Adding Value to PIRLS by Combining with National Data and Using Sophisticated Modelling Techniques

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Abstract

In this paper we give worked examples of adding national data to international datasets in order to add value to the secondary analysis of this data. We also show how more sophisticated techniques, including multilevel modelling and structural equation modelling, can be applied to such enhanced data to go beyond the potentially misleading simple correlational analysis. The paper is illustrated with data from PIRLS 2006 for England.

Keywords: secondary analysis, value added analysis, multilevel modelling, structural equation modelling, PIRLS.

Introduction

Secondary analysis of international data could be regarded as a growth industry, with researchers in many countries carrying out analyses in order to study relationships between different measures for their own country's data. Some of this work can be problematic, especially if it is interpreted simplistically. If, for example, we link student attainment scores and Teacher Questionnaire responses and find that there is a positive relationship between teachers saying they use a particular teaching style and student outcomes, it might be tempting to infer that this teaching style has a positive impact on attainment. It could be, of course, that this style is used more often with higher attaining students and the causal link is quite different. In PIRLS another very obvious example is the negative association between students saying they read aloud at home frequently and reading attainment. One of the problems is that international studies such as PIRLS are snapshots at a single point of time, with no measure of prior attainment. The attempt to link teacher and school factors to the final attainment value is fraught with difficulties if we have no measure of *change* in attainment which might be associated with these factors (see Hutchison and Schagen, 2007).

In analysing the PIRLS 2006 data for England we have attempted to get round these problems with secondary analysis by linking students' PIRLS data to information about performance in national tests at age 7 (so-called key stage 1 or KS1 tests) and to similar data for tests at age 11 (key stage 2 or KS2 tests). In addition, England's National Pupil Database (NPD) contains a great deal of information about students and schools, including measures based on the local area which are related to social and economic deprivation. Using names and school identifiers we have been able to enhance the PIRLS data in this way for about 90% of our cases.

Good data is one prerequisite for informative analysis – the other is appropriate and sufficiently sophisticated analysis which matches well the underlying research questions to be addressed. Much of the focus of the analysis carried out for the PIRLS international report (and to some extent for the initial national reports) is on estimating underlying population values from the sample as achieved; hence the emphasis on plausible values and replicate weights within the international data. However, if what we are interested in is subtle unpicking of relationships between different factors then it is probably more productive to treat the data we have (enhanced through matching to national data) as the universe of interest and to analyse it as it is. Findings from that analysis can be later generalised to the population from which it was sampled at a slightly higher level, taking advantage of the good sampling design, without trying to carry out the whole analysis at the population level.

Taking this approach, there are two main modelling paradigms which we have applied to our enhanced England PIRLS data. One is multilevel modelling (MLM), an extension of multiple regression which takes account of the clustering of students within schools (see Goldstein, 2003). We have applied this particularly to provide a 'value-added' analysis of the PIRLS outcomes, controlling for prior attainment three years earlier at KS1 and looking for significant factors from the teacher and school data which appear to be related to enhanced progress. At the same time, we have matched information from the Learning to Read Questionnaire (completed by parents), the Student Questionnaire, and the student data from the NPD which enables us to derive a consistent index of deprivation from all these sources. Inclusion of this in the modelling has led to findings regarding the link between deprivation and progress in reading.

The other modelling paradigm used is structural equation modelling (SEM) using the powerful program Mplus (see Muthen and Muthen, 2006). Our focus here has been to track down the complex relationships between students' prior attainment, their enjoyment of reading, their self-motivated reading activities, and their attainment at a later date (in PIRLS and in the national tests). There are various items in the Student Questionnaire which address these underlying constructs, and it is possible to construct a series of models with key latent variables linked to these items. From these we have gained some

important insights into possible mechanisms to explain children's reading development, which would not have been possible otherwise.

To some extent this paper is a case study, pointing a way forward beyond the limited and occasionally sterile secondary analyses of international data which are sometimes reported. On the one hand, we recommend doing whatever is possible to link to other datasets at the student level, especially to obtain measures of prior attainment. At the same time, richer data demands more sophisticated analysis. In this paper we will demonstrate some of the insights to be gained through careful application of both SEM and MLM approaches, each addressing slightly different issues.

Structural equation modelling

Because there is data on each student on a number of factors, it is possible to explore relationships and connections which are more complex than the simple ones possible in regression or multilevel modelling – this is the main strength of structural equation modelling (SEM). In SEM we assume there are unmeasured 'latent' variables plus a set of observed variables, which can relate to each other according to the theoretical assumptions which are built into the model. We will illustrate this briefly using a series of simple SEMs based on the PIRLS data for England.

Model 1: Reading ability and enjoyment

In this model we assume that there are two latent variables: ***reading ability*** in 2006 and ***reading enjoyment*** in 2006. These latent variables are linked to observed data from the questionnaire and the testing:

- ***Reading ability*** is linked to the overall calibrated reading attainment (***PIRLS reading ability***) plus the responses to Q15 of the questionnaire (see Table 1).
- ***Reading enjoyment*** is linked to responses to Q14 of the questionnaire (see Table 2).
- In addition, both latent variables are linked to KS1 prior attainment in terms of reading (***KS1 reading score***) and writing (***KS1 writing score***).

