National Foundation
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Renaissance Learning Equating Study

Report

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1 Executive summary

- An equating study was carried out in autumn 2006 by the National Foundation for Educational Research (NFER) on behalf of Renaissance Learning, to provide validation evidence for the use of the Renaissance Star Reading and Star Mathematics tests in English schools. The study aimed to investigate the correlation between the Star tests and established tests.

- Between 11 and 16 schools were involved in the study, with completed Progress in Mathematics paper tests received from 2006 primary pupils and 883 secondary pupils. Suffolk Reading Scale 2 tests were completed by 1968 primary pupils and 1034 secondary pupils.

- The numbers of pupils who took both the Renaissance Learning Star Reading test and the Suffolk Reading Scale 2 tests were close to the required number and provided a good basis for the analyses; this was also the case for the Renaissance Learning Star Mathematics test and the Progress in Mathematics tests.

- A strong correlation was established between Star Reading and the Suffolk Reading Scale 2 tests (Pearson correlation coefficient of 0.91).

- Star Reading scores were related to reading ages derived from the Suffolk Reading Scale 2, providing an equating graph for comparative purposes.

- Star Mathematics and Progress in Mathematics (PiM) tests were shown to correlate reasonably strongly (correlation coefficients ranging from 0.58 to 0.75 for different PiM tests).

- Star tests and English national curriculum teacher assessment levels correlated well (0.85 for reading and 0.81 for mathematics), particularly in view of the short length of the tests.

- Star Mathematics was equated to the English national curriculum level equivalents given in Progress in Mathematics; the correlation was good (0.84).

- The strong correlations provide evidence that both Star Reading and Star Mathematics are suitable for use in England.

- None of the results should be regarded as absolute; the appropriate sections of the report indicate any caveats.

2 Introduction

This is the report of the empirical equating study carried out as part of the launch of Renaissance Learning products in the UK, for which a variety of validation measures were required.

2.1 Aims

According to current thinking[1], the validation of a test consists of a systematic investigation of the claims that are being made for it. In the case of Star Reading and Star Mathematics, the claims are that the tests give an accurate and useful indication of students' reading and mathematical attainment. The tests are in wide use in the US, but the UK launch of the products required evidence that these claims could be made in the new educational context.

One well-established method of validation is the collection of 'concurrent' evidence. If scores on the tests to be validated correlate highly with established tests that have an already validated claim, this correlation is evidence for the validity of the new test. This equating study therefore aimed to collect concurrent validation evidence by testing the same students on Star Reading and Star Mathematics and on tests or assessments of the same subject-matter, already established in the UK. The hoped-for outcomes were:

- A substantial correlation between data from Star Reading and an established UK reading test, demonstrating that Star Reading tests the same construct as the UK test
- An equating graph showing the relationship of Star Reading scores to established reading ages, in order to include UK reading ages as an additional outcome for the Star tests

[1] See, for example: American Educational Research Association, American Psychological Association and National Council on Measurement in Education (1999). *Standards for Educational and Psychological Testing.* Washington, DC: AERA.

- A substantial correlation between data from Star Mathematics and an established UK mathematics test, demonstrating that Star Mathematics tests the same construct as the UK test

- A good correlation between the Star tests and England national curriculum teacher assessment levels, together with cut-scores on the RL ability scale. A good correlation would demonstrate that the Star tests are relevant to the England curriculum. (As the national curriculum levels are defined broadly, including aspects such as practical mathematics, full coverage cannot be expected in a short test.)

- A good correlation between the Star Mathematics tests and the national curriculum level equivalents given in the Progress in Mathematics tests; aligned with these, equivalent cut-scores on the RL ability scale.

2.2 Methodology

The Renaissance Learning tests concerned were the computer-administered adaptive tests: Star Reading; and Star Mathematics. The UK paper-based tests were selected on the basis of being well regarded and widely used, as well as relatively recently standardised for the relevant age group (from age 6 to 14 years). These were:

- Progress in Mathematics 6-14, by Tandi Clausen-May, Hanna Vappula and Graham Ruddock of NFER, published by nferNelson, standardised in 2003

- Suffolk Reading Scale 2, by Fred Hagley, published by nferNelson, standardised by NFER in 2001.

There is one test for each year group in the Progress in Mathematics series, with no overlapping items, but the Suffolk Reading Scale 2 comprises three levels for the age range, with some shared items. Primary pupils took Level 1 and 2 tests and secondary pupils took Level 3 tests. For mathematics, pupils took the age-appropriate test.

Pupils were required to take the computer-administered and paper-based tests within a two week period, initially designated as 2nd to 13th October 2006. This testing period was extended because schools reported various difficulties and therefore failed to complete all the tests with pupils within the time available. In order to compensate

for this shortfall, an additional three schools were added to the original sample and the time frame was extended to the first week in December. The final parcel of completed tests was delivered to the NFER in the second week of December.

Background information on the pupils involved was also collected. This included date of birth, gender, home language, special educational needs and eligibility for free school meals, a proxy measure of social deprivation. The latter variable is statistically associated with lower attainment. This information was gathered by means of a pupil data form (pdf) that was placed on the Renaissance Learning website. The final school returned this data in mid-January.

2.3 The samples

Samples for the study were provided by Renaissance Learning from schools known to be using their products. The samples required were specified as 450 pupils for each test in each of the relevant age groups (year 2 to year 9 inclusive). In order to allow for this number, materials for 500 pupils were provided for each test and year group.

The original plan was that Renaissance Learning would select 20 primary and 20 secondary schools to take part, testing both reading and mathematics. In the event, recruiting this number of schools proved more difficult than Renaissance Learning had anticipated and the trial took place with fewer schools in the initial sample. This number was further reduced as some schools declined to participate, a situation that did not become apparent until well into the testing period.

Tables 2.1 to 2.3 give details of materials sent out and completed, by test and subject. The details of the mathematics tests are divided according to primary (6-11) or secondary (12-14) age range.

Table 2.1: Primary mathematics (Progress in Mathematics 6-10)

Year group	**2**	**3**	**4**	**5**	**6**
Age	**6-7**	**7-8**	**8-9**	**9-10**	**10-11**
Test	**PiM6**	**PiM7**	**PiM8**	**PiM9**	**PiM10**
Number of schools in sample	17	17	17	17	17
Schools allocated materials	12	13	14	14	13
Schools returning used materials	12	13	14	14	13
Schools not submitting pupil data	1	1	1	1	1
Number of pupils allocated tests	364	404	458	462	385
Number of completed tests returned	**352**	**394**	**434**	**453**	**373**

Table 2.2: Secondary mathematics (Progress in Mathematics 11-13)

Year group	**7**	**8**	**9**
Age	**11-12**	**12-13**	**13-14**
Test	**PiM11**	**PiM12**	**PiM13**
Number of schools in sample	20	20	20
Schools allocated materials	12	13	11
Schools returning used materials	11	12	10
Schools not submitting pupil data	5	5	5
Number of pupils allocated tests	364	476	372
Number of completed tests returned	**287**	**341**	**255**

Table 2.3: Reading (Suffolk Reading Scale 2)

Year group	**2-3**	**4-6**	**7-9**
Age	**6-8**	**8-11**	**11-14**
Test	**SRS L1**	**SRS L2**	**SRS L3**
Number of schools in sample	17	17	20
Schools allocated materials	15	14	15
Schools returning used materials	15	14	15
Schools not submitting pupil data	1	1	5
Number of pupils allocated tests	764	1,305	2,069
Number of completed tests returned	**713**	**1,255**	**1,034**

All the schools were in England, rather than other parts of the UK. The samples of schools were never expected to be representative of all schools in England, but the two were nevertheless compared to the national population. Because of the small numbers of schools involved, it was not possible to establish if the differences were significant. In primary schools, there was a greater representation of schools from the Midlands and those in the lowest band of key stage 2 attainment in the sample. Additionally, there was a much higher representation of schools from London Boroughs than in the national population. In terms of secondary schools in the sample, a higher percentage came from the Midlands, but rather more of these came from the middle and second highest bands of key stage 3 attainment for reading. For mathematics, nearly half the secondary schools were in the middle band of attainment for key stage 3.

3 Outcomes

Progress in Mathematics (PiM) tests were marked and checked by NFER researchers and the data was entered by the NFER's Database Production Group. The data from the Suffolk Reading Scale 2 tests (SRS) were entered directly as no marking was required.

This test level data was then matched to background data. A further match was made to pupils' Rasch ability score for the Star Reading and Star Mathematics tests. The latter data was provided by Renaissance Learning (RL). Both RL and NFER staff made great efforts to persuade schools to complete all the background data, but in spite of this, some pupils had incomplete data and were therefore excluded from the final analyses.

3.1 Teacher assessment levels

Teacher assessment levels give an indication of the spread of attainment of the pupils in the sample. They are based on the national curriculum in England and are therefore not applicable to the UK as a whole, where four different education systems are in operation (England, Scotland, Wales and Northern Ireland). The levels used in this analysis were derived from the pupil data forms. The numbers of pupils at each level for reading (for those pupils for whom data was available) are shown in Table 3.1.

