# Appendix 3 Technical details

This appendix describes the factor analysis and multi-level modelling that was carried out on the TIMSS 2007 data for England to explore the relationships between key variables.

## A3.1 Factor analysis

Factor analysis is a statistical technique for identifying patterns in responses. In the case of TIMSS 2007 in England, it has been used to enable researchers to identify groups of questions which have been answered in a related way. The 'factors' (otherwise known as groups of related questions) which are identified as a result can then be used in more sophisticated analysis (multi-level modelling) to identify variables which are related to pupils' attainment and attitudes. Factor analysis was not done on all questions, only on those referring to variables which it was felt might be associated significantly with attainment or attitudes. This element of selection is designed to maximise the robustness of the models.

This section of Appendix 3 explores the factors derived from some of the questions discussed in Chapters 7, 8 and 9. It compares them across the grades and the two subjects, and discusses some notable differences in response patterns. The factors derived are similar to those derived in national analyses for TIMSS 2003, though not always identical. Any comparison with findings given in the national report for TIMSS 2003 should be made with this in mind.

The subsequent section (A3.2) explores the technical details of the factor analysis and is followed by sections A3.3 and A3.4, outlining the multi-level modelling and its outcomes.

### Pupils' attitudes: factors

Exhibit A3.1 shows the factors derived from the questions addressing pupils' attitudes (see Chapter 7). As can be seen, three attitudinal areas were explored: enjoyment and confidence in learning each of the TIMSS subjects and, at grade 8 only, the value that pupils place on their mathematics and science learning.

For the two questions common to both grades, a parallel series of questions was asked for each subject: about how pupils rated their own abilities and how much they enjoyed the subject. Statements to be rated included, for example, 'I enjoy learning science', 'Science is harder for me than for many of my classmates', 'I usually do well in maths' and 'I would like to do more maths at school'.

Exhibit A3.1 shows that, for science, pupils' responses to the statements about enjoyment and confidence were related: at both grades there were strong correlations between responses on all parts of the question. For mathematics, in contrast, pupils' answers fell into two groups: responses to the question parts about enjoyment of mathematics were strongly correlated with each other but not so strongly with the parts about confidence, while responses to the question parts about confidence were strongly correlated with each

**Exhibit A3.1 Attitudinal factors**

| Theme of question, grade 4 | Resulting factors, grade 4 | Theme of question, grade 8 | Resulting factors, grade 8 |
|---|---|---|---|
| Enjoyment and confidence in science | Enjoyment and confidence in science | Enjoyment and confidence in science | Enjoyment and confidence in science |
| Enjoyment and confidence in mathematics | Enjoyment of mathematics<br>Confidence in mathematics | Enjoyment and confidence in mathematics | Enjoyment of mathematics<br>Confidence in mathematics |
| ('Value' question not asked at grade 4) | n/a | Value of science and mathematics | Value of science and mathematics |

other but not so strongly with the parts about enjoyment. Thus, for science, one factor was created in each case while, for mathematics, two factors were created each time.

## The teachers and schools: factors

This section describes and compares the factors derived from teachers' and headteachers' questionnaires at each grade (see Chapter 8). These are summarised in Exhibit A3.2 (teacher factors) and A3.3 (headteacher factors).

When the patterns in responses about homework were explored using factor analysis, equivalent factors for science and mathematics were not created. At grade 4, all of the statements about science homework were correlated and formed one factor: Science homework. However, the teachers' responses about mathematics homework created two factors (Mathematics homework: teacher use, and Mathematics homework: class use). The factor related to teacher use incorporated frequency of homework, amount of homework, checking and feeding back on homework and using homework as part of teacher assessment. The second factor incorporated children marking their own homework in class and using homework as a basis for class discussion. The second factor highlights the interactive nature of homework in mathematics, with pupils involved in the process of marking homework and learning from it in class. In this approach, homework is not seen as simply a piece of work that is handed to the teacher and never revisited by the pupil; it is seen as an integral part of learning.

At grade 8, the factors related to homework questions were different for the science and mathematics teachers. The responses from the science teacher questionnaire created two factors (Homework: amount, completing sets of questions and teacher use; and Homework: other types and class use). However, the responses from the grade 8 mathematics teachers indicated that there were three factors (Homework: amount, completing sets of questions and teacher use; Homework: class use; and Homework type: active). For the mathematics teachers, responses to questions about more active approaches to homework (that is, gathering data and reporting; and finding one or more applications of the content area covered) correlated to produce the additional factor. This was not replicated in the science teacher data despite the fact that similar questions were asked. The reason for this is not clear.

## Exhibit A3.2 Teacher factors

| Theme of question, grade 4 | Resulting factors, grade 4 | Theme of question, grade 8 science teachers | Resulting factors, grade 8 science teachers | Theme of question, grade 8 mathematics teachers | Resulting factors, grade 8 mathematics teachers |
|---|---|---|---|---|---|
| Learning activities | Observation and investigation<br>Number and explanation<br>Mathematics: shape, measure and data | Learning activities | Observation and investigation<br>Explain and relate<br>Passive learning | Learning activities | Problem-solving and investigation<br>Data, geometry and algebra<br>Number and routine problem solving |
| School climate | School climate: teachers<br>School climate: children and parents | School climate | School climate: teachers<br>School climate: children and parents | School climate | School climate: teachers<br>School climate: children and parents |
| Calculator use | Routine calculator use<br>Complex calculator use | n/a<br>n/a | n/a<br>n/a | Calculator and computer use | Routine calculator use<br>Complex calculator use |
| Computer use | Computer access<br>Mathematics discovery and practice<br>Science procedure and practice<br>Look up and simulation | Computer use | Computer use | | Computer use |
| Limitations to teaching the TIMSS class | Student motivation<br>Student range: science<br>Student range: mathematics | Limitations to teaching the TIMSS class | Teaching resources<br>Computer resources<br>Student motivation<br>Student range | Limitations to teaching the TIMSS class | Teaching resources<br>Computer resources<br>Student motivation<br>Student range |
| Professional develop-ment | Mathematics professional development<br>Science professional development | Professional development | Professional development | Professional development | Professional development |
| Interaction with other teachers | Interaction with other teachers (Q7 variable) | Interaction with other teachers | Interaction with other teachers | Interaction with other teachers | Interaction with other teachers |
| Homework | Science homework<br>Mathematics homework: teacher use<br>Mathematics homework: class use | Homework | Homework: amount, question sets and teacher use<br>Homework: other types and class use | Homework | Homework: amount, question sets and teacher use<br>Homework: class use<br>Homework type: active |

Exhibit A3.3 shows the outcomes of the factor analysis of question responses from headteachers at grade 4 and grade 8. Patterns of response were quite different at each grade, resulting in different factors.

**Exhibit A3.3 Headteacher factors**

| Theme of question, grade 4 | Resulting factors, grade 4 | Theme of question, grade 8 | Resulting factors, grade 8 |
|---|---|---|---|
| Resources which may affect the school's capacity to provide education | Computer and laboratory equipment<br>Calculator availability<br>Materials/budget<br>Infrastructure<br>Library/audio-visual resources | Resources which may affect the school's capacity to provide education | Budget, materials and staff<br>Library and audio-visual resources<br>Computers and software<br>Infrastructure and special equipment |
| School climate and attendance | Problem behaviours<br>School climate<br>Severity of problem: 1<br>Severity of problem: 2<br>Absenteeism/ lateness | School climate<br>Severity of problem behaviour | Problem behaviours: 1<br>Problem behaviours: 2<br>School climate: teachers and students<br>School climate: parents<br>Severity of problem: 1<br>Severity of problem: 2 |
| Professional development | Professional development | Professional development | Professional development |
| Teacher recruitment | Difficulty filling vacancies (Q15 variable) | Teacher recruitment | Recruitment incentives |
| Recruitment incentives | (Not used) | | Difficulty filling vacancies |

At grade 4, headteachers' response patterns led to the creation of five resourcing factors: Computer/ laboratory equipment (incorporating computers and software for maths and science work, and laboratory equipment and materials); Calculator availability (incorporating calculators for science and maths work, and teachers); Materials/budget (incorporating teaching materials and budget for supplies); Infrastructure (incorporating buildings, grounds, teaching space, and heating and lighting systems); and Library/audio-visual resources (incorporating library and audio-visual equipment for science and mathematics).

Responses about schools' capacity to provide education based on a shortage of teachers and computer support staff were seen, at grade 8, as correlating with other budget and resourcing issues; this was not seen in the grade 4 factor analysis, where these responses did not correlate strongly with any of the factors.

The provision of special equipment was seen as related to infrastructure by headteachers in grade 8, but did not correlate strongly in the grade 4 headteacher responses. It is possible that this reflects the increased numbers of pupils with physical disabilities in individual secondary schools (as compared with the smaller primary schools) and therefore the lack of specialist equipment might affect individual secondary schools' capacity to provide education for a larger group of pupils with such needs.

