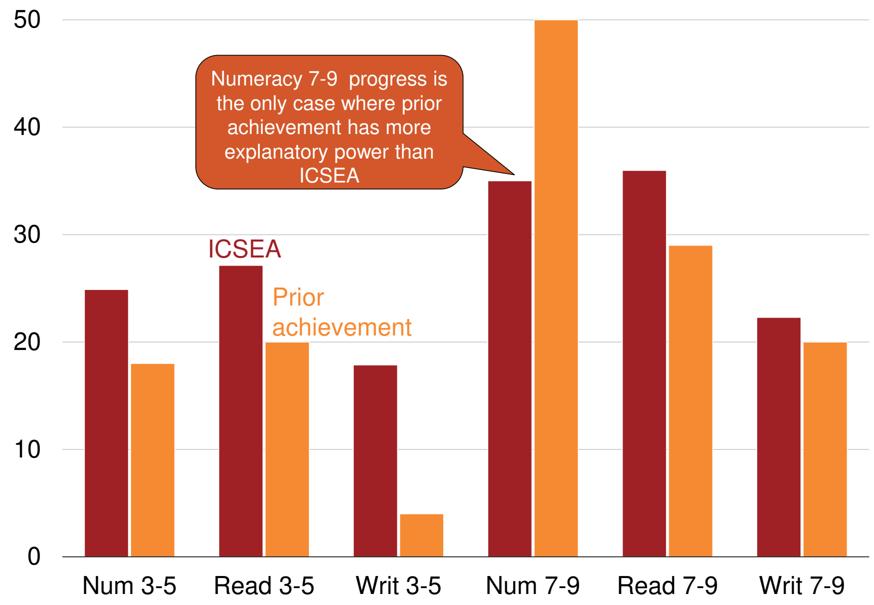
5.5 Potential for mis-measurement of school advantage by state

To confirm the robustness of our findings, we conducted further investigation into the potential for a bias in the ICSEA measure for particular

37. Discussed in Section 4.3 of the main report, also Goss and Sonnemann (2016), Masters (2005, p. 17), Allington (2008), Dougherty and Fleming (2012) and Hanson and Farrell (1995).

Figure 5.3: ICSEA explains more of the variance in student progress than prior achievement for most subjects and year levels

Proportion of variance in student progress explained, per cent



Notes: Data shown are R-squared values from regressions of school-level student progress in NAPLAN (translated into EYL), averaged across relevant year levels and domains. The progress dataset includes five cohorts (2010-12 to 2014-16) for numeracy and reading, and four cohorts (2011-13 to 2014-16) for writing. The regression models include either ICSEA or prior achievement as a linear explanatory variable.

Source: Grattan analysis of ACARA (2017b).

states or territories, especially the ACT. We found no evidence of a significant bias in ICSEA as a measure of school advantage. It is unlikely that such a bias in ICSEA could materially influence our findings.

Our methodology adjusts for ICSEA to compare states and territories on a 'like-for-like' basis. While ICSEA is the most appropriate nationally-available measure to use for this purpose (see Section 4.1 on page 15), it is *possible* that ICSEA over- or under-states the true socio-educational advantage in some jurisdictions, particularly in smaller states or territories with a non-typical demographic, such as the ACT.

In particular, our finding that ACT schools make less student progress on a 'like-for-like' basis is evident across subject domains and year levels, which is consistent with a systematic over-statement of school advantage in the ACT.

Preliminary testing of our results indicates that the bias would need to be very large in ICSEA to change our results. If ACT schools are, in reality, making similar student progress to the rest of Australia on a 'like-for-like' basis, our results could only be explained by ICSEAs in ACT schools being overstated by around 30 points on average.[38]