Table 1 Questionnaire items 'reading confidence'

ASBGRD1	Q15a	Reading is very easy for me.
ASBGRD2	Q15b	I do not read as well as other students in my class.
ASBGRD3	Q15c	When I am reading by myself, I understand almost everything I read.
ASBGRD4	Q15d	I read slower than other students in my class.

Table 2 Questionnaire items 'reading enjoyment'

ASBGRST1	Q14a	I read only if I have to.
ASBGRST2	Q14b	I like talking about books with other people.
ASBGRST3	Q14c	I would be happy if someone gave me a book as a present.
ASBGRST4	Q14d	I think reading is boring.
ASBGRST5	Q14e	I need to read well for my future.
ASBGRST6	Q14f	I enjoy reading.

When this model is fitted to the data the output from Mplus is best displayed as a 'path diagram', which shows these linkages plus the estimated strength of the relationships, expressed as a dimensionless quantity between -1 and +1 (equivalent to a correlation). The path diagram for Model 1 is shown in Figure 1 below. Ovals represent latent variables, while rectangles are observed variables. Figures in italics are non-significant relationships.

<insert Figure 1>

The results imply that reading enjoyment is measured by Q14a to Q14f, though not significantly by Q14b and negatively for Q14a and Q14d. Reading ability is strongly related to the calibrated outcome of PIRLS 2006, but also to Q15b to Q15d, negatively in two cases (Q15b, Q15d). Reading enjoyment also relates to KS1 reading level, though not to KS1 writing. Reading ability in 2006 relates significantly to both KS1 reading and writing.

The relationship between reading enjoyment and ability is also significant and positive.

Model 2: Reading ability, enjoyment and activities

In order to unpick the relationship between reading enjoyment and attainment, an extra latent variable was included in the model, relating to reading activities carried out by the students themselves and one that we termed ***self-motivated reading***. This is linked to certain questionnaire items from Q3 and one from Q4, shown in Table 3. The link between enjoyment and attainment is now assumed to be indirect, via reading activities.

Table 3		Questionnaire items 'reading activities'
ASBGTOC3	Q3c	Outside of school, how often do you talk with friends about reading?
ASBGTOC4	Q3d	Outside of school, how often do you talk with family about reading?
ASBGTOC5	Q3e	Outside of school, how often do you read for fun?
ASBGTOC6	Q3f	Outside of school, how often do you read to find out things you want to learn?
ASBGRTO2	Q4b	Outside of school, how often do you read stories or novels?

The outcome of the model-fitting is shown in the SEM diagram in Figure 2.

<insert Figure 2>

This model tends to support the idea that the link between enjoyment and attainment may be via personal reading activities. The link from enjoyment to activities is very strong, and fairly strong between activities and attainment.

Model 3: Separate models for boys and girls

One question that the above model may raise is: are the relationships different for boys and girls? In order to answer this question a 'multiple groups' model was run, in which the relationships between latent variables were allowed to be different for males and females. This model showed no substantive differences in the coefficients for boys and girls, implying that the relationships were by and large the same for the two genders.

Model 4: Relationship between gender and other variables

Even if it is true that the relationships are the same for boys and girls, it may be the case that gender is a factor which influences things like enjoyment and ability over and above other factors. To investigate this, Model 2 was extended to allow for gender (essentially girls as opposed to boys) to be related to KS1 results as well as enjoyment, reading activities and attainment. The model is not included in this paper but the results are summarised below.

The link between gender (girls) and reading enjoyment is 0.22, and between gender (girls) and self-motivated reading is 0.10. Both are significant. The link between gender (girls) and reading ability is -0.06 and is not significant.

It seems that girls have enhanced enjoyment and personal reading activities, compared with boys, although there is a very slight apparent reduction in their reading attainment.

This may be for two reasons:

- there is an indirect effect of gender on attainment via enjoyment and activities; the slight negative direct effect may tend to balance this;
- in terms of progress from KS1, boys may tend to 'catch up' slightly with girls.

It seems, however, that most of the gender difference in reading attainment in grade 4 is mediated by reading enjoyment and personal reading activities.

Model 5: Inclusion of key stage 2 reading outcomes

For most of the cases it has been possible to match in their key stage 2 2007 test results, in particular the score achieved on the reading test (***key stage 2 reading score***). The previous model was modified to include this as a final outcome, related to reading ability in 2006 (***reading ability***) and also to gender. Results of this model are shown graphically in Figure 3.

<insert Figure 3>

All the previous results and relationships still hold, but in this model we can see a strong (and not surprising) relationship between reading ability in 2006 and KS2 reading score. There is also a small negative relationship between KS2 reading score and gender – girls do not achieve quite as high a score at KS2 as would be predicted on the basis of their 2006 ability as do boys, indicating that the gap may narrow slightly in the year between PIRLS and taking the end of key stage 2 reading test.