Responses to some questions (such as grade 4 headteacher responses on special equipment for physically disabled children and the provision of IT support staff) did not correlate with any of the factors. Such questions were either not entered into the multi-level model or, if they were of particular interest, were entered into the model as separate variables.

At grade 8, headteachers' response patterns led to the creation of four resourcing factors: Budget, materials and staff (incorporating teaching materials, budget for supplies, calculators for maths and science work, science laboratory equipment and materials, teachers and computer support staff); Library and audio-visual resources (incorporating library and audio-visual equipment for science and mathematics); Computers and software (incorporating calculators for science and maths work, and teachers); and Infrastructure and special equipment (incorporating buildings, grounds, teaching space, heating and lighting systems, special equipment for physically disabled pupils). This analysis has resulted in one less factor than at grade 4.

In addition to questions about school climate, headteachers were asked to rate a series of pupil behaviours according to the frequency with which they occurred, as well as the perceived severity of the problem in their school. This included absenteeism, late arrival, truancy, swearing, vandalism, and abuse and injury to staff or other pupils. These ratings, along with responses about school climate, were analysed in order to explore further the relationship between school climate and pupil behaviour. Factor analysis for grade 4 led to the creation of five separate factors. Headteachers' answers to the statements about the frequency of the behaviours as well as their severity were correlated and formed the factor Problem behaviours. However, the first two statements concerning lateness and absenteeism did not fit this factor and were formed into an additional factor.

At grade 8 there were two Problem behaviours factors: Problem behaviours 1 (incorporating arriving late at school, absenteeism, missing lessons, not keeping to the dress code, classroom disturbance, cheating and vandalism); and Problem behaviours 2 (incorporating theft, intimidation or verbal abuse of other pupils, physical injury to other pupils, intimidation or verbal abuse of teachers or staff, and physical injury to teachers or staff). In secondary school (unlike primary school), teachers viewed the possible problem behaviours in two distinct categories, one of which is less severe and seems to involve mostly, though not exclusively, more minor disciplinary issues, and then the more severe behavioural issues which include aggressive behaviour towards other people at the school. In contrast, at grade 4 only a single behaviour factor emerged from the factor analysis. At grade 8, headteachers' severity ratings correlated less strongly with their frequency ratings than at grade 4 and so formed two separate factors.

Interestingly, primary headteachers' response patterns to the statements about school climate did not result in the same number of factors as the analysis of primary teachers' responses. That is, the outcome of the factor analysis on teacher responses showed that there were strong correlations between their responses to each of the four statements about teachers and between their responses to each of the four statements about parents and children, whereas for headteachers at grade 4, there was only a single factor: School

Climate. In order to make the findings from the multi-level model more meaningful, the one factor derived from the analysis of headteacher responses was split into two factors (School climate: teachers and School climate: parents and pupils) in order to make it directly comparable with the teacher data and the headteacher data at grade 8.

## Pupils and the home: factor analysis

This section describes and compares the factors obtained from the responses to questions given by pupils at each grade about such matters as the facilities available to them at home and the activities they like to do in their spare time (see Chapter 9).

**Exhibit A3.4 Pupils and the home factors**

| Theme of question, grade 4 | Resulting factors, grade 4 | Theme of question, grade 8 | Resulting factors, grade 8 |
|---|---|---|---|
| Frequency of science activities | Science activities | Frequency of science activities | Science activities: experiment and observation |
| | | | Science activities: theory and explanation |
| Frequency of mathematics activities | Mathematics activities | Frequency of mathematics activities | Mathematics activities |
| Working independently | Independent work | Working independently | Independent work |
| (Not asked at grade 4) | n/a | Whole class teaching in maths and science | Whole class teaching mode |
| School climate | Pupil perception of school climate | School climate | Pupil perception of school climate |
| Time spent on homework | Time spent on homework | Time spent on homework | Time spent on homework |
| | | Frequency of homework | Frequency of homework |
| | | Check homework in class | Check homework in class |
| Time spent on various activities outside of school | Out of school activities: 1 | Time spent on various activities outside of school | Out of school activities: 1 |
| | Out of school activities: 2 | | Out of school activities: 2 |
| Resources in the home including books and computers | Resources | Resources in the home | (Q5 variable) |
| | | Books at home | (Q4 variable) |
| Computer use for school work | Use of computer: school work | Computer use for school work | Use of computer: school work |

As was the case with headteachers' responses, different response patterns were seen for each grade. For two grade 8 factors (Whole class teaching mode and Check homework in class), the corresponding questions were not asked at grade 4, and so this accounts for the difference.

At grade 4 the responses to all questions about resources in the home, including books and access to computers correlated to form a single factor on home resources, which was used in the multi-level modelling analysis. The responses from grade 8 pupils on all the separate questions about resources in the home did not correlate to form a single factor. Therefore, in order to establish the impact of resources in the home on achievement, the main resources question (question 5) and the books in the home question (question 4) were entered individually into the multi-level model.

At both grade 4 and grade 8 the pupils were asked to indicate how frequently they undertook certain activities in their science and mathematics classes (they completed one question for science and another for mathematics). Interestingly, the factor analysis created only one factor for the mathematics activities at both grade 4 and grade 8. However, for grade 8 science activities two factors were created, while only one arose at grade 4.

Exhibit A3.5 shows how the responses to questions about science activities loaded onto these factors. This factor analysis suggests that the activities that pupils undertake in science lessons at grade 8 seem to fall into two distinct categories in the way that pupils respond to them: the more hands-on investigation-led approach and the more theoretical study of science.

**Exhibit A3.5 Factors associated with the frequency of science activities**

| Factor | Questions from grade 8 pupil questionnaire |
|---|---|
| Science activities: | We make observations and describe what we see |
| experiment and observation | We watch the teacher demonstrate an experiment or investigation |
| | We design or plan an experiment or investigation |
| | We carry out an experiment or investigation |
| | We work in small groups or pairs on an experiment or investigation |
| Science activities: | We read our science textbooks and other resource materials |
| theory and explanation | We memorise science facts and principles |
| | We use scientific formulas and laws to solve problems |
| | We give explanations about what we are studying |
| | We relate what we are learning in science to our daily lives |

Pupils at grade 4 and grade 8 were asked a parallel series of questions about homework in both subjects: how often they are given homework by their teacher and how many minutes they normally spend on their homework. At grade 4 only one factor related to homework was created: time spent on homework. However, at grade 8 the questions about frequency and amount of homework created two separate factors, indicating that for grade 8 pupils the frequency and time spent on homework are less well related.

Both grade 4 and grade 8 pupils were asked about the activities that they do outside school. At both grades, responses about the activities correlated to form two factors. At grade 4, these two factors included all but one of the activities listed, 'Going to a breakfast or after-school club' which was not correlated with any of the other activities. The two factors created from the pattern of pupil responses are Out of school activities: 1 and Out of school activities: 2.

As far as the grade 8 responses on this question are concerned, five activities did not correlate with the two factors. As at grade 4, there was a distinction between Out of school activities: 1 and Out of school activities: 2. The split was similar, but not identical, to that seen at grade 4.

Exhibit A3.6 shows how the responses to questions about outside school activities loaded onto these factors.

**Exhibit A3.6 Factors associated with after school activities**

| Factor | After school activities listed in grade 4 pupil questionnaire | Factor | After school activities listed in grade 8 pupil questionnaire |
|---|---|---|---|
| Out of school activities: 1 | I watch television and videos | Out of school activities: 1 | I watch television and videos |
| | I play computer games | | I play computer games |
| | I play or talk with friends | | I play or talk with friends |
| | I play sports | | I use the internet |
| | I use the internet | | I listen to music |
| | I listen to music | | |
| Out of school activities: 2 | I do jobs at home | Out of school activities: 2 | I read a book for enjoyment |
| | I read a book for enjoyment | | I play a musical instrument |
| | I do homework | | I do homework |
| | I play a musical instrument | | |
| | I do art (e.g. drawing, colouring or painting) | | |

## A3.2 Technical details of the factor analysis

As part of the national analysis for the TIMSS 2007 data for England, the student, teacher and school questionnaire data for both grades was analysed to develop a set of attitude scales.

The following method was used for developing the scales:

1. Identify groups of attitude items which seem to relate together using exploratory factor analysis
2. Derive composite scores from the values of the original variables re-scored in a scale from 0 to 10.

Although simple, this approach has the advantage that it is possible to compare each scale's mean value with the other scales, and hence evaluate the relative strength of feeling about each.

The scales derived for each of the questionnaires are described in Exhibits A3.7 to A3.13.