Table 3.1 Teacher assessment levels for reading

	Frequency	Percent	Cumulative Percent
Working towards Level 1	49	1.8	1.8
Level 1	239	9.0	10.9
Level 2	671	25.3	36.2
Level 3	537	20.3	56.5
Level 4	567	21.4	77.8
Level 5	480	18.1	96.0
Level 6	92	3.5	99.4
Level 7	12	0.5	99.9
Level 8	3	0.1	100.0
Total	2650	100.0	

As can be seen in the table, there were substantial numbers of pupils between Levels 2 and 5, with enough for analyses at Level 1 and 6. Any results relating to Levels 7 and 8 should be treated with considerable caution because of the low numbers of pupils.

The teacher assessment levels for mathematics are shown in Table 3.2.

Table 3.2 Teacher assessment levels for mathematics

	Frequency	Percent	Cumulative Percent
Working towards Level 1	28	1.0	1.0
Level 1	197	7.3	8.3
Level 2	864	31.8	40.1
Level 3	604	22.2	62.3
Level 4	466	17.2	79.5
Level 5	379	14.0	93.4
Level 6	136	5.0	98.5
Level 7	39	1.4	99.9
Level 8	3	0.1	100.0
Total	2716	100.0	2716

As for reading, there were substantial numbers of pupils at levels 2 to 5, with enough

for analysis at levels 1 and 6. The low numbers of pupils at levels 7 and 8 indicate that any results for these levels should be treated with caution.

3.2 Test scores

3.2.1 Suffolk Reading Scale test scores

Pupils' mean scores on the three levels of the Suffolk Reading Scale 2 are shown in Table 3.3. The table also shows the numbers of pupils in the sample.

Table 3.3: Mean scores in Suffolk Reading Scale tests

	SRS1A	SRS2A	SRS3A
Marks available	75	86	76
Mean score	35.1	50.0	48.4
Median	37	52	49
Standard deviation	17.0	13.5	11.0
Mark range	0-71	6-80	2-72
Age standardised score – mean	96.3	99.3	100.4
– standard deviation	15.3	14.8	13.7
Number	*713*	*1255*	*926*
Number boys / girls	*337 / 371*	*633 / 600*	*376 / 499*

The age standardised scores give an indication of the overall attainment of the sample, as the nationally standardised mean is set to 100, with a standard deviation of 15. This shows that the samples were very close to average attainment overall, with the sample for SRS1 being slightly lower-attaining than the national average. Boys and girls were fairly evenly represented in SRS1 and SRS2, with a higher proportion of girls in SRS3. There was no statistically significant difference between their mean scores, which were very close to the mean score for the relevant test.

Pupils' performance was also analysed by the 'free school meal' variable. The mean scores of pupils identified by this variable were consistently lower than those of the rest of the samples; the difference was statistically significant for SRS1 and SRS2, but there was no significant difference between the mean scores of these groups for SRS3.

As would be expected, scores by teacher assessment levels increased level by level with mean scores showing statistically significant differences in most cases.

Where the differences were non-significant, the levels were at the extremes for the age group.

The reliability coefficient (Cronbach's Alpha) was very good for all three tests, ranging from 0.97 for SRS1 to 0.92 for SRS3, showing that the tests were internally consistent and were measuring the same construct – something to be expected in established tests of this nature.

3.2.2 Progress in Mathematics test scores

Pupils' mean scores on the Progress in Mathematics tests are shown in Table 3.4. The table also shows the numbers of pupils in the sample.

Table 3.4: Mean scores in Progress in Mathematics tests

	PiM 6	PiM 7	PiM 8	PiM 9	PiM 10	PiM 11	PiM 12	PiM 13
Marks available	28	28	35	45	45	50	50	50
Mean score	18.7	17.2	21.7	25.3	24.8	31.7	27.9	23.0
Median	20	18	23.5	26	25	35	28	22
Standard deviation	6.0	5.7	8.4	10.2	10.5	11.8	10.6	11.6
Mark range	2-28	2-28	0-35	3-44	1-45	1-50	0-49	1-50
Age standardised score – mean	92.7	90.8	96.9	96.6	95.2	95.3	100.9	98.7
– standard deviation	16.2	14.2	16.4	15.4	14.4	14.2	14.2	12.6
Number	*352*	*394*	*434*	*453*	*373*	*287*	*341*	*255*
Number: boys	*170*	*180*	*206*	*242*	*194*	*134*	*141*	*113*
girls	*175*	*206*	*217*	*202*	*176*	*151*	*199*	*142*

The age standardised scores show that the pupils in the primary age groups were, on average, rather low attaining, whereas the secondary pupils were close to the national average. There were more girls than boys in the sample overall, with girls outnumbering boys by between five and 58 cases on all tests with the exception of PiM 9 and 10 (for pupils age 9-11). There was no statistically significant difference in their mean scores apart from the highest test, PiM 13, where the higher mean score for boys (25.8) was significantly different from that of girls (20.8) at the one per cent level of significance (highly significant in statistical terms).

As for the reading tests, pupils' performance was also analysed by the 'free school meal' variable. There was a statistically significant difference between the mean scores of those pupils receiving free school meals and other pupils for all the tests apart from PiM 12 and 13. The level of significance varied, with PiM 7, 10 and 11 showing the most significant difference.

As would be expected, scores by teacher assessment levels increased level by level with mean scores showing statistically significant differences in most cases.

The reliability coefficient (Cronbach's Alpha) was very good for all tests, ranging from 0.87 for PiM 7 to 0.94 for PiM 11 and 13.

4 Equating

4.1 Equating reading

4.1.1 Scores

To equate the RL and the Suffolk Reading scale in terms of ability, two methods were used: the first equated raw scores on the Suffolk Reading Scale to the RL Star Reading tests. The graphs relating to this model are Figures 1.1 to1.3 in Appendix 1. For any given score on the test on one axis, the equivalent score on the other test can be read off from the other axis. The broken lines on the graph are the 95 per cent confidence intervals, representing a five per cent 'margin of error' for the equating line. These graphs show that for SRS1, the confidence intervals are quite narrow for the range of scores, whereas for SRS2 and SRS3 the confidence bands are much wider at lower scores. The narrower the confidence interval, the greater is the reliability of the equating findings. Individually, the correlation coefficient of each of these with the RL Star Reading scale was good: for SRS1 it was 0.84, for SRS2 it was 0.88 and for SRS3 it was 0.78.

The second method involved two stages: The Suffolk raw scores were equated to a Suffolk ability scale using a 2-parameter IRT model. This was possible because there were common items in the different tests. The resulting graphs, by test, are Figures 1.4 to 1.6 in Appendix 1. This ability scale was then equated to the RL Star Reading ability scale. The resulting graph can be seen in Figure 1.7 in Appendix 1. This method of equating would seem to be more reliable as it makes use of the whole sample measure of reading ability, whereas the alternative one stage model is done for each of the three Suffolk tests. Using the evidence from this graph, where zero on the Suffolk scale equates to greater than zero on the RL scale, it would seem that the RL Star Reading test is designed for slightly less able pupils overall and is certainly appropriate for the pupils tested. It should be noted that the width of the confidence intervals at the top and bottom of the graph indicate that there is more uncertainty in these areas. The overall correlation of the Suffolk ability scale to the RL ability scale was 0.91, a high figure which shows that both tests are likely to be concerned with a similar construct of reading.

4.1.2 Reading ages

Direct equipercentile equating was used to link SRS reading ages to the RL Star reading tests. The resulting graph can be seen in Figure 1.8 in Appendix 1. Reading ages above 192 months (16 years) have been excluded as suggested in the Teacher's Guides that accompany the tests.

The graph shows that although both scales increase together, they do not increase at a uniform rate. In spite of this, reading ages can be read off the graph for any Star reading ability. For example, a RL ability of 0 would give a reading age of 104 months (8 years 8 months). A score of 2 on the RL scale would give a reading age of 131 months (10 years 11 months).

When using reading ages, it should be noted that there is some uncertainty in the original reading ages given in the Suffolk Reading Scales because reading ages are derived from the standardised score calculations and represent a less reliable metric than standardised scores. This uncertainty is likely to be compounded by using the data for a further level of equating. Because of this uncertainty in the measure, the reading ages should be used with care.

4.1.3 Teacher assessment levels

Teacher assessment levels were used to equate to the RL Reading Rasch Ability scale, resulting in cut scores as shown in Table 4.1. This table is expressed as cut score, i.e. the lowest score for the level. In this table, RL scores of -5.39 to -3.48 represent the range within Level 1.