Discussion

This very brief discussion identifies some of the different methodologies that have been deployed to investigate this aspect of students' development as readers.

As early as 1991, Rowe, an Australian academic writing in a British journal, suggested that it was no longer enough to identify associative or bivariate relationships but that instead, we must develop explanatory models which specify directions and estimate magnitudes of effects of critical variables in the cycle of student achievement. Using structural equation modelling, Rowe went on to investigate the powerful influence of home reading on reading attainment. He also found a strong interdependence of attitudes to reading and reading activity at home, and that the impact of reading activity at home and reading attitudes variables increased with student age.

Critics of international surveys point to the cross-sectional nature of the data collected and the inability therefore to attribute causality. This issue is not associated solely with

international surveys. Leppanen, Aunola and Nurmi (2005) looked at children's reading performance and reading habits and regretted the lack of research investigating 'the prospective associations' between these two factors. In their experimental study from Finland, they looked at cross-lagged associations between reading performance and reading attainment of young children in grades 1 and 2. The researchers found that, for students at this early stage of schooling, children's reading skills influenced the subsequent amount of out-of-school reading undertaken. They also found that children's book reading habits were not stable at this age.

In a classic longitudinal study, Cunningham and Stanovich (1997) looked at reading attainment and exposure to print, among other measures, of students at grade 1 and then again 10 years later at grade 11. The authors were exploring the notion of a reciprocal model (the Matthew effect) with a lack of reading experience contributing to reading problems, and reading problems leading to lack of exposure to print. They concluded that "(e)arly success at reading acquisition is one of the keys that unlocks a lifetime of reading habits. The subsequent exercise of this habit serves to further develop reading comprehension ability in an interlocking positive feedback logic" (Cunningham and Stanovich, 1997, p.943).

In terms of the methodology adopted, Cunningham and Stanovich's measures of exposure to print were the (now) familiar author recognition test and the magazine recognition test, in contrast to PIRLS where we have self-report data on the frequency of students' out of school reading activities.

In their correlational study, Greaney and Hegarty (1987) collected their data about children's leisure time reading by asking them to complete a diary for four days in which the children listed what they read and for how often. The researchers also obtained background information from the parents, enabling them to draw conclusions about socio-economic status and educational level. Greaney and Hegarty found that time spent book reading (as opposed to comic or newspaper reading) correlated more highly with 'attitude to reading' and 'reading for enjoyment and stimulation' than it did with reading ability, verbal ability or class position. The significance of this study is its focus on out of school reading (analogous to our 'self-motivated reading'), although it consisted of just a small sample (N = 127 / grade 4 students) from one school.

Conlon, Zimmer-Gembeck, Creed, and Tucker (2006) investigated students' attitudes and perceptions of reading competence using a scale published by Chapman and Tunmer. They recognised the limitations of the design of their cross-sectional study (and anticipated having longitudinal data in future analyses). Conlon *et al.* identified three factors: attitudes to reading, perceptions of reading competence, and difficulty with reading. They concluded: "in all analyses, children's perceptions of their own reading

competence and the level of difficulty they reported with reading explained a significant portion of the variance for the different reading skills" (p28). They discuss the situation in which they see "a growing consensus that a child's perceptions of himself or herself as [a] reader are related to their actual reading achievement" but that controversy would remain as to their causal ordering.

Limitations

This work uses data obtained in PIRLS for England only; any relationships and associations may well be related to specific cultural and educational factors.

Central to the SEM is the matched data of attainment at three time points, at age 7 (KS1), at age 10 (PIRLS) and at age 11 (KS2). What would strengthen the investigation substantially would be to have background data providing information about reading attitudes, confidence and habits at age 7 i.e. from a longitudinal study.

A further extension of the analyses would be to include 'reading confidence' as a latent variable.

Multilevel model

Multilevel modelling is a statistical technique that attempts to takes into account ('control for') factors ('background variables') that might influence what is being measured, in this case, reading attainment. In this analysis, the aim was to explore how much these variables affected students' achievement scores on PIRLS. More detailed information about the statistical analysis undertaken and the results derived from this is contained in the national report for England (Twist, Hodgson and Schagen, 2007); in this section the summary results are reported. These focus in particular on the findings related to a generic scale of deprivation that was defined based on data from the student and the Learning to Read Questionnaires, as well as data on England's Pupil Level Annual School Census (PLASC). The construction of this is summarized in the appendix.

The research issues to be explored included:

- What are the relationships between student and school characteristics and student outcomes and attitudes?
- What are the relationships between reading attainment and student attitudes and activities?

The analysis looked at factors affecting the five outcomes measurable on PIRLS:

• overall reading achievement

• reading for literary experience

• reading to acquire and use information

• attainment on the retrieving and straightforward inferencing scale

• attainment on the interpreting, integrating and evaluating scale.