### Exhibit A3.7 Grade 4 pupil questionnaire factors

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| enjconfs | SQ - enjoyment and confidence in science | q8a q8b q8c_neg q8d q8e_neg q8f q8g_neg q8h | 6.28 | 2.50 | 8 | 0.881 |
| enjm | SQ - enjoyment of maths | q6b q6d q6f q6g_neg q6h | 6.33 | 3.08 | 5 | 0.850 |
| confm | SQ - confidence in maths | q6a q6c_neg q6e_neg q6f | 6.88 | 2.27 | 4 | 0.736 |
| activs | SQ - science activities | q9a q9b q9c q9d q9e q9h | 6.42 | 1.87 | 6 | 0.695 |
| activm | SQ - maths activities | q7a q7b q7c q7d q7e q7f q7g | 5.31 | 1.51 | 7 | 0.623 |
| spare1 | SQ - out of school activities 1 | q13a q13b q13c q13e q13g q13i | 4.64 | 1.86 | 6 | 0.673 |
| usecomp | SQ - use of computer for school work | q7k q9j q10c1 q10c2 | 3.27 | 2.17 | 4 | 0.658 |
| resource | SQ - resources | q4 q5 q10ab | 7.29 | 1.63 | 3 | 0.473 |
| indepen | SQ - independent work | q7i q9i | 7.12 | 2.35 | 2 | 0.461 |
| timehw | SQ - time spent on homework | q14b q15b | 3.88 | 1.40 | 2 | 0.581 |
| spare2 | SQ - out of school activities 2 | q13d q13f q13h q13j q13k | 3.04 | 1.53 | 5 | 0.571 |
| schenv | SQ - pupil perception of school climate | q11a q11b q11c | 8.11 | 1.73 | 3 | 0.456 |
| safety | SQ - extent of bullying | q12a q12b q12c q12d q12e | 2.99 | 2.88 | 5 | 0.635 |

### Exhibit A3.8 Grade 4 teacher questionnaire factors

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| tsciobsinv | TQ - science - observation + investigation | q33a q33c q33d q33e q33h | 5.58 | 1.57 | 5 | 0.773 |
| tnumexp | TQ - number and explanation | q20a q20b q20f q20g q20h q20i q33h q33i q33j | 6.08 | 1.35 | 9 | 0.742 |
| tmathsmd | TQ - maths - shape, measures + data | q20c q20d q20e | 3.52 | 0.61 | 3 | 0.745 |
| tsclkidpar | TQ - school climate - teachers | q10a q10b q10c q10d | 7.73 | 1.18 | 4 | 0.737 |
| tsclteach | TQ - school climate - children + parents | q10e q10f q10g q10h | 5.97 | 1.76 | 4 | 0.840 |
| tsafety | TQ - teachers' perception of safety | q8a q8b q8c | 8.13 | 1.70 | 3 | 0.798 |
| tscihw | TQ - science homework | q38 q39 q39Ba q39Bb q39Bc q39Bd q39Be | 3.39 | 2.87 | 7 | 0.938 |
| tmahwtea | TQ - maths homework - teacher use | q24 q25 q25Ba q25Bb q25Be | 6.27 | 1.67 | 5 | 0.720 |
| tmahwcla | TQ - maths homework - class use | q25Bc q25Bd | 4.50 | 2.55 | 2 | 0.626 |

**Exhibit A3.8 Grade 4 teacher questionnaire factors** *cont'd ...*

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| tcalcrout | TQ - routine calculator use | q17c q17d | 3.49 | 1.09 | 2 | 0.596 |
| tcalccomp | TQ - complex calculator use | q17a q17b | 3.18 | 1.24 | 2 | 0.518 |
| tcompacc | TQ - computer access | q18 q31 | 6.54 | 4.13 | 2 | 0.747 |
| tmadiscpra | TQ - maths - discover + practice | q19a q19b | 3.36 | 1.48 | 2 | 0.696 |
| tsciprocprac | TQ - science - procedures + practice | q32a q32c | 2.95 | 1.46 | 2 | 0.665 |
| tlookupsim | TQ - lookup + simulations | q19c q32b q32d | 3.25 | 1.16 | 3 | 0.531 |
| tmascimot | TQ - maths + science - motivation | q26d q26e q40d q40e | 3.49 | 2.33 | 4 | 0.866 |
| tscistudran | TQ - science - student range | q40a q40b q40c | 3.36 | 2.34 | 3 | 0.778 |
| tmastudran | TQ - maths - student range | q26a q26b q26c | 3.75 | 2.34 | 3 | 0.689 |
| tmacpd | TQ - maths professional development | q41a q41b q41c q41d q41e q41f | 3.25 | 3.67 | 6 | 0.876 |
| tscicpd | TQ - science professional development | q27a q27b q27c q27d q27e q27f | 5.34 | 3.61 | 6 | 0.831 |

**Exhibit A3.9 Grade 4 school questionnaire factors**

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| hcomlabeq | HQ - computer/lab equipment | q18g q18h q18l q18m q18n | 2.84 | 2.36 | 5 | 0.897 |
| hcalcavail | HQ - calculator availability | q18i q18o | 0.74 | 1.40 | 2 | 0.758 |
| hmatbud | HQ - materials/budget | q18a q18b | 1.78 | 2.23 | 2 | 0.808 |
| hinfrast | HQ - infrastructure | q18c q18d q18e | 3.22 | 2.58 | 3 | 0.763 |
| hlibav | HQ - library and audio-visual resources | q18j q18k q18p q18q | 2.44 | 2.22 | 4 | 0.885 |
| hprobbehav | HQ - problem behaviours | q17a3 q17a4 q17a5 q17a6 q17a7 q17a8 q17a9 q17a10 q17a11 q17a12 q17a13 | 2.11 | 1.22 | 11 | 0.865 |
| hschclim1 | HQ - school climate - teachers | q8a q8b q8c q8d | 7.72 | 1.29 | 4 | 0.840 |
| hsevprob1 | HQ - severity of problem 1 | q17b5 q17b7 q17b10 q17b11 q17b12 | 2.07 | 2.18 | 5 | 0.864 |
| hsevprob2 | HQ - severity of problem 2 | q17b3 q17b4 q17b6 q17b8 q17b9 | 0.77 | 1.42 | 5 | 0.792 |
| hablate | HQ - absenteeism/lateness | q17a1 q17a2 q17b1 q17b2 | 3.55 | 2.30 | 4 | 0.789 |
| hschclim2 | HQ - school climate - children and parents | q8e q8f q8g q8h | 6.48 | 1.66 | 4 | 0.833 |
| hprofdev | HQ - professional development | q13a q13b q13c q13d q13e | 7.93 | 2.51 | 5 | 0.890 |

## Exhibit A3.10 Grade 8 pupil questionnaire factors

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| SQencos | SQ - enjoyment and confidence in science | q11a q11b q11c_neg q11d q11e_neg q11f q11g_neg q11h | 6.054 | 2.339 | 8 | 0.897 |
| SQvalms | SQ - value of science and maths | q9a q9b q9c q9d q9e q12a q12b q12c q12d q12e | 6.301 | 1.885 | 10 | 0.842 |
| SQactm | SQ - maths activities | q10a q10b q10c q10d q10e q10f q10g q10h q10i q10o | 4.712 | 1.552 | 10 | 0.786 |
| SQenjm | SQ - enjoyment of maths | q8b q8d q8g_neg q8h | 4.832 | 2.567 | 4 | 0.851 |
| SQconm | SQ - confidence in maths | q8a q8c_neg q8e_neg q8f | 6.316 | 2.310 | 4 | 0.791 |
| SQsciex | SQ - science activities - experiment and observation | q13a q13b q13c q13d q13e | 6.002 | 2.101 | 5 | 0.827 |
| SQindwk | SQ - independent work | q10l q13m | 6.090 | 2.345 | 2 | 0.541 |
| SQscith | SQ - science activities - theory and explanation | q13f q13g q13h q13i q13j | 5.462 | 2.088 | 5 | 0.757 |
| SQoutac | SQ - out of school activities 2 | q17g q17i q17k | 2.177 | 1.525 | 3 | 0.458 |
| SQtimhw | SQ - time spent on homework | q18b q19b | 4.180 | 1.304 | 2 | 0.720 |
| SQteach | SQ - whole class teaching mode | q10k q13l | 7.595 | 2.486 | 2 | 0.632 |
| SQsclim | SQ - pupil perception of school climate | q15a q15b q15c | 6.627 | 1.986 | 3 | 0.585 |
| SQcomsw | SQ - use of computer - school work | q10q q13p q14c1 q14c2 | 3.139 | 1.744 | 4 | 0.584 |
| SQfrehw | SQ - frequency of homework | q18a q19a | 4.476 | 1.584 | 2 | 0.574 |
| SQchkhw | SQ - check homework in class | q10j q13k | 4.693 | 2.763 | 2 | 0.530 |
| SQoutac1 | SQ - out of school activities 1 | q17a q17b q17c q17h q17j | 5.400 | 1.765 | 5 | 0.591 |