Table 4.1 Teacher assessment levels related to RL Rasch Ability scale

TA level	Approximate RL Star Reading cut score	Number
Level 1	-5.39	*183*
Level 2	-3.47	*574*
Level 3	-0.25	*483*
Level 4	1.30	*524*
Level 5	2.68	*433*
Level 6	4.45	*86*
Level 7	5.29	*12*
Level 8	5.76	*3*

The RL Star Reading test correlated well with teacher assessment levels, with a coefficient of 0.85 based on 2324 pupils. The cut scores for Levels 7 and 8 should be treated with caution because of the very small numbers and it should also be borne in mind that teacher assessment levels are not subject to moderation by other teachers or external bodies. For the purposes of this analysis, the ordinal variable representing teacher assessment levels has been treated as though the intervals were of equivalent size. This should add to the caution with which the results are treated.

4.2 Equating mathematics

4.2.1 Correlations

The Progress in Mathematics tests, unlike the Suffolk Reading Scale tests, do not have any common items. The raw scores for the tests, therefore, have been mapped to the RL scale individually. The graphs showing these relationships are Figures 2.1 to 2.8 in Appendix 2. The correlations relating to these graphs are shown in Table 4.2.

Table 4.2 Pearson correlation coefficients for PiM and RL Rasch Ability scale

Test	Coefficient	Number
PiM 6	0.58	*290*
PiM 7	0.73	*297*
PiM 8	0.74	*403*
PiM 9	0.74	*415*
PiM 10	0.75	*354*
PiM 11	0.74	*257*
PiM 12	0.70	*311*
PiM 13	0.73	*233*

The equating trials show a reasonable correlation between performance on most tests, (0.70 or higher), with a lower value for PiM 6 (0.58). For the higher correlations, this means that one score explains 50 per cent or more of the variation of the other score. Figure 2.1 in Appendix 2 demonstrates the wide confidence bands around the equating, indicating that the relationship is not secure. It should be noted that there is similar uncertainty at the lower ability end of PiM 9 and more generally with the tests taken by secondary pupils (PiM 11-13).

The slope of the graphs for pupils aged 6 to 8 (PiM 6 and 7) are similar in their central sections, suggesting that improvement on one scale is matched by similar improvement on the other. PiM 8 to 11 – based on their central sections – suggest that scores on Progress in Mathematics tests increase more rapidly than the increase on the RL ability scale for Star Mathematics. The relationship between the two tests at the upper end of the age band (PiM 12 and 13) is somewhat erratic, with varying confidence bands. It is possible that some of these tests are focusing on slightly

different constructs of mathematical skills. However, the smaller sample size has also affected these extremes in particular.

4.2.2 Teacher assessment levels

Teacher assessment levels were used to equate to the RL Mathematics Rasch Ability scale, resulting in cut scores as shown in Table 4.3.

Table 4.3 Teacher assessment levels related to RL Rasch Ability scale

TA level	Approximate RL Star Mathematics cut score	Number
Level 1	-6.44	*157*
Level 2	-4.30	*757*
Level 3	-1.70	*576*
Level 4	-0.49	*438*
Level 5	0.52	*348*
Level 6	1.73	*125*
Level 7	2.48	*38*
Level 8	3.74	*3*

The RL Star Mathematics test correlated well with teacher assessment levels, with a coefficient of 0.81 based on 2460 pupils. As discussed above, the cut scores for Levels 7 and 8 should be treated with caution and it should also be borne in mind that teacher assessment levels are not subject to moderation by other teachers or external bodies. Also, as indicated for the levels in the reading tests, the ordinal variable that represents teacher assessment levels has been treated as though the intervals were of equivalent size, even if they are not.

4.2.3 PiM national curriculum levels

The Progress in Mathematics tests provide a link to English national curriculum levels, although this is not provided for the Suffolk Reading Scale tests. The Teacher's Guides emphasise that a relatively short assessment such as the Progress in Mathematics tests can only offer an indication of the pupil's probable level of attainment. These levels should therefore be regarded as a contribution to teachers' overall judgments.

The national curriculum level cut scores and the number of pupils at each level can be seen in Table 4.4. These values are very similar, though not identical, to the teacher assessment results in Table 4.3, giving support that both measures are reasonably accurate.

Table 4.4 PiM National curriculum levels related to RL Rasch Ability scale

National curriculum level	Approximate RL Star Mathematics cut score	Number
Level 1	-6.00	*130*
Level 2	-4.21	*559*
Level 3	-1.83	*610*
Level 4	-0.39	*491*
Level 5	1.14	*265*
Level 6	2.18	*53*

The figures do not include pupils whose NC level was ambiguous from the Teacher Guide (eg '2c and below'), but the numbers were adequate for the analysis. The correlation between the PiM national curriculum levels and the RL ability scale for mathematics was based on 2131 pupils and was a good value (0.84).

5 Conclusions

Star Reading and Star Mathematics correlate highly with established UK tests of reading and mathematics, demonstrating concurrent evidence of their validity for use in this country.

Star Reading and Star Mathematics also correlate well with teacher assessments of English national curriculum levels, and in the case of Star Mathematics also with published national curriculum levels, demonstrating that they are likely to test a substantial subset of national curriculum skills and understandings.