Also included in the analysis was a sixth outcome: achievement on the key stage 2 reading test as a mark out of 50. This test was taken when the PIRLS sample were at the end of their primary education, one year after the PIRLS assessment.

Various scales were constructed from the PIRLS data, largely using factor analysis of questionnaire data, and these are not all reported here but one or two interesting findings emerged from this in relation to what has been observed in the SEM findings.

The three scales were derived from the Teacher Questionnaire and these can be summarized as dealing with the following classroom activities:

• teaching reading strategies and vocabulary

• teacher and students reading aloud

• students reading silently and reading own choice material.

Three scales derived from an exploratory factor analysis of the Student Questionnaire data were included as outcomes in the model:

• reading activities (reading outside school and classroom reading activities)

• reading enjoyment and reading confidence

• reading alternative media (non-book reading including computer-based reading) and television viewing.

From the School Questionnaire, six scales emerged in the factor analysis. Three of these were associated with the context and environment of the school:

• disadvantage and other problems

• proportions with early literacy skills on entry to year 1

• shortages and inadequacies of human and material resources.

A further three concerned school practices:

• curricular emphasis on early literary skills

• curricular emphasis on early advanced reading skills

• family programs and support.

These various scales were included in the multilevel model. The deprivation index (see appendix) was also included in the model.

Results

The model was set up with three levels: school, class and student. Variables which were clearly not significant in a particular model were deleted, but in some cases variables of borderline significance were retained. The final models for each outcome are not presented here. Instead, we have presented the outcomes in the form of 'quasi effect sizes' (see Schagen and Elliott, 2004) – these enable us to present the results of complex models in a way which shows how much difference each factor makes to the expected student scores in each case. Table 4 shows quasi effect sizes for all six outcomes, for background factors which are statistically significant at the 5% level. A quasi effect size shows the expected change in the outcome score which might be attributed to the relevant background factor, controlling for other factors, as a percentage of the standard deviation in the outcome associated with one standard deviation change in the background factor. Thus a value of 100 is equivalent to a correlation of 1.0, and negative values show negative associations.

Table 4 Significant Quasi Effect Sizes from Multilevel Modelling

Variable	PIRLS overall attain-ment	PIRLS purposes		PIRLS processes		KS2 Reading score
		Literary attainment	Information attainment	Retrieving & straightforward inferencing	Interpreting, integrating & evaluating	
PIRLS attainment score						76
KS1 reading score	59	57	58	55	56	37
KS1 writing score	31	24	29	30	30	9
Gender (male = 1, female = 2)						-6
Term of birth	-3					
Black ethnic groups						
Asian ethnic groups						
Other ethnic groups						
Unknown ethnicity						
Stage of SEN (from PLASC)	-15	-17	-15	-15	-16	-8
Missing SEN						19
Other language spoken at home	-6	-9	-7	-9	-5	
English not normally used						
Born outside UK	-13		-11	-22	-17	
Possessions: consumer electronics	-10	-8	-9	-10	-9	
Possessions: desk, books, instrument	9	9	9	11	12	3
Composite deprivation measure	-9	-11	-7	-14	-11	-7
Teaching reading strategies & vocabulary (Q15)						
Reading aloud (Q15)						
Students reading silently and reading own choice books (Q15)				5		
Length of teaching experience						
Percent female teaching						
School environment 1: Low SES + disadvantage	-8	-8	-9	-8	-12	-8
School environment 2: Early literacy skills on entry to year 1	8	8	7	7	9	
School environment 3: Shortages & inadequacies of resources						
School practices 1: Curricular emphasis on early reading skills	6	6	8	6	9	
School practices 2: Early advanced reading skills						
School practices 3: Family support						

(Quasi effect size = expected change in outcome score due to one standard deviation change in variable, as % of outcome standard deviation)

Based on this table, we can draw the following main conclusions from the analysis, related to the five PIRLS outcomes analysed:

- Prior attainment measures at KS1 in both reading and writing were significantly related to PIRLS attainment.
- There was no overall difference between boys and girls once prior attainment at KS1 and other factors had been taken into account.
- Term of birth was related to attainment only for the overall measure, and not significantly for any of the others. Younger students performed slightly better than expected.
- Having a special educational need and having English as an additional language were both negatively related to attainment for all outcomes.
- Being born outside the UK was negatively related to attainment in three outcomes.
- The possession of consumer electronics was negatively related to attainment, while possession of more study-related goods was positively related.
- The composite deprivation measure was negatively related to attainment.
- The only teacher factor found to be significantly related to attainment was the scale for students reading silently and books of their own choice, which was positively related to the 'interpreting, integrating and evaluating' scale.
- The school context and environment factor measuring disadvantage and school problems was negatively related to all outcomes, while the environment factor measuring readiness for reading at starting school (early literacy skills) was positively related.
- The school policy and practice factor measuring the early introduction of basic reading skills was positively related to all outcomes.