## Exhibit A3.11 Grade 8 maths teacher questionnaire factors

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability SQencos |
|---|---|---|---|---|---|---|
| TQMact1 | TQM - frequency of activities: problem solving & explanation | mq17h mq17i mq17j mq17k mq17l | 5.036 | 1.611 | 5 | 0.670 |
| TQMact2 | TQM - frequency of activities: data, geometry, algebra | mq17c mq17d mq17e | 3.499 | 0.702 | 3 | 0.593 |
| TQMact3 | TQM - frequency of activities: number & routine problem solving | mq17a mq17b mq17g | 5.209 | 1.655 | 3 | 0.433 |
| TQMsc1 | TQM - school climate: children & parents | mq12e mq12f mq12g mq12h | 5.181 | 1.691 | 4 | 0.840 |

**Exhibit A3.11 Grade 8 maths teacher questionnaire factors** *cont'd ...*

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| TQMsc2 | TQM - school climate: teachers | mq12a mq12b mq12c mq12d | 7.032 | 1.229 | 4 | 0.730 |
| TQMsafe | TQM - teacher perception of safety | mq10a mq10b mq10c | 7.710 | 1.762 | 3 | 0.802 |
| TQMhw1 | TQM - homework: amount, question sets and teacher use | mq26 (inc. mq25) mq27 mq28a mq29a mq29b mq29e | 6.181 | 1.440 | 6 | 0.699 |
| TQMhw2 | TQM - homework: class use | mq29c mq29d | 4.737 | 2.152 | 2 | 0.394 |
| TQMhw3 | TQM - homework type: active | mq28b mq28c | 2.373 | 2.067 | 2 | 0.402 |
| TQMcc1 | TQM - computer use | mq23a mq23b mq24a mq24b mq24c mq24d | 2.008 | 1.912 | 6 | 0.908 |
| TQMcc2 | TQM - routine calculator use | mq22a mq22b | 4.212 | 2.328 | 2 | 0.742 |
| TQMcc3 | TQM - complex calculator use | mq22c mq22d | 4.235 | 2.306 | 2 | 0.648 |
| TQMlim1 | TQM - limitation: teaching resources | mq18i mq18j mq18k mq18l mq18m | 1.771 | 1.750 | 5 | 0.770 |
| TQMlim2 | TQM - limitation: computer resources | mq18f mq18g mq18h | 2.628 | 2.593 | 3 | 0.815 |
| TQMlim3 | TQM - limitation: student motivation | mq18d mq18e | 4.695 | 3.010 | 2 | 0.886 |
| TQMlim4 | TQM - limitation: student range | mq18a mq18b mq18c | 2.853 | 1.856 | 3 | 0.548 |
| TQMcpd | TQM - professional development | mq9a mq9b mq9c mq9d mq9e mq9f | 5.957 | 3.179 | 6 | 0.745 |
| TQMint | TQM - interaction with other teachers | mq8a mq8b mq8c mq8d | 2.923 | 1.731 | 4 | 0.654 |

**Exhibit A3.12 Grade 8 science teacher questionnaire factors**

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| TQSact1 | TQS - frequency of activities: observe/ investigate | sq17a sq17c sq17d sq17e | 4.966 | 1.494 | 4 | 0.676 |
| TQSact2 | TQS - frequency of activities: explain & relate | sq17i sq17j | 6.812 | 2.347 | 2 | 0.733 |
| TQSact3 | TQS - frequency of activities: passive learning | sq17b sq17f sq17g sq17h | 4.350 | 1.429 | 4 | 0.541 |
| TQSsc1 | TQS - school climate: children and parents | sq12e sq12f sq12g sq12h | 5.293 | 1.770 | 4 | 0.844 |
| TQSsc2 | TQS - school climate: teachers | sq12a sq12b sq12c sq12d | 6.950 | 1.441 | 4 | 0.801 |
| TQSsafe | TQS - teacher perception of safety | sq10a sq10b sq10c | 7.691 | 1.665 | 3 | 0.775 |
| TQShw1 | TQS - homework: amount, question sets and teacher use | sq24 (inc. sq23) sq25 sq26a sq27a sq27b sq27e | 5.922 | 1.492 | 6 | 0.732 |
| TQShw2 | TQS - homework: other types and class use | sq26b sq26c sq26d sq26e sq26f sq26g | 3.663 | 1.299 | 8 | 0.647 |

### Exhibit A3.12 Grade 8 science teacher questionnaire factors *cont'd ...*

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| TQScom | TQS - computer use | sq21 sq22a sq22b sq22c sq22d sq22e | 2.041 | 1.665 | 6 | 0.845 |
| TQSlim1 | TQS - limitation: teaching resources | sq18i sq18j sq18k sq18l sq18m | 2.562 | 1.981 | 5 | 0.809 |
| TQSlim2 | TQS - limitation: computer resources | sq18f sq18g sq18h | 3.536 | 2.738 | 3 | 0.851 |
| TQSlim3 | TQS - limitation: student motivation | sq18d sq18e | 4.580 | 2.871 | 2 | 0.879 |
| TQSlim4 | TQS - limitation: student range | sq18a sq18b sq18c | 2.813 | 1.901 | 3 | 0.668 |
| TQScpd | TQS - professional development | sq9a sq9b sq9c sq9d sq9e sq9f | 5.656 | 3.488 | 6 | 0.816 |
| TQSint | TQS - interaction with other teachers | sq8a sq8b sq8c sq8d | 3.248 | 1.785 | 4 | 0.688 |

### Exhibit A3.13 Grade 8 school questionnaire factors

| Scale name | Scale label | Items | Mean | Std | No. items | Reliability |
|---|---|---|---|---|---|---|
| HQres1 | HQ - resourcing: budget, materials and staff | q19a q19b q19i q19l q19o q19r q19s | 2.198 | 1.856 | 7 | 0.822 |
| HQres2 | HQ - resourcing: library and audio-visual resources | q19j q19k q19p q19q | 2.630 | 2.218 | 4 | 0.909 |
| HQres3 | HQ - resourcing: computers and software | q19g q19h q19m q19n | 3.765 | 2.727 | 4 | 0.906 |
| HQres4 | HQ - resourcing: infrastructure and special equipment | q19c q19d q19e q19f | 4.533 | 2.841 | 4 | 0.832 |
| HQvac1 | HQ - vacancies: recruitment incentives | q17a q17b q17c | 1.976 | 3.679 | 3 | 0.934 |
| HQvac2 | HQ - vacancies: difficulty filling vacancies | q16a q16b q16c | 5.182 | 2.806 | 3 | 0.704 |
| HQcpd | HQ - professional development | q13a q13b q13c q13d q13e | 6.764 | 2.314 | 5 | 0.855 |
| HQsc1 | HQ - school climate: problem behaviours 2 | q18a8 q18a9 q18a10 q18a11 q18a12 q18a13 | 2.773 | 1.327 | 6 | 0.854 |
| HQsc2 | HQ - school climate: problem behaviours 1 | q18a1 q18a2 q18a3 q18a4 q18a5 q18a6 q18a7 | 5.170 | 2.115 | 7 | 0.866 |
| HQsc3 | HQ - school climate: school climate: teachers and students | q8a q8b q8c q8d q8g q8h | 7.268 | 1.273 | 6 | 0.859 |
| HQsc4 | HQ - school climate: school climate: parents | q8e q8f | 5.376 | 1.787 | 2 | 0.771 |
| HQsc5 | HQ - school climate: Severity of problem 1 | q18b1 q18b2 q18b3 q18b4 q18b5 q18b7 q18b10 | 3.731 | 2.040 | 7 | 0.863 |
| HQsc6 | HQ - school climate: Severity of problem 2 | q18b6 q18b8 q18b9 q18b11 q18b12 q18b13 | 1.751 | 1.864 | 6 | 0.849 |

## A3.3 Details of multi-level regression analysis

The following types of data were available for the analysis of the international study outcomes in England:

- Internationally derived scales for pupils' performance in mathematics and science (at grade 4 and grade 8)
- Nationally derived factor scores for pupils, teachers and schools derived from questionnaire information
- Pupil background information, both from questionnaires and the National Pupil Database
- Class and school information.

Analysis was undertaken to investigate which factors at the school, class and pupil levels might be associated with the international attainment scales and nationally derived attitudinal factors.

### Setting up multi-level models

Multi-level modelling is a development of a common statistical technique known as 'regression analysis'. This is a technique for finding a straight-line relationship which allows us to predict the values of some measure of interest ('dependent variable') given the values of one or more related measures. For example, we may wish to predict schools' average test performance given some background factors, such as free school meals and school size (these are sometimes called 'independent variables').

Multi-level modelling takes account of data which is grouped into similar clusters at different levels. For example, individual pupils are grouped into classes, and those classes are grouped within schools. There may be more in common between pupils within the same class than with other classes, and there may be elements of similarity between different classes in the same school. Multi-level modelling allows us to take account of this hierarchical structure of the data and produce more accurate predictions, as well as estimates of the differences between pupils, between classes, and between schools.