Appendix 1: Reading equating

Figure 1.1: Suffolk 1A raw score equated to RL Star Reading scale

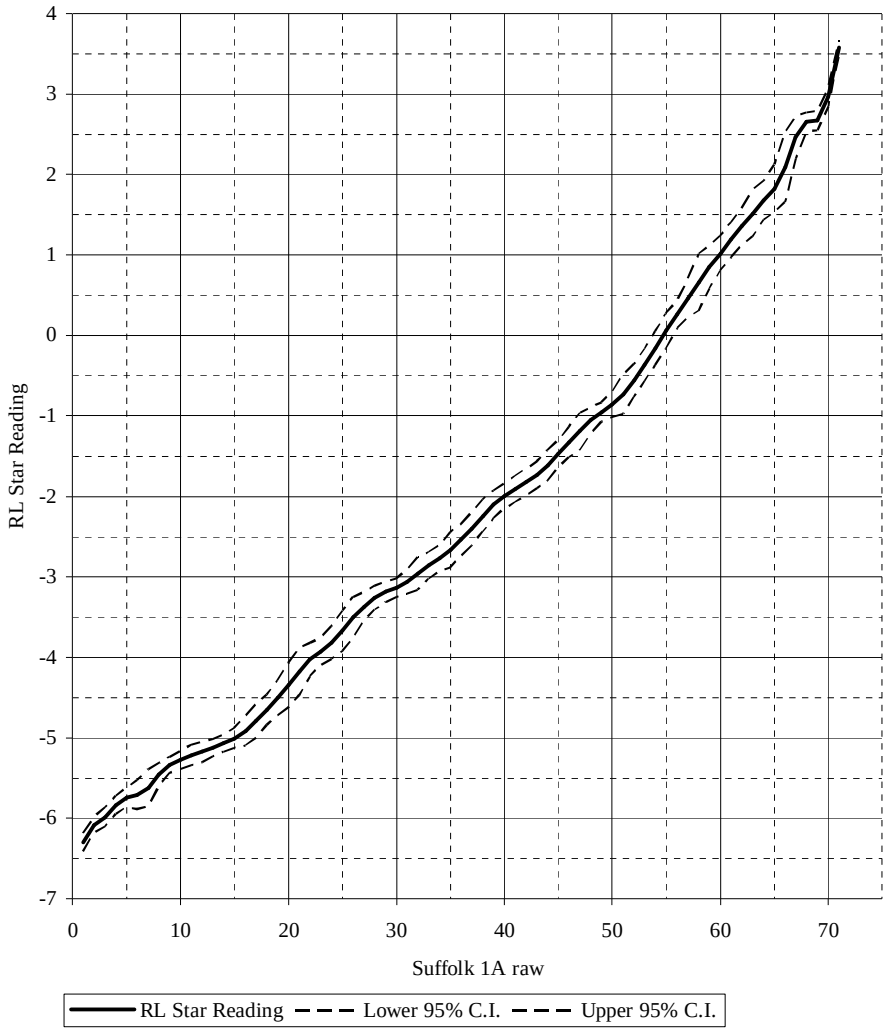


Figure 1.2: Suffolk 2A raw score equated to RL Star Reading scale

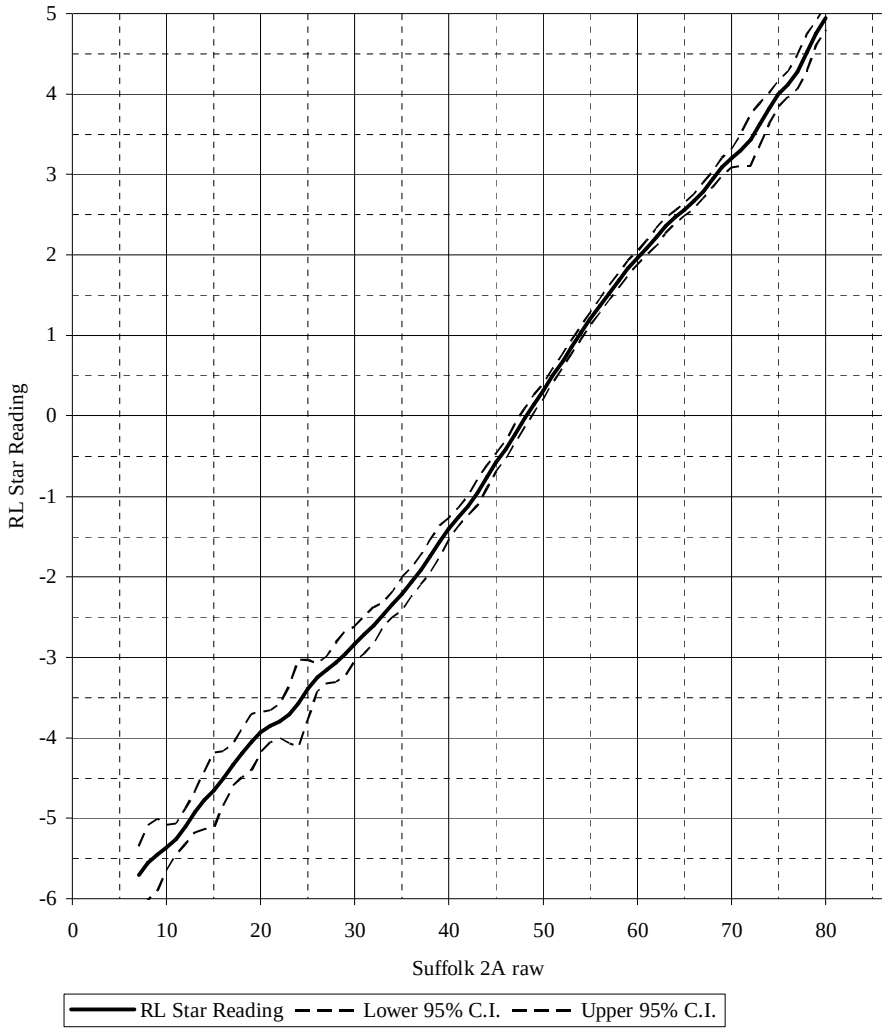


Figure 1.3: Suffolk 3A raw score equated to RL Star Reading scale

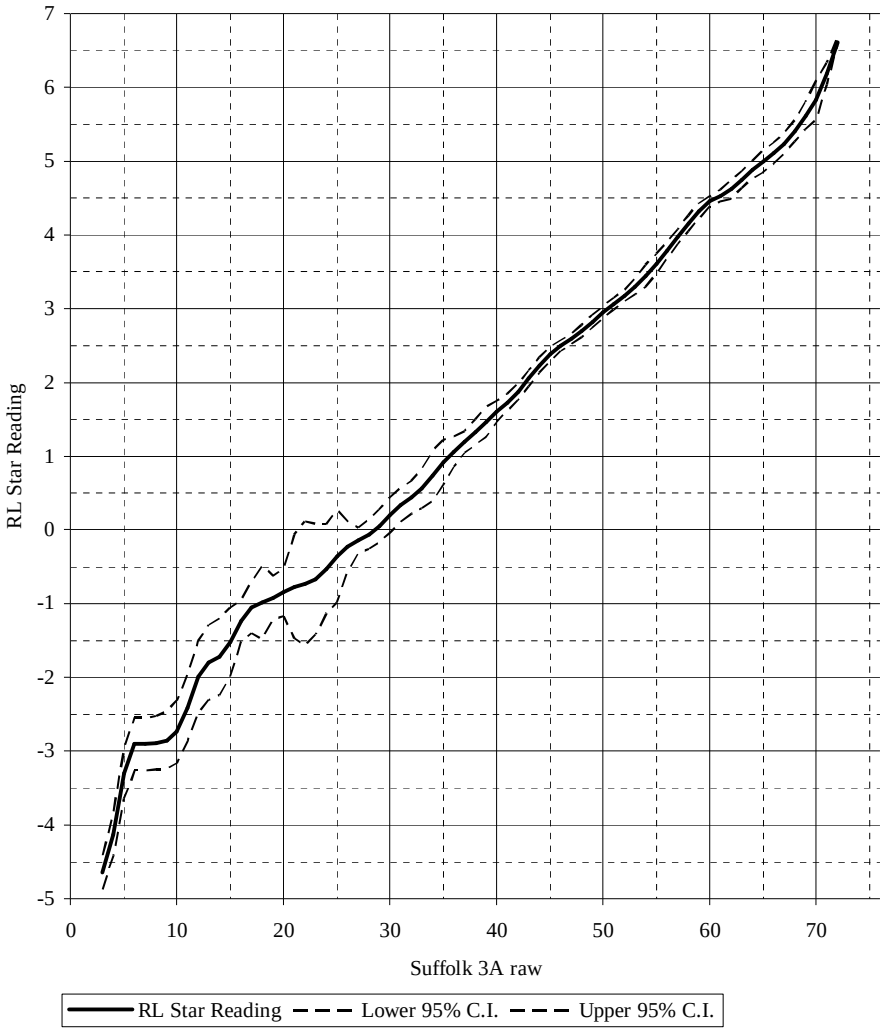


Figure 1.4: Suffolk 1a to Suffolk Ability scale