For KS2 reading score the following conclusions may be drawn:

- PIRLS reading attainment was strongly related to KS2 score, and also to prior attainment at KS1.
- Controlling for PIRLS score and other factors, including prior attainment, girls tended to have slightly lower scores than boys.
- SEN stage was negatively related to KS2 score, and those with unknown SEN tended to have higher scores.
- The school context and environment factor measuring disadvantage and school problems was negatively related to KS2 score.
- The possession of consumer electronics was not significantly related to KS2 score, but the possession of study-related goods was positively related.
- The composite deprivation measure was negatively related to KS2 score.

In order to investigate the relationships between reading attainment and the three factors derived from the Student Questionnaire, these were included in turn in the final model for

the former. Table 5 shows the quasi effect sizes for each of these, when controlling for other significant factors which are related to attainment.

Table 5 Quasi Effect Sizes for Student Questionnaire Scales related to Reading Attainment

Variable	Overall attainment	PIRLS purposes		PIRLS processes		KS2 Reading score
		Literary attainment	Information attainment	Retrieving & straightforward inferencing	Interpreting, integrating & evaluating	
Student major factor: reading activities	-19	-20	-17	-28	-22	-11
Student major factor: reading enjoyment	37	36	36	48	45	18
Student major factor: use of alternative media	-10	-8	-10	-11	-7	

It seems that the second factor, reading enjoyment, was positively related to attainment, while reading activities and use of other media were negatively related. This negative association between attainment and reading activities is an interesting one. A close look at the items that comprise this factor reveals that most are concerned with reading aloud, talking about books and doing activities related to reading in school (eg talking with other students about what has been read). All these are most commonly undertaken by students who need support in their reading. Other items such as reading outside school and reading stories and novels are more heavily loaded on the reading enjoyment factor.

Finally, in order to investigate these student factors as outcomes in their own right, models were run to predict each with all the background factors included. These results are shown in Table 6.

Table 6 Quasi Effect Sizes for Student Questionnaire Scales as Outcomes

Variable	Reading activities	Reading enjoyment	Other media
KS1 reading score	-11	39	-10
KS1 writing score			
Gender (male = 1, female = 2)	43	33	-20
Term of birth			
Black ethnic groups			35
Asian ethnic groups			
Other ethnic groups			
Unknown ethnicity			
Stage of SEN (from PLASC)			-6
Missing SEN			
Other language spoken at home	15	8	30
English not normally used			-17
Born outside UK	23		
Possessions: consumer electronics		-6	32
Possessions: desk, books, mus. instrument	27	20	19
Composite deprivation measure	-21	-26	
Teaching strategies & vocab (Q15)	10		
Reading aloud (Q15)			
Reading silently and reading own choice books (Q15)		7	
Length of teaching experience			
Percent female teaching			
School environment 1: Low SES + disadvantage			9
School environment 2: Early literacy skills on entry to year 1	-10	-9	
School environment 3: Shortages and inadequacies of human/material resources			
School practices 1: Curricular emphasis on early reading skills			
School practices 2: Early advanced reading skills		8	
School practices 3: Family programmes and support			9

From Table 6 we can draw the following conclusions:

- Girls were more likely than boys to do more reading activities and have higher enjoyment, while boys were more likely to use alternative media.
- Those with higher KS1 reading scores were more likely to have higher enjoyment, but do fewer reading activities and be less likely to use alternative media.
- The possession of consumer electronics was negatively related to reading enjoyment, but positively to the use of alternative media.
- All three scales were positively related to the possession of study-related goods.
- Pupils of a black ethnic background were more likely to use alternative media.
- Pupils with SEN were less likely to use alternative media.
- Pupils with English as an additional language were likely to have higher scores on all three scales.
- Pupils who did not normally use English at home were less likely to use alternative media.
- Pupils born outside the UK tended to do more reading activities.
- Pupils whose teachers emphasised reading strategies and vocabulary learning tended to do more reading activities.
- Pupils whose teachers emphasised reading silently and books of their own choice tended to have higher reading enjoyment scores.
- Pupils in schools with low SES and reporting problems tended to use alternative media more.
- Pupils in schools which reported better readiness for reading at the start of year 1 tended to do fewer reading activities and also to have lower enjoyment.
- Pupils in schools which promoted earlier advanced reading skills tended to have higher enjoyment.
- Pupils in schools which emphasised family programmes and collaboration tended to use more alternative media.

When all other factors were controlled, only one of the Teacher Questionnaire scales was significantly related to attainment: the scale concerning how frequently students read silently in class and had time to read books of their own choosing, with greater frequency being positively related to attainment on the reading process scale of retrieval and straightforward inferencing.

All the above results are based on a 'value-added' analysis, in that they control for prior attainment at KS1 (age 7) and are thus more likely to give insights into progress during KS2 (ages 7-11) and its relationship to other factors than an analysis of attainment alone. However, none of these results should necessarily be interpreted as implying a causal connection between activities or other factors and outcomes.