As an improvement on the national analysis of 2003 TIMSS data, prior attainment data from the National Pupil Database has been included in these 2007 models. The analysis reported here is therefore a 'value-added' analysis. This means that any reported association between an independent and dependent variable is acting 'over and above' the effect of prior attainment.

The models fitted to the data incorporated three levels:

1. School

2. Class

3. Pupil

Thus, there are assumed to be variations between schools in their average scores, between classes in the same school, and, within each class, variations between pupils in their attitudes and cognitive scores. The sizes of these variations at each level of the model are measured in terms of 'random variances', and the relative sizes of these are of interest.

For each outcome measure the fitting process was carried out in two stages:

1. The 'base case', with no background variables

2. Including school-level, class-level and pupil-level variables in the final model, removing those which were clearly not significant.

Pupil, class and school composite variables were derived following factor analysis of selected attitude questions on each instrument (see above).

Internationally derived TIMSS attainment scales have five plausible values for each pupil within each subject. A brief sensitivity analysis was carried out to confirm that taking the mean of these five values leads to an underestimate of model coefficient standard errors. Instead, five multi-level models were run for each subject at each grade: one for each set of plausible values. The final model results were obtained by averaging the results of these five interim models. In order to end up with a model containing broadly significant coefficients, terms had to be significant at the 10 per cent level in all five interim models. In other words, it was important to use a generous significance level in the interim models, so that key variables that might be significant at the five per cent level were not inadvertently lost too early in the modelling process. Items identified as significant in the final model were significant at the five per cent level. To aid interpretation, only those terms which were significant at the five per cent level were plotted in the final charts.

## Results of multi-level analysis - relationships with background variables

In technical language, the multi-level model results comprise the random variances at each level at each stage of model fitting, plus the coefficients of the background variables in the final model. From estimated standard errors we may deduce whether or not variances or coefficients are statistically significant at the 5 per cent level, as well as 95 per cent confidence intervals for each parameter.

These results may not be easy to interpret for all readers. To aid in interpretation, therefore, the coefficients which express the estimated relationships between the scales and each of the background variables have been converted into 'Quasi Effect Size coefficients' (Schagen and Elliot, 2004) which represent the expected change (in percentage of the standard deviation) in the outcome for an average switch between low and high values in the background variables.

Quasi Effect Size coefficients are plotted in Exhibits A3.14 to A3.23 for each of the international scales at Grade 4 and Grade 8 in science and mathematics, as well as for each of the attitude scales analysed. For each variable, the estimated Quasi Effect Size coefficient is plotted as a diamond, with a vertical line indicating the 95 per cent confidence interval for the estimate. Any variable whose line intersects the horizontal zero axis can be regarded as not statistically significant (at the 5 per cent level). Positive values imply a positive relationship with the international scale outcome; negative values imply that scale values tend to decrease with higher values of the given background variable. A list of variables that were used for the modelling at each grade is included in Exhibits A3.24 and A3.25. A summary of the quasi effect sizes for significant variables in each model is found in Exhibits A3.26 to A3.35.

To further aid interpretation, the main findings from each of the models have been summarised as a series of bullet points. These written results can be compared with the tables and figures. Care should be taken when interpreting the coefficients of some variables due to correlations between these variables. For example, attitude measures were included in the attainment models and, since particular attitudes (e.g. confidence in mathematics) are biased towards one gender, the coefficient for gender is often strongly influenced by attitude variables.

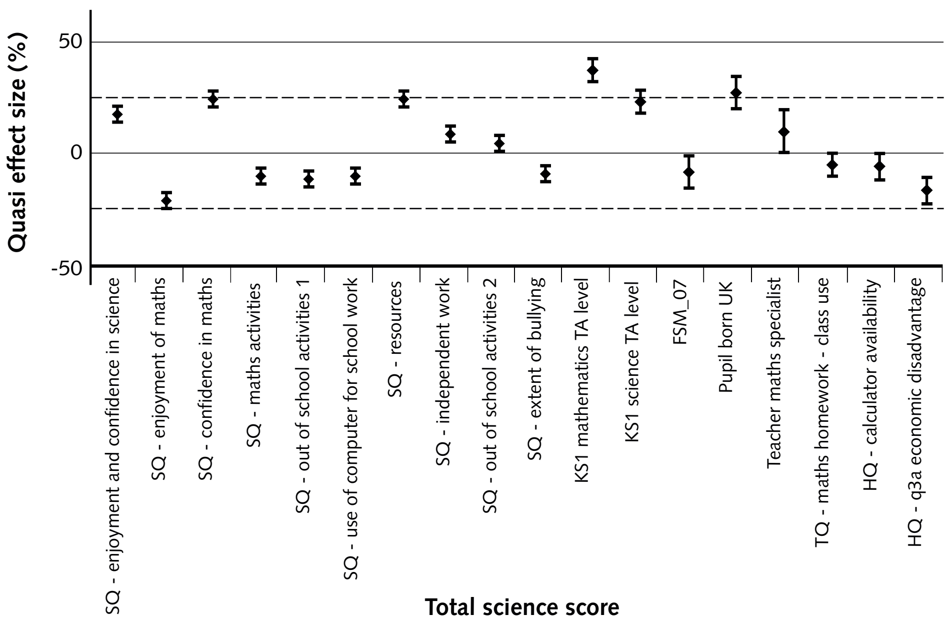
It should be emphasised at this point that *the results of these models document associations and not causal relationships*. Also, since many variables were included in the models, we would always expect some to come out significant that were not genuine associations due to the significance level used. Using a more stringent significance level, however, could have resulted in missing genuine associations, hence it was decided to use the 5 per cent level.

## A3.4 Results of multi-level modelling

### Grade 4 science

Models were run for the five science plausible values. All available variables, including prior attainment measures, were used in the initial models and those that remained significant (at the 10 per cent level) for all five initial models were selected for the interim models. The final model was derived by averaging the outcomes of the five interim models. The outcomes are summarised in Exhibit A3.14. Only the statistically significant findings are listed below.

**Exhibit A3.14 Quasi effect sizes for grade 4 science**



- Taking no background variables into account, the pupil-level variance was greater than both the teacher-level and school-level variances, indicating that differences between individual pupils within a school were larger than those between pupils in different classes or schools. When background variables were controlled for, 86 per cent of the school-level and 68 per cent of the teacher-level variances were explained, but only a 44 per cent reduction was achieved for the pupil-level variance, in terms of science achievement at grade 4.
- Taking other background variables into account, the strongest positive predictor of science attainment was key stage 1 (KS1) mathematics teacher assessment (TA) level. Similarly, KS1 science TA level also had one of the strongest positive effects. The higher the TA levels, the better the pupils did on TIMSS 2007.
- If the pupils' teacher was a mathematics specialist, this had a positive association with pupils' science scores.
- The second strongest positive predictor of attainment in science at grade 4 was being born in the UK.
- Percentage of economically disadvantaged pupils in the school and each pupil's eligibility for free school meals were both significant negative predictors of attainment in science at grade 4. In contrast, resources (i.e. books and other resources at home and computer resources accessible elsewhere) was a significant positive predictor. However, caution must be exercised when looking at these effect sizes from the model, as these three factors were likely to be correlated. In general, pupils from wealthier families were likely to do better in science.
- Enjoyment and confidence in science was one of the strongest positive predictors of science attainment. Confidence in mathematics was also a strong positive predictor of attainment in science, but enjoyment of mathematics turned out to have strong negative effects on science attainment. However, the attitude models showed that the confidence and enjoyment of mathematics were strongly correlated. Therefore, the negative effect of enjoyment of mathematics could be a result of collinearity between these two explanatory variables. On the other hand, enjoyment and confidence in science did not seem to correlate with enjoyment or confidence in mathematics.
- Pupil reports of being bullied were a significant negative predictor of science attainment. The greater the extent of perceived bullying (e.g. verbal or physical bullying, or social exclusion), the lower the science scores. But, unlike the mathematics model, teachers' perception of school climate (i.e. the extent to which parents and children support the school) was not a significant predictor of science attainment at grade 4.
- In the classroom, mathematics activities and computer use for school work were both negative predictors of grade 4 science attainment, while independent work during lessons was a positive predictor. This might indicate that grade 4 pupils who are encouraged to work independently consequently do better in science than those who are not. Conversely, it might indicate that those who do better are consequently encouraged to work independently to a greater extent. The direction of causality cannot be confirmed by these findings.