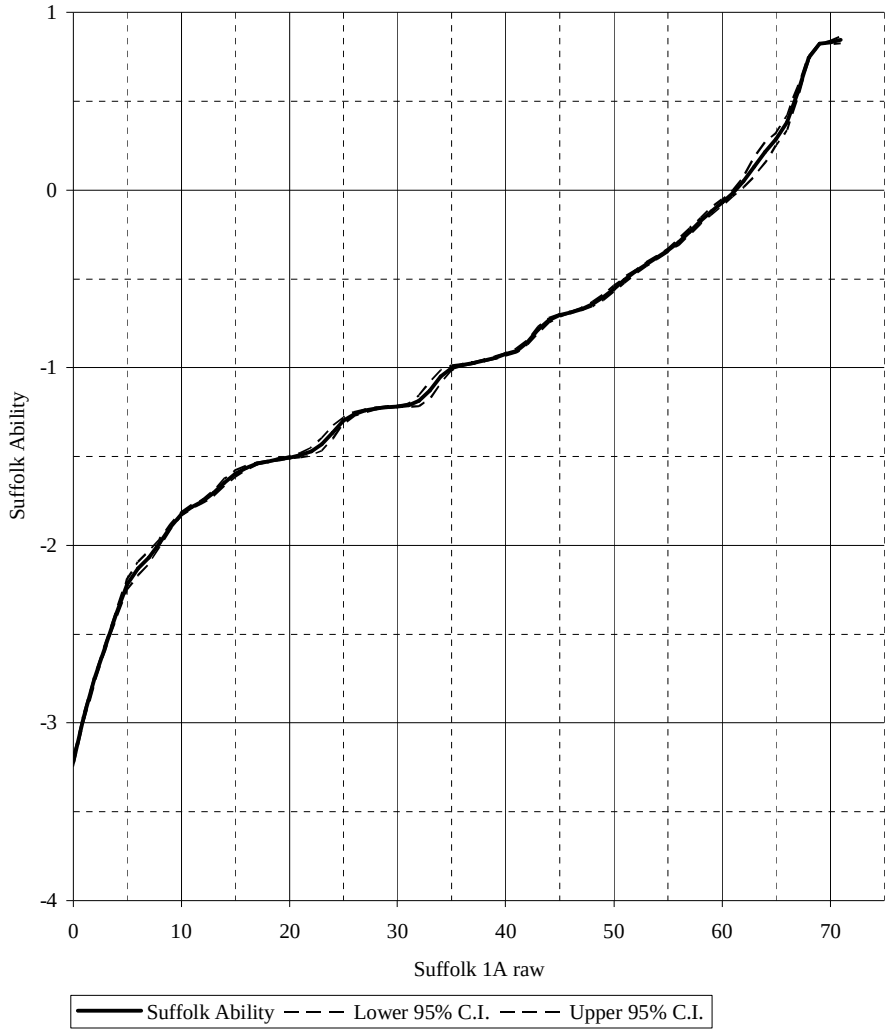


Figure 1.5: Suffolk 2a to Suffolk Ability scale

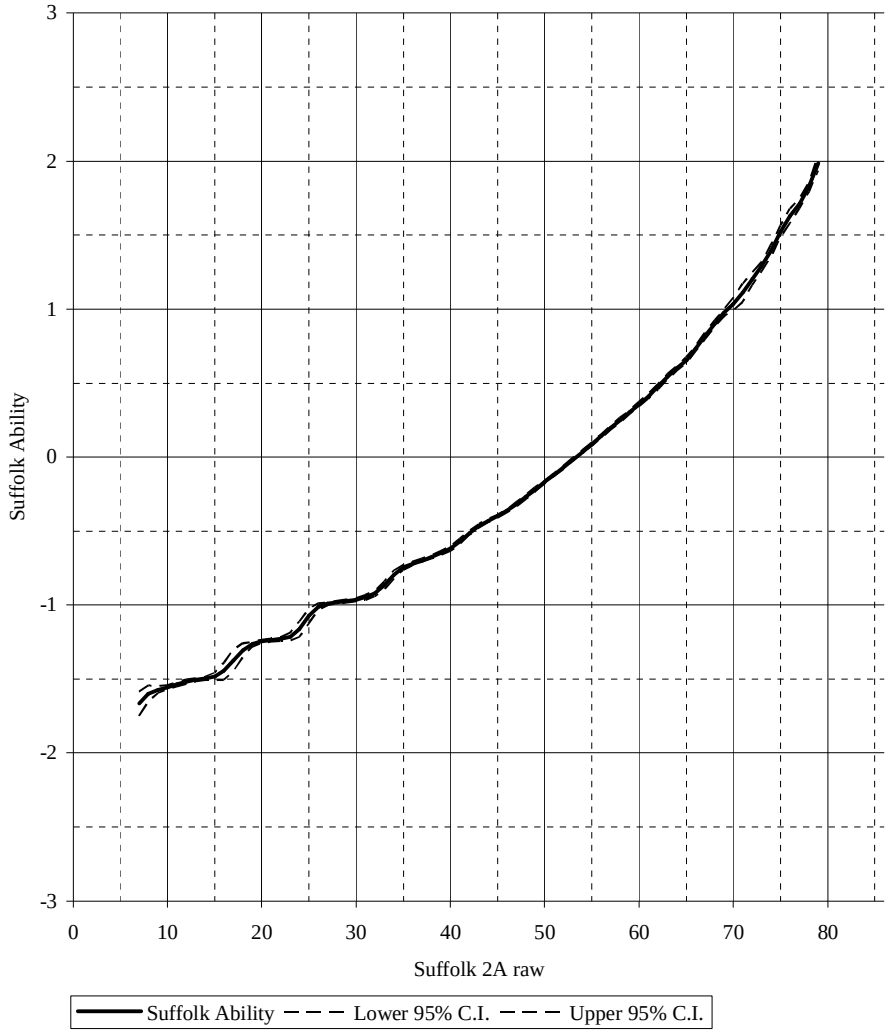


Figure 1.6: Suffolk 3a to Suffolk Ability scale

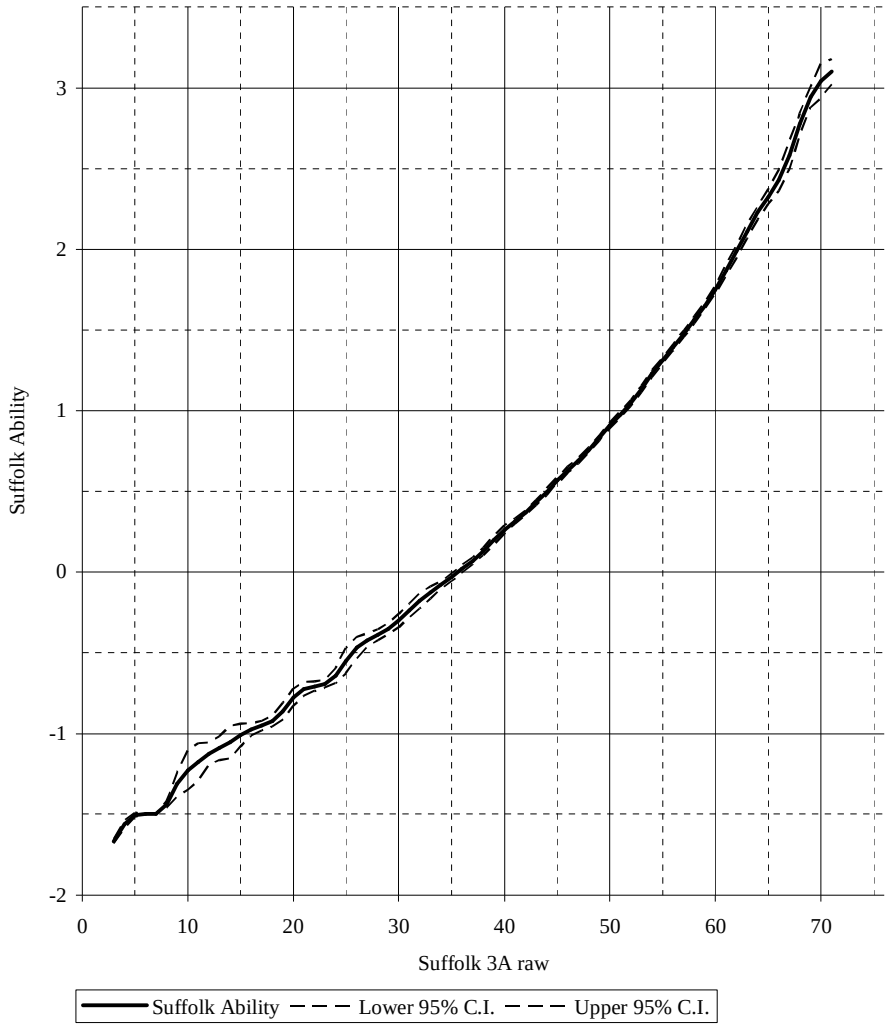


Figure 1.7: Suffolk Ability scale to RL Star Reading (equipercentile equating)

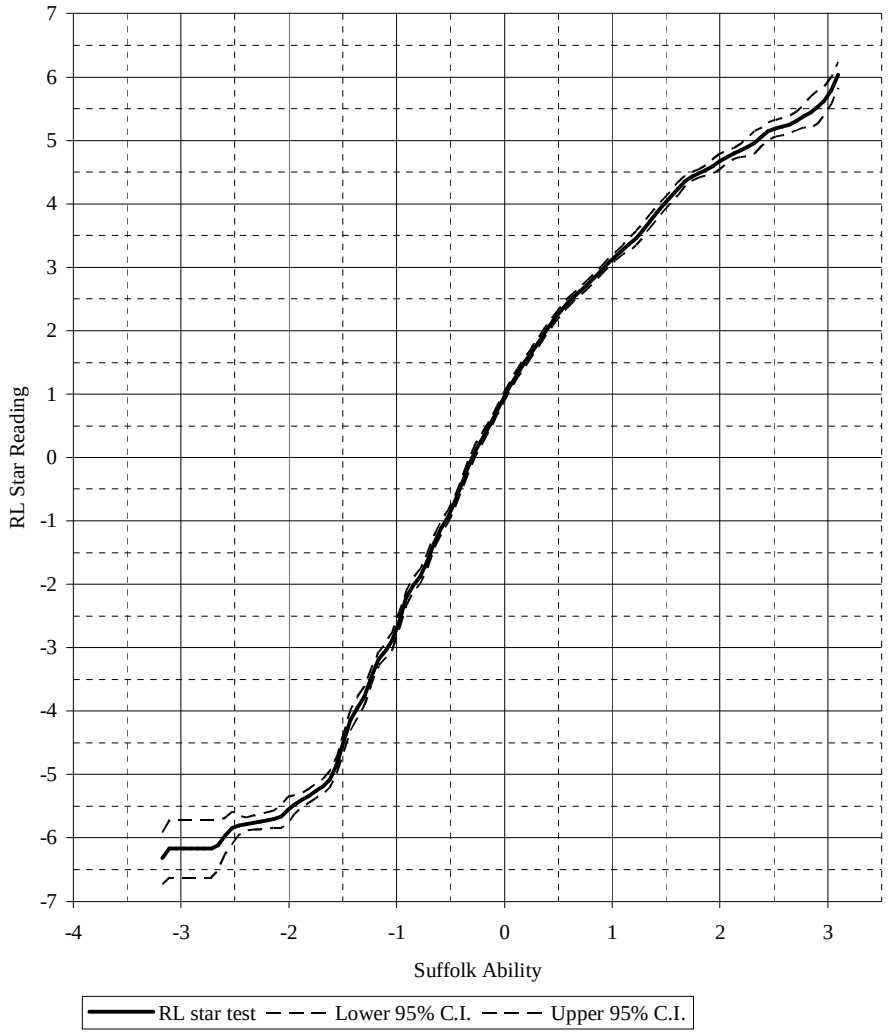
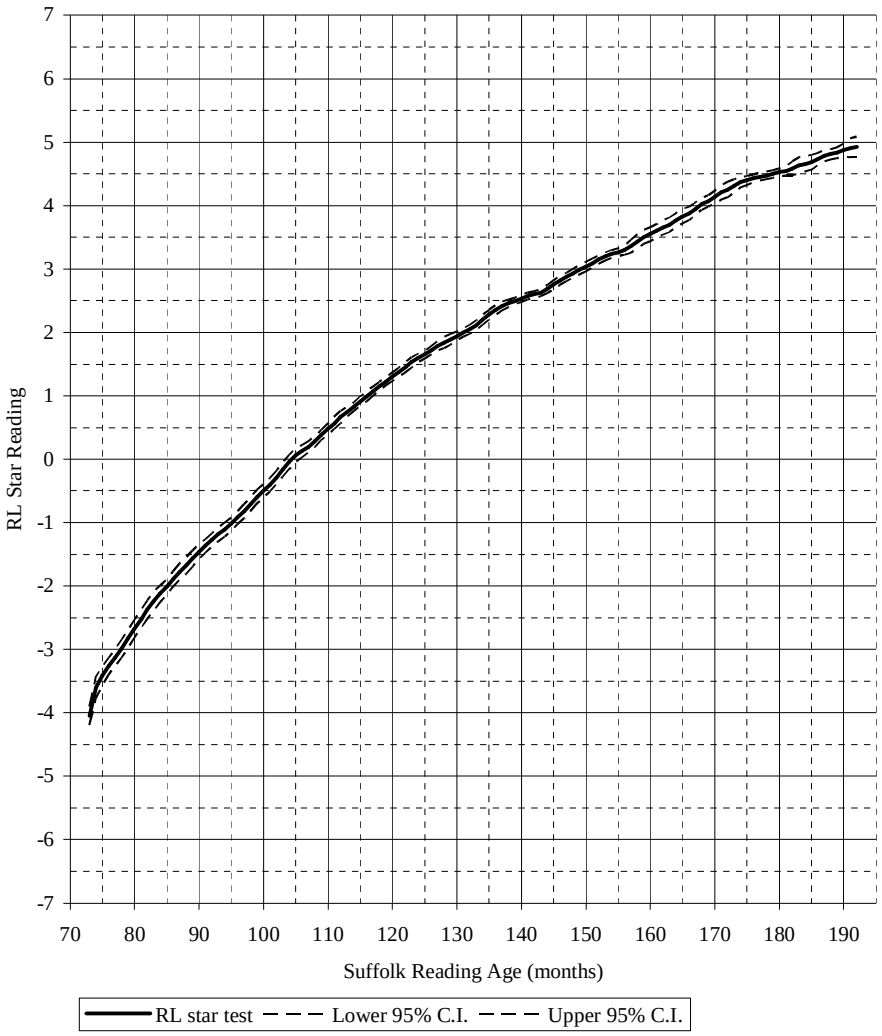