Concluding discussion

This paper has two main purposes: to demonstrate how additional national data linked to the PIRLS dataset, in conjunction with sophisticated statistical analytical methods, can add value over and above the relatively simplistic secondary analyses sometimes reported; and to derive from such an analysis some insights into the relationships between prior attainment, reading enjoyment, self-motivated reading, and reading attainment.

With reference to the first purpose, we believe we have achieved our aim of demonstrating how it is possible to extract insight and meaning from international data by going beyond the simple descriptive statistics and country rankings which dominate much of the analysis of such data. Ritchie (1999) bemoans the poor quality and relative lack of secondary analysis of TIMSS data, and concludes "…further analysis of the TIMSS data set by competent researchers would go a long way towards making this a less wicked world". Similar remarks could be made about PIRLS data, and that from other international studies.

The substantive results of our analyses need to be considered alongside those from other researchers in the same area, such as: Wigfield and Guthrie (1995), who have pointed out that students who develop positive reading habits at a young age tend to persist with this behaviour as they mature; McKenna (2001) with a model of acquisition of reading attitudes; Shen (2002), looking at the relationship between achievement and self-perceived competence within and between countries; Davis and Brember (1993) for comparison of attitudes of boys and girls at different ages.

The models described here are tentative and provisional, and based on largely cross-sectional data. However, they demonstrate the importance of considering factors such as reading enjoying and self-confidence, as well as self-motivated reading behaviour, alongside test-based reading attainment measures. It could be argued that, in the drive to embed improved reading efficacy in a nation's children, the last measure is of less importance in the long term than the others.

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Appendix 1 Construction of the deprivation index

More detailed information about this is provided in the national report (Twist, Hodgson and Schagen, 2007). Information about student attainment (PIRLS and prior attainment at age 7), Student Questionnaire data and national background data (PLASC) was combined. This included the following indicators related to deprivation / advantage:

- Number of books in the home (Q20[1])
- Possession of other goods (Q21.1 to Q21.10)
- IDACI[2] indicator from PLASC, based on postcode (IDACI_06)
- Indicator of eligibility for free school meals from PLASC (FSM_06).

The list of possessions in Q21.1 to Q21.10 is quite wide-ranging, and it is not clear that all are related to deprivation in the same way. In order to reduce the dimensionality of this part of the data, exploratory factor analysis was used. This seemed to indicate two main factors, with loadings as shown in Table A1 below.

Table A1 Factor loadings for possessions

Possessions	Factor 1	Factor 2
Computer	0.03	0.26
Desk/table for own use	0.04	**0.44**
Books of own	-0.01	**0.38**
Daily newspaper	0.03	0.28
Own bedroom	0.21	0.25
Mobile phone	**0.44**	-0.01
TV	**0.79**	-0.05
Musical instrument	0.02	**0.44**
CD/DVD player	**0.50**	0.13
Satellite, digital or cable TV	0.21	0.23

Values in bold show loadings greater than 0.3 – this reveals three main possessions for each factor. Two additional variables were created:

[1] Question numbers refer to the position in the student questionnaire for England.
[2] The Index Deprivation Affecting Children Index (IDACI) measures the proportion of children under the age of 16 living in low income households and is related to postal districts.

- POSSESS1: Number of items on the first list (mobile phone, TV, CD/DVD player) – labelled as number of consumer electronic goods;
- POSSESS2: Number of items on the second list (desk, books, musical instrument) – labelled as number of study-related goods.

The extent and manner to which these two variables were related to deprivation was of interest.

More information on family background, including deprivation, is available from the Learning to Read Questionnaire, although not all parents responded to this and there is evidence that responses were biased towards less deprived families. Within this questionnaire, the following items were related to deprivation:

- Number of books in the home (Q15);
- Number of children's books in the home (Q16a);
- Highest level of education completed by father/mother (Q18a/b);
- Employment situation of father/mother (Q19a/b);
- Question on how well-off family is financially (Q21).

In addition there was a question (Q20a/b) on the father/mother's jobs, but the relationship between these codes and deprivation may not be straightforward.

The Learning to Read Questionnaire data was matched to the student data, and 1890 students (47% of the total) were found to have matched data. The relationship between the 'books in the home' question on both questionnaires was interesting. The correlation was 0.483 between the items on the two instruments, but Cohen's Kappa measure of exact agreement was only 0.218. Although 40% of cases agreed exactly on the number of books, there were some extreme cases. Six students claimed to have more than 200 books while their parents said zero to 10; contrariwise, eight students said they had zero to 10 books while their parent claimed over 200.

The next step was to use the relevant items on the Learning to Read Questionnaire to derive a single measure of deprivation, again using exploratory factor analysis. Factor loadings for this are shown in Table A2 below.