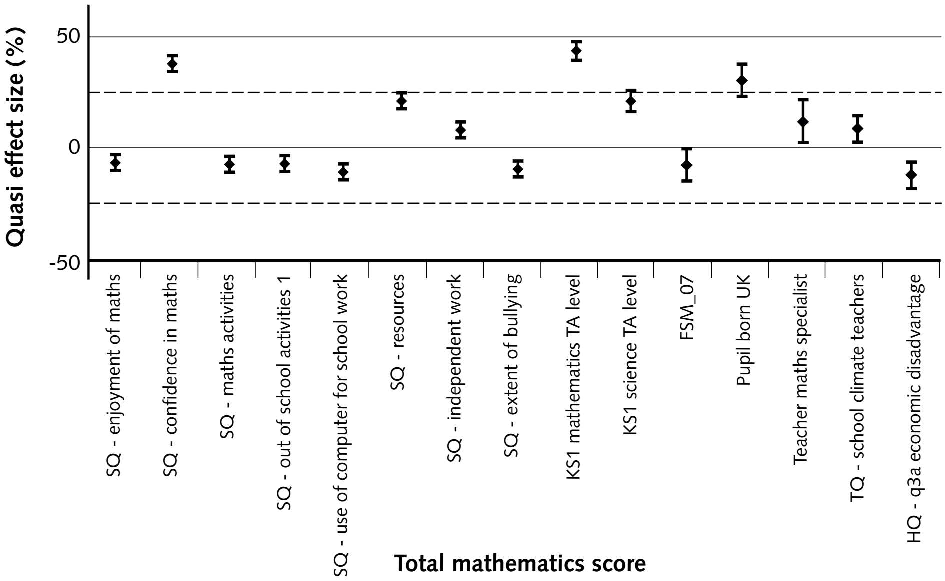
- Using homework in class and having more calculators available for school work both had borderline significant negative effects on science attainment. These are potentially surprising findings, since using homework as the basis for classroom learning and using a calculator to support learning in mathematics might be seen as a useful means of enhancing learning, even in science where mathematical skills are useful. It is not obvious why this finding should have arisen and it is possible that, being borderline significant, it is a spurious result. It is possible that discussion of homework tasks in class time might follow from lower attainment rather than necessarily being a cause of it or, again, this might be a spurious result.

- 'Time spent on out of school activities 1' (i.e. watch TV, play computer games, use the internet, play sports, listen to music) was a significant negative predictor. On the other hand, 'time spent on out of school activities 2' (i.e. read a book for fun, do homework, do art, play musical instruments, do jobs at home) was a significant positive predictor. Again, it cannot be stated with certainty what the direction of causality is for these findings. All that can be said for sure is that pupils who spend more time on the first group of leisure activities do less well than those who spend more time on the second group.

## Grade 4 mathematics

Models were run for the five mathematics plausible values. All available variables, including prior attainment measures, were used in the initial models and those that remained significant (at the 10 per cent level) for all five initial models were selected for the penultimate models. The final model was derived by averaging the outcomes of the five penultimate models.

**Exhibit A3.15 Quasi effect sizes for grade 4 mathematics**




- Taking no background variables into account, the pupil-level variance was greater than both the teacher-level and school-level variances. When background variables were controlled for, 77 per cent of the school-level and 68 per cent of the teacher-level variance was explained, but only a 50 per cent reduction was achieved for the pupil-level variance.

- Taking other background variables into account, the strongest positive predictor of mathematics attainment at grade 4 was KS1 mathematics TA level. Similarly, KS1 science TA level also had one of the strongest positive effects. As was the case for science, the higher the TA levels, the better the pupils did.

- If the pupils' teacher was a mathematics specialist, this had a positive association with pupils' mathematics scores.

- The second strongest positive predictor was confidence in mathematics, whilst enjoyment of mathematics was a weak but significant negative predictor. However, the attitude models showed that the confidence and enjoyment of mathematics were strongly correlated. Therefore the negative effect of enjoyment of mathematics could be a result of collinearity between these two explanatory variables.

- Being born in the UK was the third strongest positive predictor of pupils' mathematics score.

- Percentage of economically disadvantaged pupils in the school and each pupil's eligibility for free school meals were both significant negative predictors. Resources (i.e. books and other resources at home and computer resources accessible elsewhere) was a significant positive predictor. However, caution must be taken when looking at these effect sizes from the model, as these three factors were likely to be correlated. In general, pupils from wealthier families were likely to do better in mathematics.

- Teachers' perception of their contribution to school climate was a significant positive predictor of mathematics attainment. In other words, where teachers were more positive about the job satisfaction of teachers in their school, thought that they understood the school's curricular goals, were successfully in implementing the curriculum, and had high expectations for children's achievement, so attainment in mathematics rose.

- Conversely, pupils being bullied (verbally, physically or socially) was a significant negative predictor of mathematics attainment. The safer pupils feel, the better their mathematics scores.

- Mathematics activities, together with computer use for school work, were both negative predictors of attainment in mathematics at grade 4. Thus, as pupils do more of the classroom activities listed and as they use computers more for school work, so their attainment in mathematics decreases. This sounds counter-intuitive, but might indicate that additional practice is being offered to lower achieving pupils.

- On the contrary, independent work was a positive predictor. Thus, as pupils more frequently work independently in class, so their attainment rises. This might be either a cause or an effect of higher attainment in mathematics.

- Out of school activities 1' (watch TV, play computer games, use the internet, play sports, listen to music) was a weak but significant negative predictor. The more time a pupil spent on such activities each day, the lower their mathematics score. Such activities might have distracted a pupil from studying at home and hence resulted in negative effects, or they might have been a result of lower attainment. In contrast, 'out of school activities 2' (read a book for fun, do homework, do art, play musical instruments, do jobs at home) was not associated with mathematics attainment at grade 4, although it was associated with science attainment at the same grade.

## Grade 4 attitude models

Models were run for each of the three factors derived from the student questionnaire factor analysis:

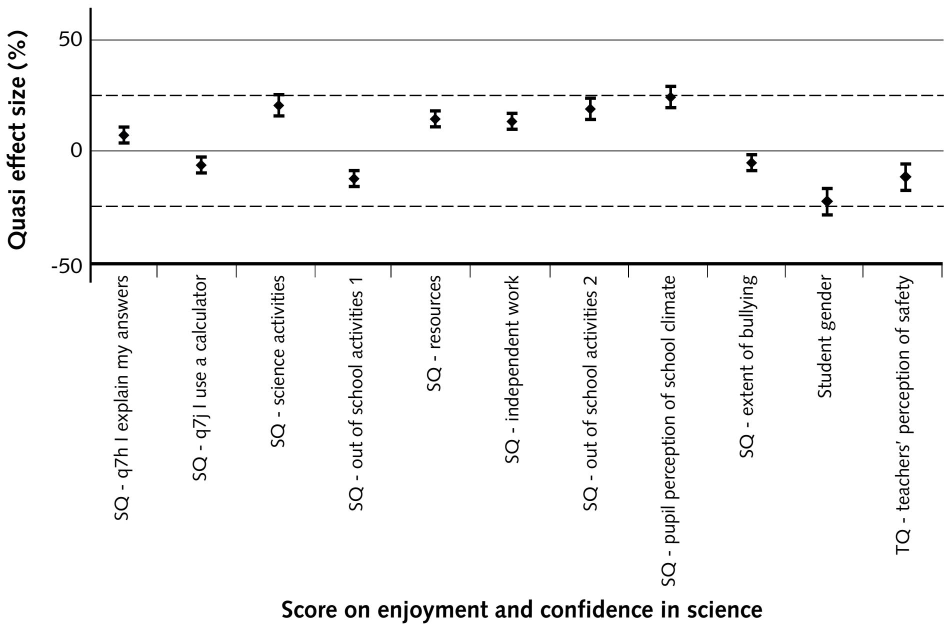
- enjoyment and confidence in science
- enjoyment of mathematics
- confidence in mathematics.

All available variables, including prior attainment measures, were used in the initial models and those that remained significant (at the 5 per cent level) were selected for the final models.

In all three cases, the pupil-level variance was greater than the class-level and school-level variances, indicating that difference between individual pupils were larger compared to those between pupils in different classes/schools.

## Enjoyment and confidence in science

**Exhibit A3.16 Quasi effect sizes for grade 4 enjoyment and confidence in science**




- A strong positive predictor for enjoyment and confidence in science was pupils' perception of school climate (i.e. pupils like being at school and want to do their best, while they believe that teachers also want them to do their best). Being bullied acted as a negative predictor of enjoyment and confidence in science. Having a positive atmosphere at school probably boosts pupils' enjoyment of school and hence impacts on their enjoyment and confidence in science.

- On the other hand, teachers' perception of safety was a significant negative predictor (i.e. the safer teachers feel their school is, the less their pupils enjoy and are confident in science). However, this factor might be correlated to the extent of bullying at school, and to pupils' perception of school climate. Collinearity could be an issue, rendering the reliability of this result suspect.

- Pupil gender turned out to be a strong predictor, with boys scoring significantly higher in enjoyment and confidence in science than girls, when all other background variables were controlled for. This has been discussed in Chapter 7.