Figure 1.8: Suffolk reading age to RL Star Reading



Appendix 2: Mathematics equating

Figure 2.1: Progress in Mathematics 6 raw score equated to RL Star mathematics scale

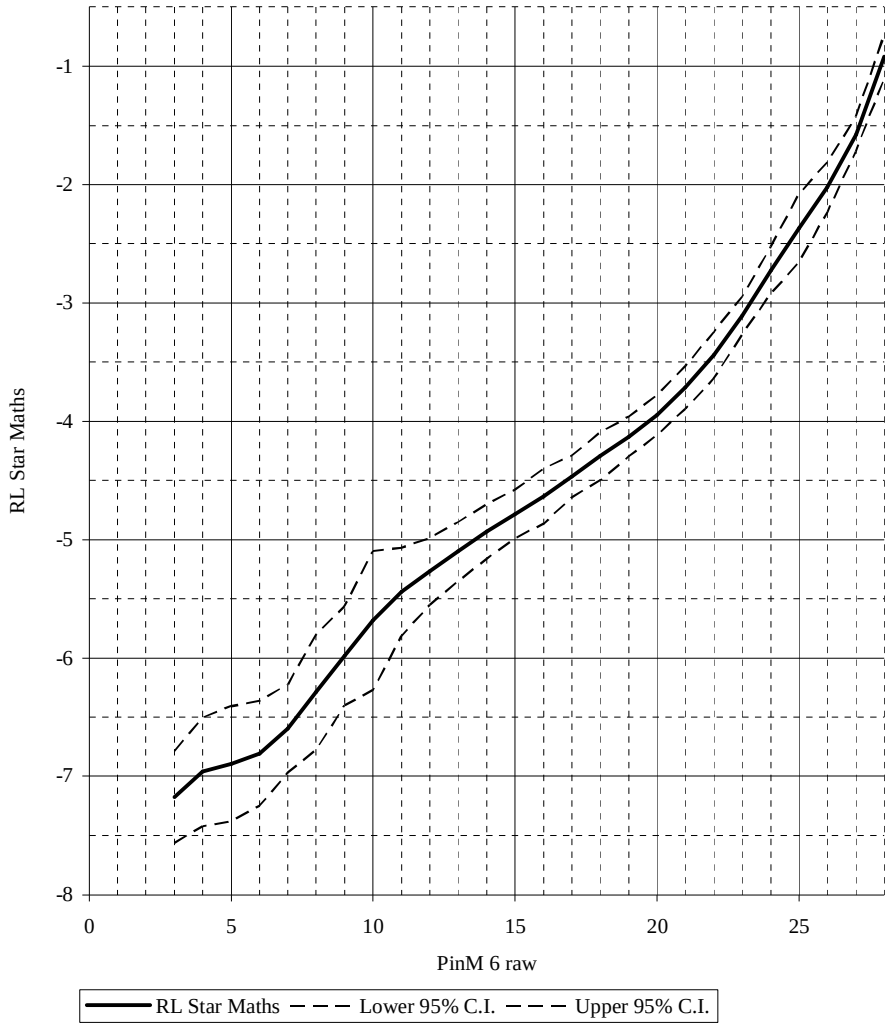


Figure 2.2: Progress in Mathematics 7 raw score equated to RL Star mathematics scale

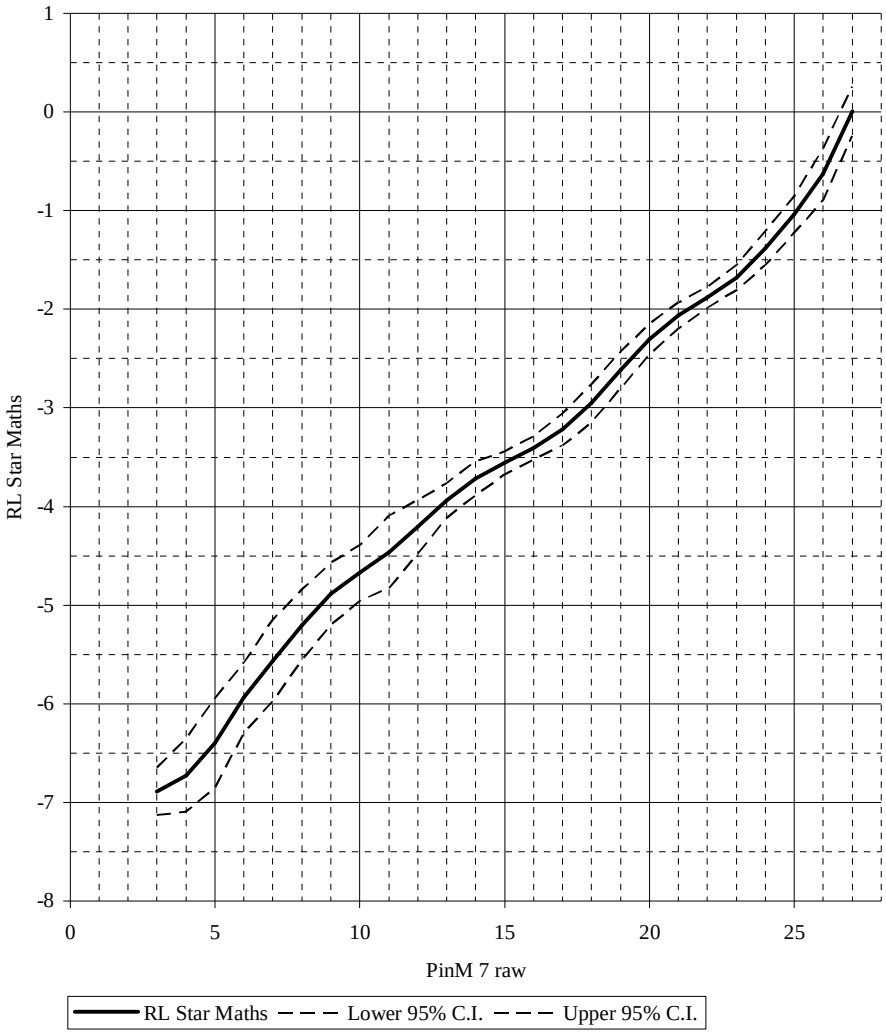


Figure 2.3: Progress in Mathematics 8 raw score equated to RL Star mathematics scale