Table A2 Factor loadings for deprivation measure

Item	Factor 1
Number of books in the home	**0.69**
Number of children's books	**0.55**
Highest level of education - father	**0.64**
Highest level of education – mother	**0.69**
Employment situation – father	-0.19
Employment situation – mother	-0.10
How well-off family is	**-0.42**

Factor scores were produced for all cases with full data, and these were normalised to have a mean of 100 and standard deviation of 15 within this data (and such that higher values implied greater deprivation). The next step was to translate this composite measure into one that could be used with most cases within the student data, not just the subset with full Learning to Read Questionnaire data. A set of regression models were fitted, to predict the above deprivation measure from student deprivation variables. The first model used all student variables (books in the home, two sets of possession, IDACI and free school meals). The second regression omitted the free school meals indicator, while the third also omitted the IDACI measure. The fourth model omitted everything except IDACI and free school meals, while the fifth model used IDACI only. Regression coefficients are given in Table A3 below.

Table A3 Regression coefficients to predict deprivation measure

Variable	Model 1	Model 2	Model 3	Model 4	Model 5
Constant	109.35	110.02	114.74	95.86	95.62
Books in home (STDBOOKS)	-3.76	-3.90	-4.26		
Consumer electronic goods (POSSESS1)	3.83	3.81	4.17		
Study-related goods (POSSESS2)	-2.62	-2.75	-3.36		
IDACI code (IDACI_06)	18.25	21.35		29.35	33.43
Free school meal eligibility (FSM_06)	5.65			6.83	

In this way deprivation measures could be defined for 4031 out of 4039 students. The mean of the regressed values was 104.1 with a standard deviation of 8.9 – different from the nominal means of 100 and standard deviation of 15 for the derivation on the Learning to Read Questionnaire. This illustrates again the bias in the sample who completed the Learning to Read Questionnaires. Values were renormalised to mean 100, standard deviation 15, for the full student data. Correlations between this deprivation measure and the main outcomes and prior attainment values are given below in Table A4.

Table A4 Correlations with deprivation measure

Performance measure	Correlation
Average plausible value (overall)	-0.45
Average plausible value (information)	-0.45
Average plausible value (literary)	-0.45
KS1 reading score	-0.36
KS1 writing score	-0.33

The deprivation index was included in the multilevel model.