- Resources (i.e. books and other resources at home and computer resources accessible elsewhere) was a significant positive predictor. In other words, as the number of available resources rises, so too does enjoyment and confidence in science. This suggests that a positive attitude to learning is associated with access to such resources.

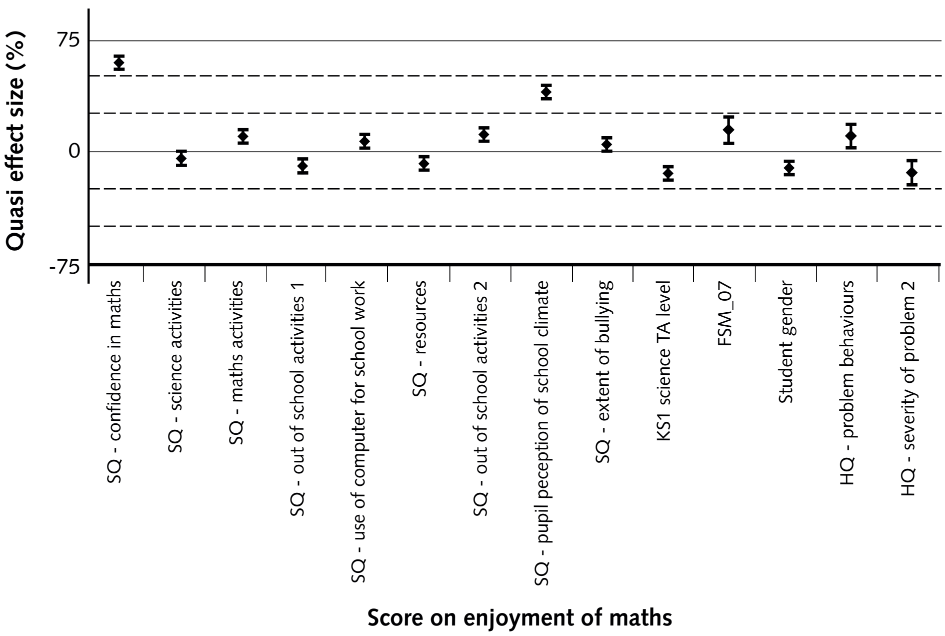
- In the classroom, science activities, independent work and chances for the pupils to explain their own answers in mathematics were all significant positive predictors of enjoyment and confidence in science, suggesting that active engagement is key to a positive attitude. Using calculators in mathematics lessons, however, turned out to be a negative predictor: as use of a calculator in mathematics lessons increased, so enjoyment and confidence in science decreased. This might be because lower attaining pupils depend on their calculators to a greater extent than others, suggesting that this is simply an effect of lower attainment and lower engagement with learning. It is also possible that collinearity could be an issue, if pupils answered from the perspective of independent work and science activities involving calculator use. This seems unlikely, however.

- 'Time spent on out of school activities 1' (i.e. watch TV, play computer games, use the internet, play sports, listen to music) was a significant negative predictor. On the other hand, 'time spent on out of school activities 2' (i.e. read books for fun, do homework, do art, play musical instruments, do work at home) was a significant positive predictor. Although not directly related to science, these activities had positive impacts on pupils' enjoyment and confidence in science. The science attainment model showed that such activities also had a positive association with pupils' science achievement, though not with their mathematics achievement.

- Enjoyment of mathematics and confidence in mathematics were not significant predictors of confidence and enjoyment in science.

## Enjoyment of mathematics

**Exhibit A3.17 Quasi effect sizes for grade 4 enjoyment of mathematics**



- The strongest positive predictor for enjoyment of mathematics was confidence in mathematics. Enjoyment and confidence in science was not a significant variable.

- Collinearity was an issue for factors concerning the school environment, thus the results for these factors may be less reliable. Pupils' perception of school climate was the second strongest positive predictor as indicated by the results. Thus, as pupils' views of their school as a positive environment increased, so too did their enjoyment of mathematics. 'Severity of problem 2' (i.e. the extent to which headteachers viewed truanting, nonconformity with uniform rules, cheating, vandalism and theft as problematical in school) was a significant negative predictor of enjoyment in mathematics. These findings are as might be expected. Surprisingly, however, the extent of bullying and problem behaviours turned out to have positive effects: as each of these increased, so enjoyment of mathematics also increased. This is counter-intuitive and was likely to arise from collinearity.

- In the classroom, mathematics activities and use of computer for school work were both positive predictors of enjoyment in mathematics.

- Science activities turned out to be a negative predictor of enjoyment in mathematics, but this result was borderline.

- 'Time spent on out of school activities 1' (i.e. watch TV, play computer games, use internet, play sports, listen to music) was a significant negative predictor of enjoyment in mathematics. On the other hand, 'time spent on out of school activities 2' (i.e. read a book for fun, do homework, do art, play musical instruments, do jobs at home) was a significant positive predictor of enjoyment. Although not directly related to mathematics, these activities had positive impacts on pupils' enjoyment of mathematics.

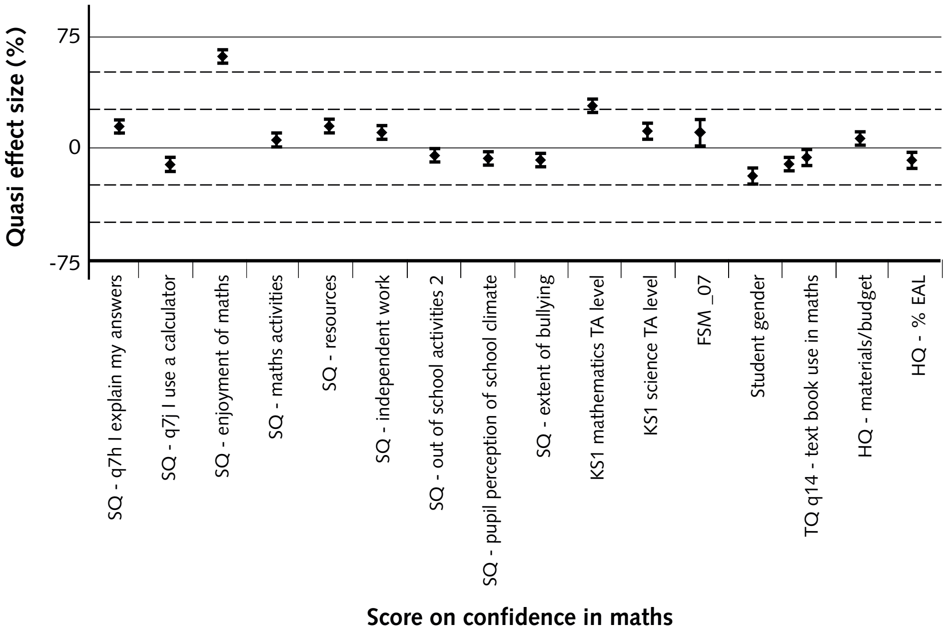
- Boys turned out to enjoy mathematics more than girls did, when all other background variables were controlled for. The difference was significant but not large, although there were no significant differences in achievement overall.

- Eligibility for free school meals was a positive predictor of enjoyment in mathematics: pupils who were eligible for free school meals enjoyed mathematics more, on average, than those who were not eligible, controlling for other variables. The availability at home of resources such as books and other educational resources, however, was a negative predictor. As in other cases, these variables may be correlated and working against each other in the model.

- KS1 science TA level turned out to be a negative predictor of enjoyment in mathematics. However, the mathematics confidence model suggested that there was a significant correlation between confidence in mathematics and KS1 science TA level. As confidence in mathematics played a critical role in predicting the enjoyment of mathematics, it was not surprising that the effect of KS1 science TA level might appear more negative than it really is.