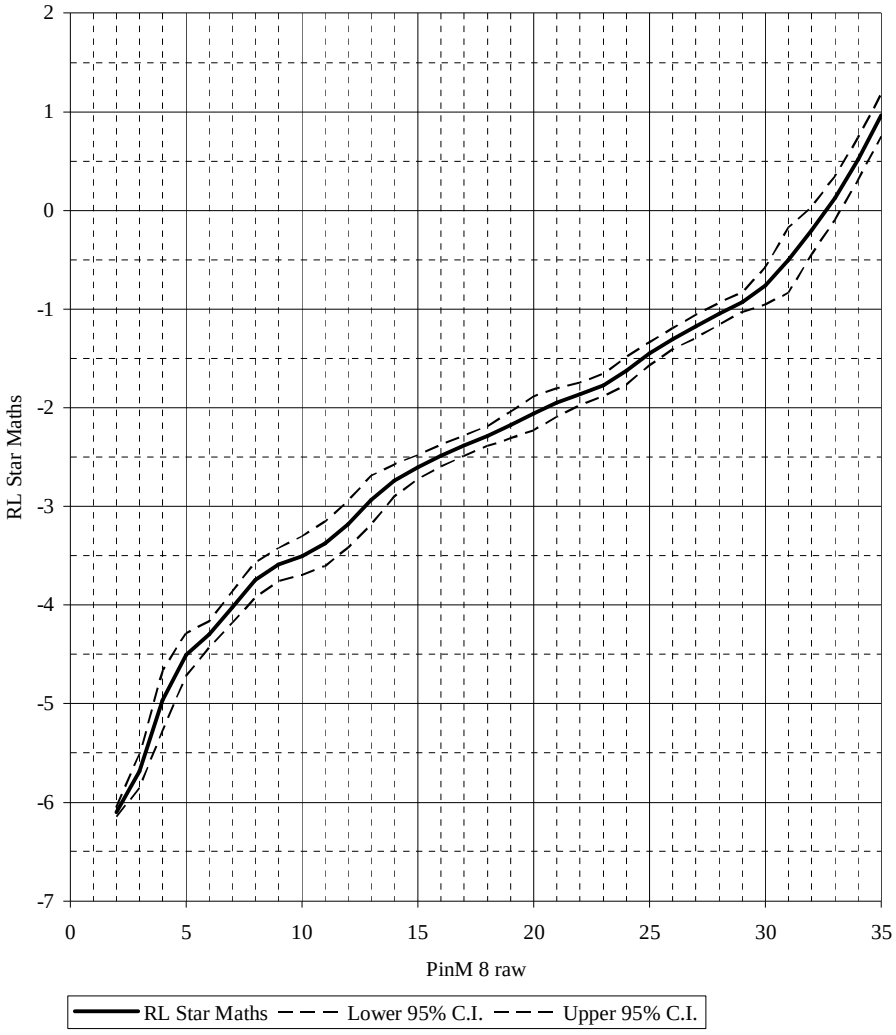


Figure 2.4: Progress in Mathematics 9 raw score equated to RL Star mathematics scale

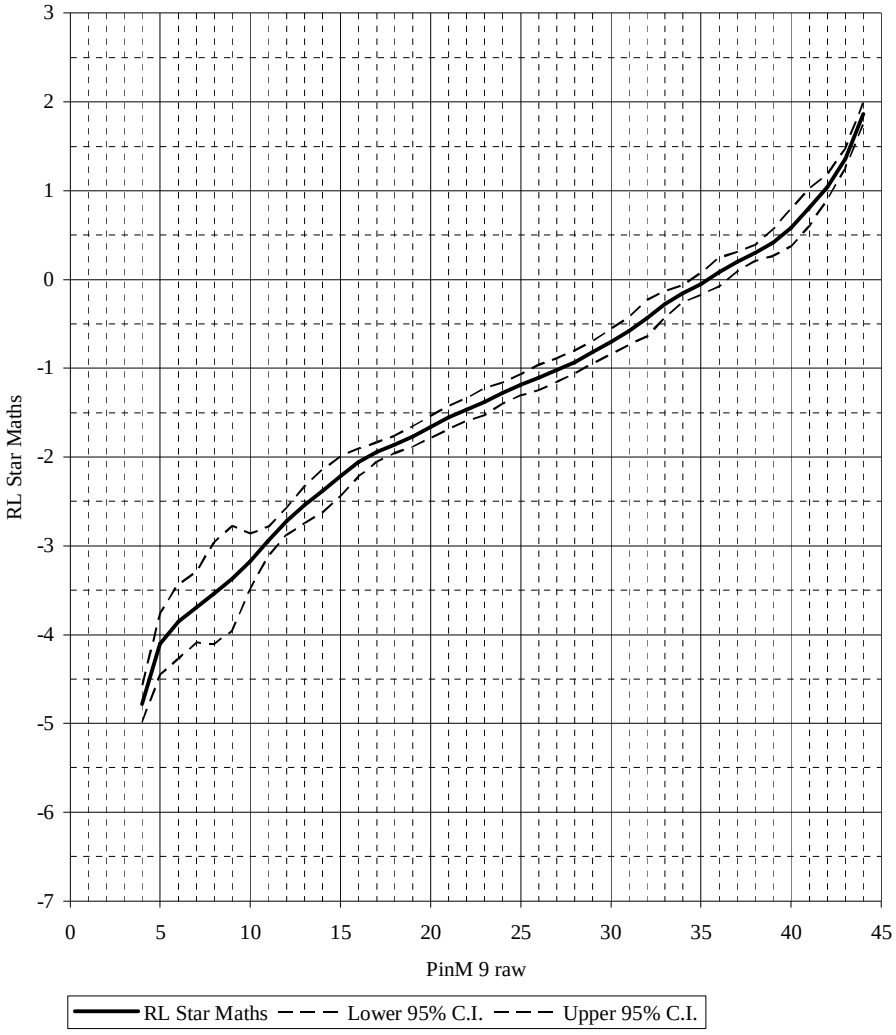


Figure 2.5: Progress in Mathematics 10 raw score equated to RL Star mathematics scale

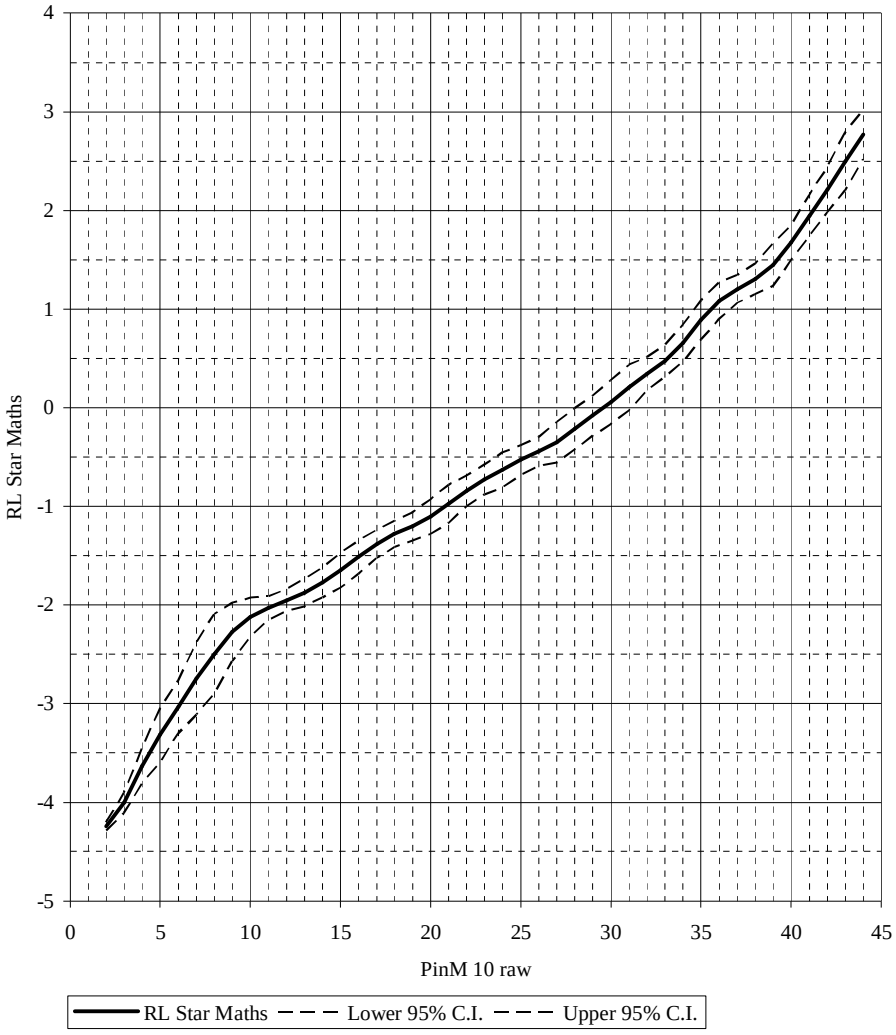


Figure 2.6: Progress in Mathematics 11 raw score equated to RL Star mathematics scale