Figure 1: Reading ability and enjoyment

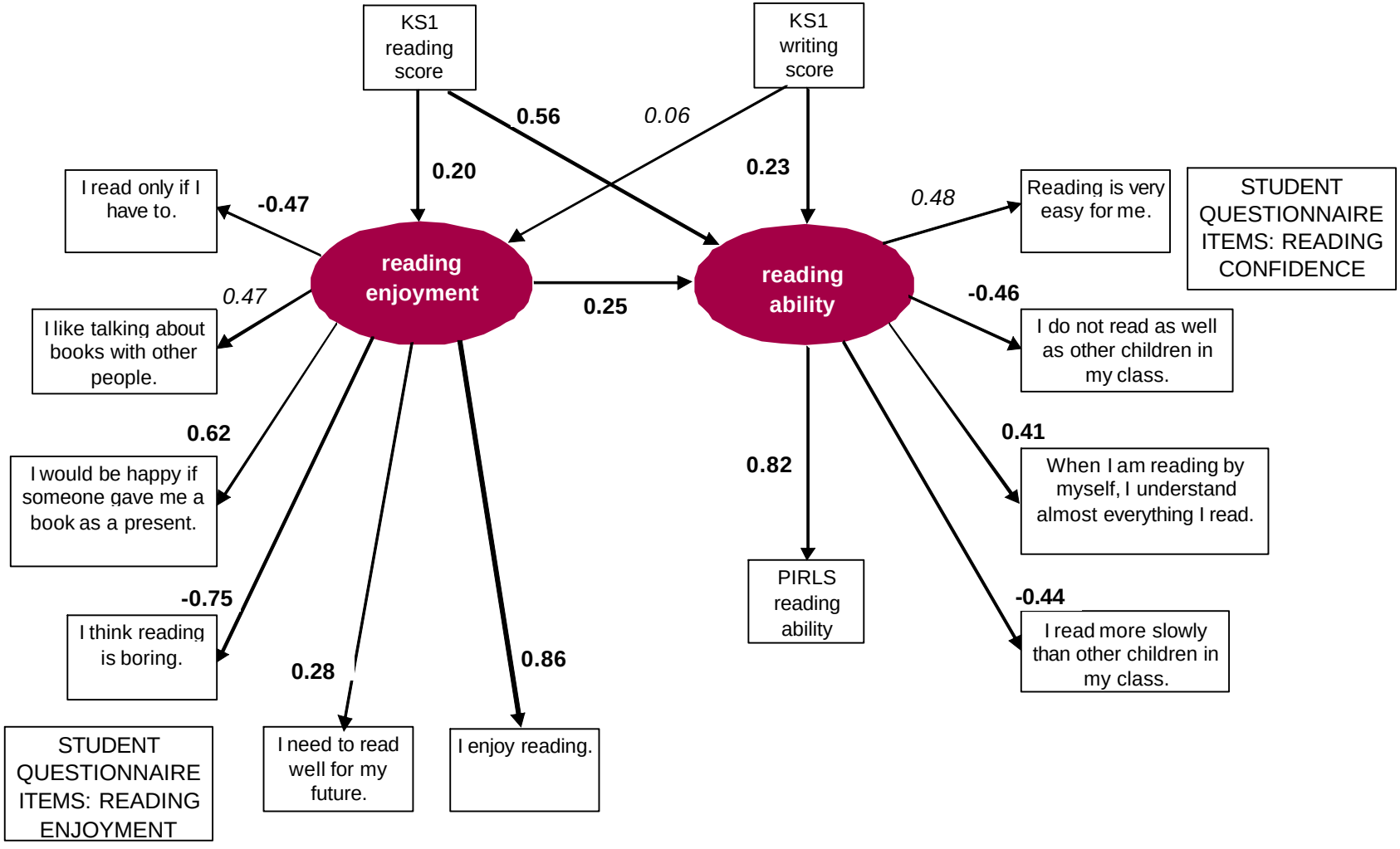

Figure 2: Reading ability, reading enjoyment and reading activities

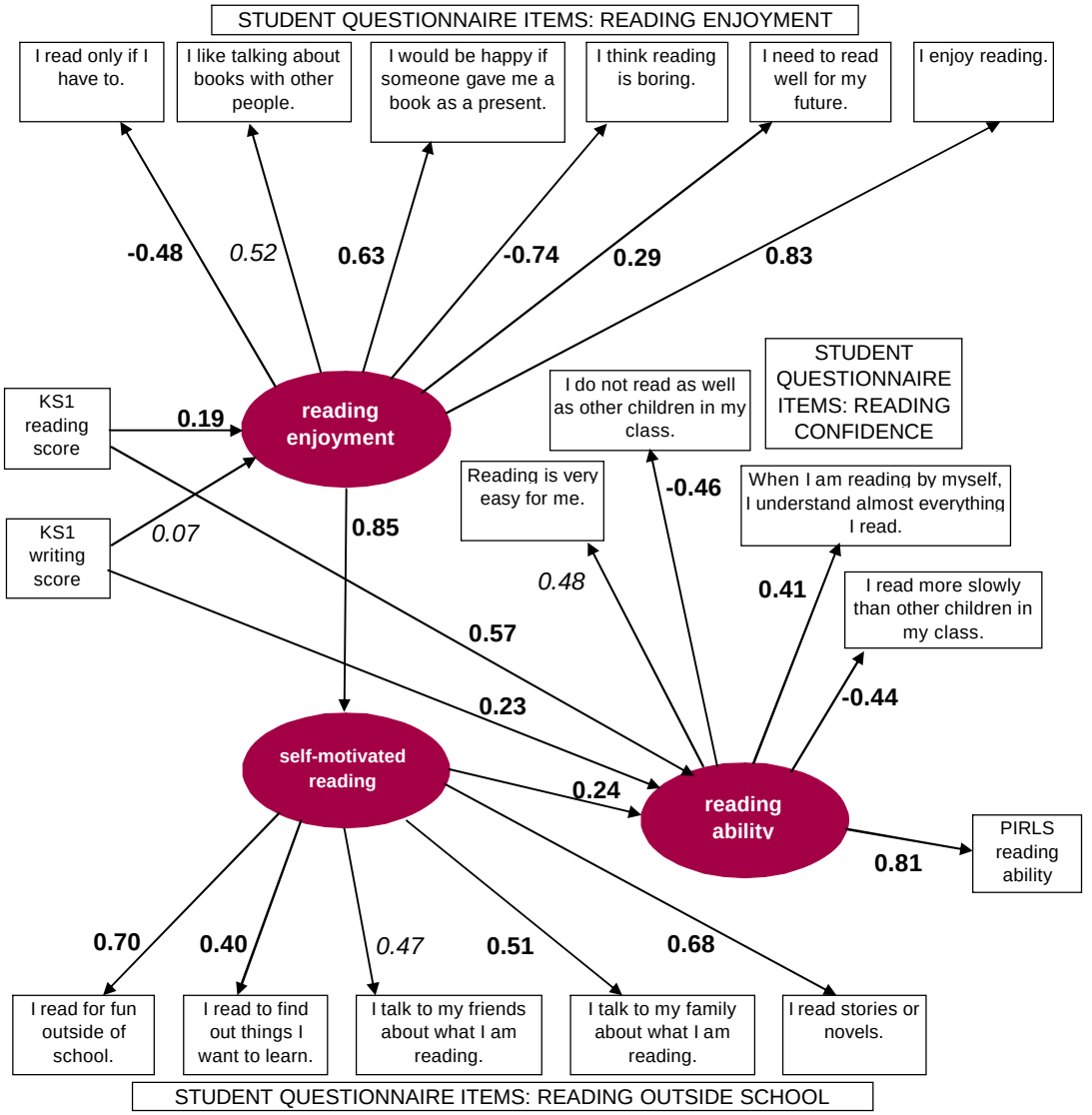

Figure 3: Reading ability, reading enjoyment and reading activities