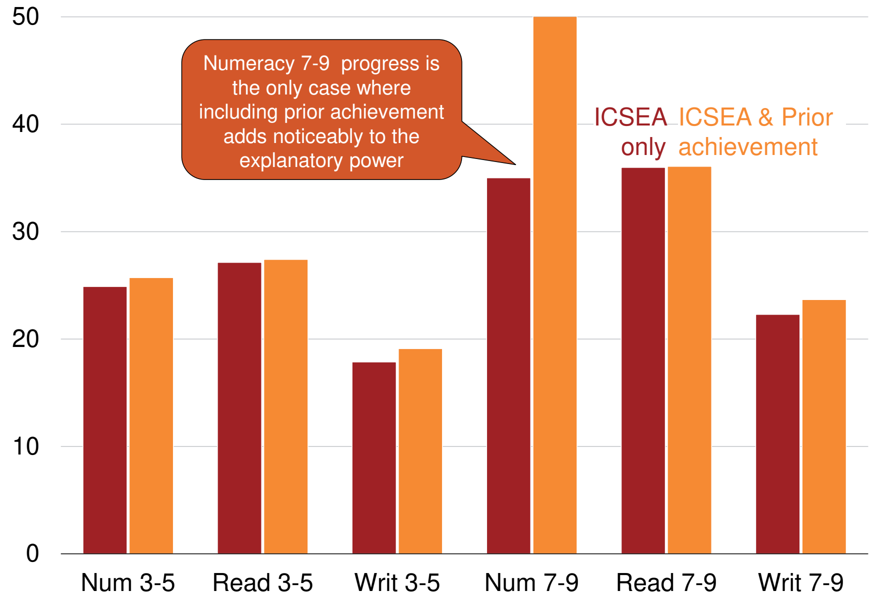
5.5.1 Potential for systematic bias arising from ICSEA mis-measurement

The calculation of ICSEA is based on four factors:

- Parental education levels
- Parental occupation
- School geographic location

Figure 5.4: Prior achievement adds little explanatory power once ICSEA is accounted for

Proportion of variance in student progress explained, per cent



Notes: Data shown are R-squared values from regressions of school-level student progress in NAPLAN (translated into EYL), averaged across relevant year levels and domains. The progress dataset includes five cohorts (2010-12 to 2014-16) for numeracy and reading, and four cohorts (2011-13 to 2014-16) for writing. The regression models include ICSEA only, or ICSEA and prior achievement, as linear explanatory variables.

Source: Grattan analysis of ACARA (2017b).

38. Around 40 points in numeracy, around 20 points in reading.

- The proportion of Indigenous students.[39]

We can speculate about potential sources of a bias that would mean ACT schools are less advantaged than their ICSEA measure would suggest. However, none are likely to cause a bias large enough to have a material impact on our findings.

- **Remoteness** – A distinctive feature of the ACT is that there are no remote schools. Almost all the ACT falls into the 'major cities' category.[40] However, remoteness has little impact on ICSEA measures in the ACT. ICSEA values are driven more by parental education and parental occupation. If remoteness and indigeneity were excluded from the ICSEA calculation, we estimate ICSEA in the ACT could be no more than three points lower – clearly insufficient to explain our results.

- **Classroom diversity** – Macintosh et al. (2017, Section 4.1) raised the possibility that ACT schools are more diverse than similar-ICSEA schools elsewhere. That is, for a given *average* level of student advantage, ACT schools may have more students in the top *and* bottom quartiles of the socio-educational advantage distribution, compared with more homogeneous schools elsewhere.[41] But we were able to investigate further, and found that, on average, ACT schools have a similar proportion of students in the top and bottom quartiles of the socio-educational advantage distribution, compared with similar ICSEA schools elsewhere.

- **Classification of government employees** – The ACT has a higher proportion of government employees than other states and territories.[42] It is possible that people working in low- to mid-level government positions may be classified in a higher-than-warranted parental occupation category for ICSEA. This could bias towards high ICSEAs for ACT schools, if these parents are, on average, less advantaged than parents in the equivalent parental occupation category elsewhere in Australia.[43] We cannot disprove the possibility that mis-classification of government employees could be causing a significant bias in ICSEA for ACT schools, but there is little evidence that it is doing so. This imay be an area for further investigation.

39. ACARA (n.d.).
40. 99.8 per cent of ACT students are categorised as being in 'Major cities', compared with 70 per cent nationally.
41. The ACT has a high proportion of 'diverse' suburbs, that is suburbs with high numbers of both the most and the least disadvantaged individuals living side by side (ACT Government (2012)). However, this does not necessarily mean we would expect *schools* to be more socially diverse.
42. Around 24 per cent of the population are government employees, compared with around 8 per cent in the rest of Australia. Grattan analysis of ABS (2017) and ABS (2018).
43. Parental occupation is captured in the following categories:
    - Senior management in large business organisation, government administration and defence and qualified professionals
    - Other business managers, arts/media/sportspersons and associate professionals
    - Tradesmen/women, clerks and skilled office, sales and service staff
    - Machine operators, hospitality staff, assistants, labourers and related workers
    - Not in paid work in past 12 months

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