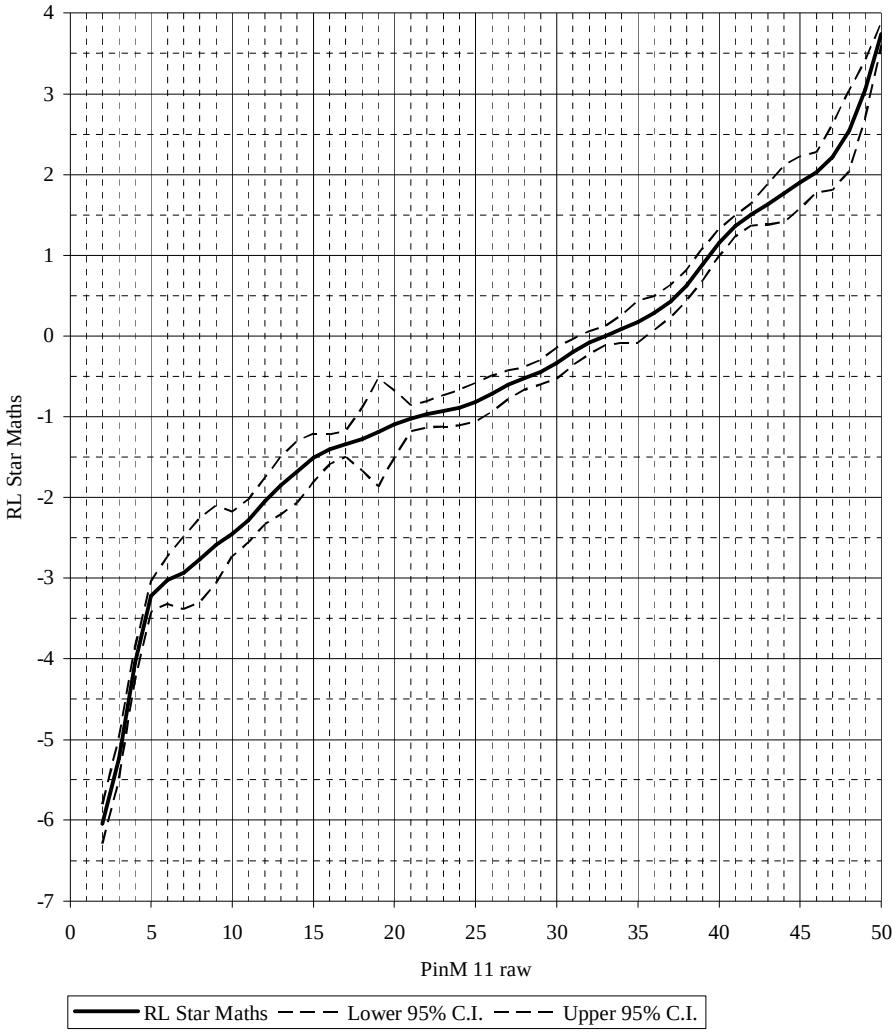


Figure 2.7: Progress in Mathematics 12 raw score equated to RL Star mathematics scale

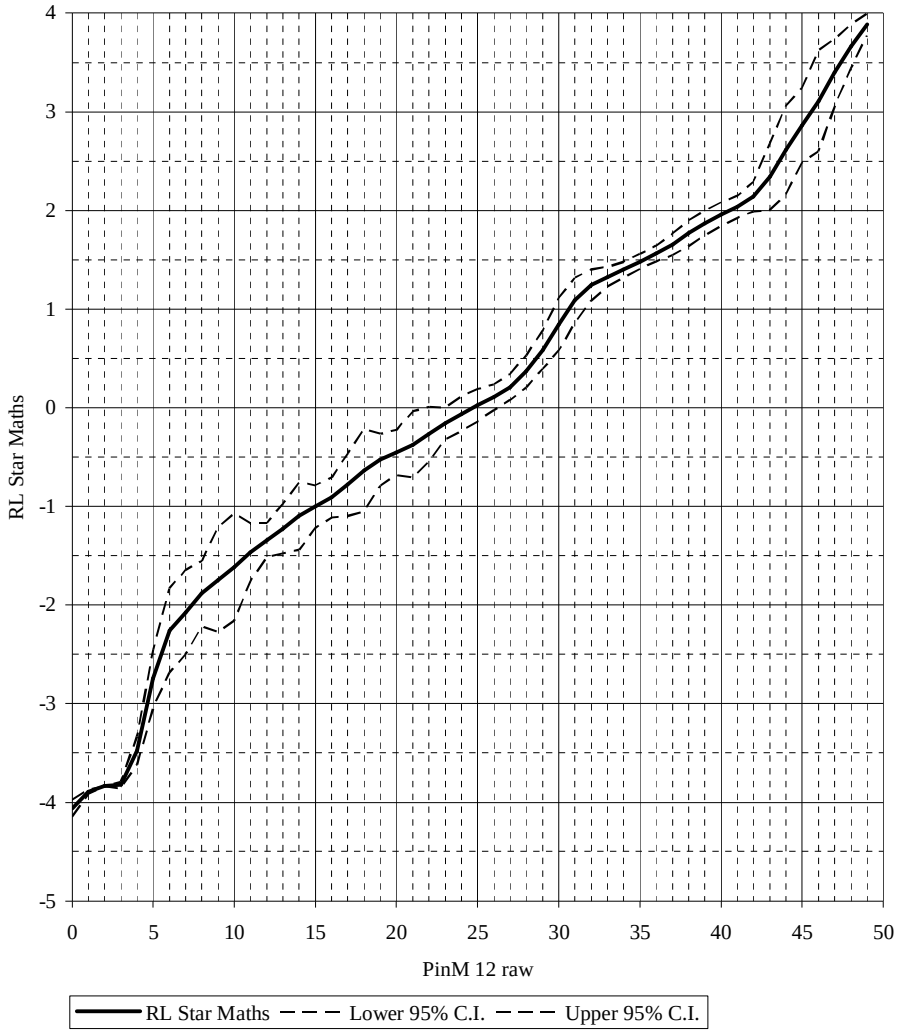
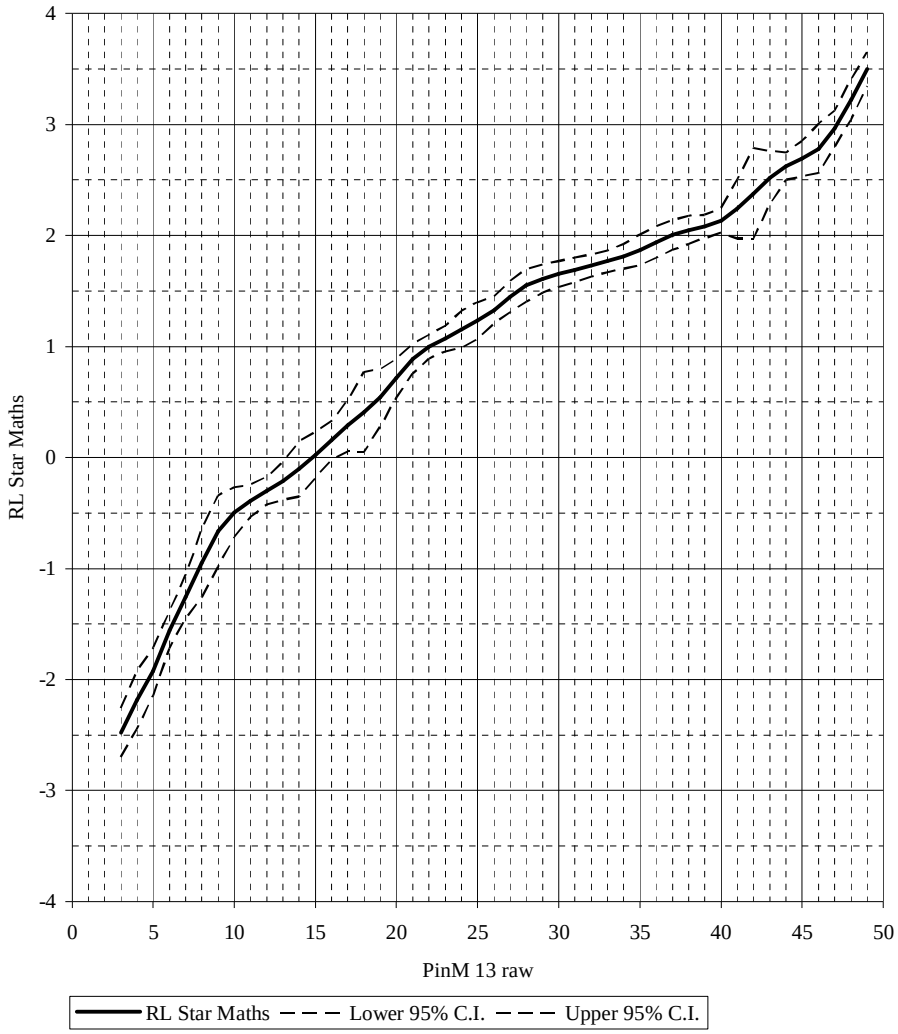


Figure 2.8: Progress in Mathematics 13 raw score equated to RL Star mathematics scale



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