## Confidence in mathematics

**Exhibit A3.18 Quasi effect sizes for grade 4 confidence in mathematics**



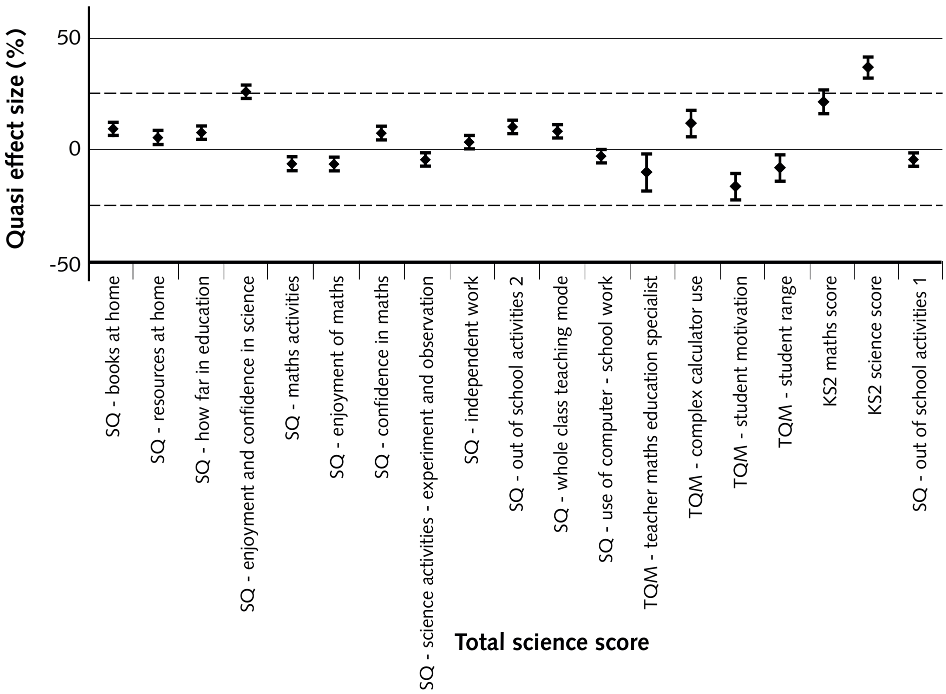

- The strongest positive predictor for confidence in mathematics was enjoyment of mathematics. Enjoyment and confidence in science was not a significant variable.
- KS1 mathematics TA level and KS1 science TA level were both significant positive predictors, with mathematics TA level having the stronger effect on pupils' confidence in mathematics.
- In the classroom, mathematics activities, independent work and chances for the pupils to explain their answers were all significant positive predictors of confidence in mathematics. Use of calculators and use of textbooks, however, turned out to be negative predictors. In the questionnaires it was not specified whether independent work or mathematics activities involved the use of calculators or textbooks. If so, collinearity could be an issue here. However, it is equally possible that these are real effects. It is possible that less confident pupils rely more on their calculators than do more confident pupils. Similarly, textbooks might be associated with poor confidence if their use results in more 'book learning' and less active engagement with mathematics, or if they are used more by less confident pupils using them for additional practise of insecure concepts.
- Outside the classroom, extent of bullying was a significant negative predictor of confidence in mathematics.
- Interestingly, pupils' perception of school climate (i.e. whether they like being at school, want to do their best and believe that their teachers want pupils to do their best) was also a negative predictor of confidence in mathematics, despite being a positive predictor of enjoyment in mathematics. It was not clear whether collinearity exists between this variable and bullying. One possible explanation is that high expectations from teachers could potentially affect confidence in two different ways: pupils could perceive high expectations as following from good performances and hence become more confident; alternatively, pupils might perceive high expectations as pressure and demand, losing confidence in themselves if they felt such expectations were not being met.

- At the school level, materials and budget was a significant positive predictor of confidence in mathematics, while percentage of pupils with English as an additional language was a significant negative predictor.
- 'Time spent on out of school activities 2' (i.e. read a book for fun, do homework, do art, play musical instruments, do work at home) was a significant but borderline negative predictor of confidence in mathematics. From the enjoyment of mathematics model, it was clear that 'out of school activities 2' and enjoyment of mathematics were correlated. This collinearity issue renders the reliability of the estimation of the effect of 'out of school activities 2' on confidence in mathematics suspect.
- Boys turned out to be more confident in mathematics than girls (controlling for all background variables).
- Resources was a positive predictor of confidence in mathematics. In other words, increased access to books and other resources in the home is associated with increased confidence in mathematics.
- Eligibility for free school meals was also a positive predictor of confidence in mathematics. It is not clear why this variable should be working in this way, though, given the general relationship between economic background and attainment, it might reflect positive encouragement given by teachers to lower attainers as a means of motivating them.

## Grade 8 science

Models were run for the five science plausible values. All available variables, including prior attainment measures, were used in the initial models and those that remained significant (at the 10 per cent level) for all five initial models were selected for the interim models. The final model was derived by averaging the outcomes of the five interim models.

**Exhibit A3.19 Quasi effect sizes for grade 8 science**



- Taking no background variables into account, the class-level variance was greater than both the pupil-level and school-level variances. This reflects the policy of many secondary schools (87 per cent of the schools surveyed) to place pupils in sets according to their ability for science.

- However, when background variables were controlled, in all five interim models (and hence the final model), pupil-level variance was greater than both school-level and class-level variances. The background variables explained 90 per cent of the class-level variance, but only 34 per cent of the pupil-level variance.

- Interestingly, none of the variables from the science teacher questionnaire were significant in predicting pupils' science attainment, but some of the variables from the mathematics teachers were. TIMSS pupils were sampled on the basis of their mathematics class. Questionnaires were then sent to all the mathematics and science teachers for each pupil. There are likely to be more science teachers per pupil than mathematics teachers, so science teacher results relating to each pupil are averaged over more teachers. This could mean that the effects of science teacher responses are diluted. Some of the variables in the science and mathematics teacher questionnaires were very similar and this could explain why they are only apparent from the mathematics teachers here. Another possible explanation for this phenomenon could be that science tests tend to be high in mathematics content, so the influence of mathematics teacher responses is more crucial.

- Compared to the mathematics attainment model, more pupil-level variables were significant (pupil level factors are denoted by the prefix SQ in the Exhibits).

- Taking other background variables into account, the strongest negative predictors of attainment in science were unmotivated pupils in the mathematics class and wide range (in terms of ability, special needs, economic and language backgrounds, etc.) of pupils in the mathematics class.

- Other significant but weaker negative predictors of grade 8 science attainment were mathematics activities in class (based on pupils' reports), frequency of science experiments and observations, use of computer for schoolwork and the mathematics teacher being a mathematics education specialist. The latter result is borderline and may be influenced by other variables in the model and, as such, might be spurious. The outcome regarding use of computers might suggest that computers are predominantly used by weaker pupils for extra practice, although this is perhaps more likely to be true for mathematics than for science. Similarly, extra mathematics activities might be undertaken by weaker pupils, accounting for an effect on mathematics attainment, but less obviously on science attainment. It is less clear why being taught mathematics by a specialist teacher would impact negatively on science attainment. It is also unclear why the results regarding frequency of science investigations might impact negatively on science attainment: this is counter-intuitive. It seems likely that these variables are being influenced by others in the model.

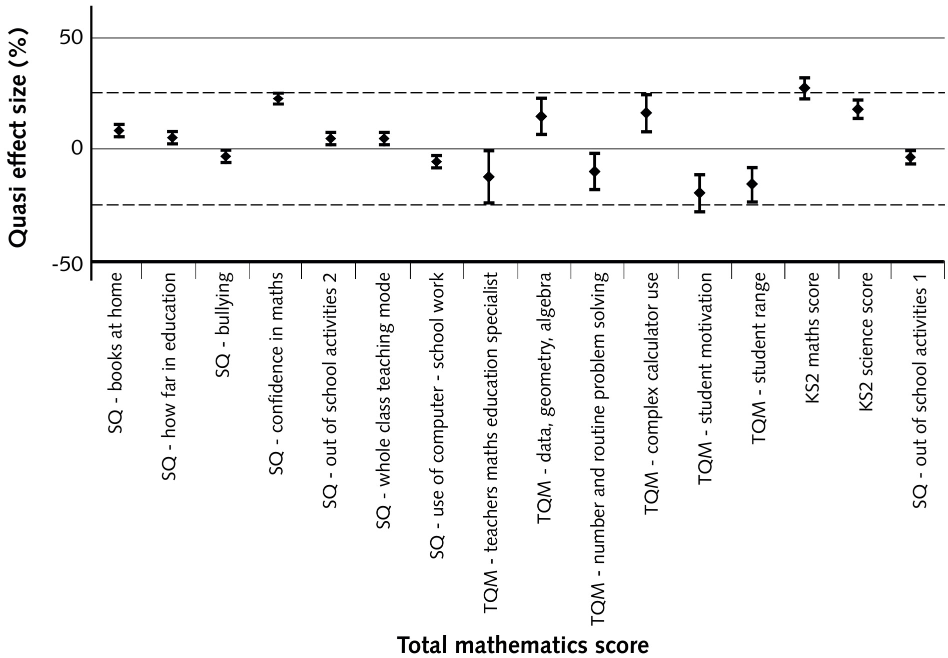
- Confidence in mathematics appeared as a significant positive predictor of science attainment, whereas enjoyment of mathematics worked in the opposite direction. However, as enjoyment of mathematics and confidence in mathematics are strong positive predictors for each other (see the attitude models outlined earlier in this appendix), these variables are likely to be 'working against each other' in the model to generate this unexpected result.

- Enjoyment and confidence in science was a strong positive predictor of attainment in science. However, gender was not a significant predictor of science attainment, even though boys rated significantly higher on enjoyment and confidence in science compared with girls. Since these variables are related, the effect of confidence may be masking the effect of gender.
- Prior attainments (KS2 mathematics and science scores) were also strong positive predictors, as expected, for science especially.
- Significant positive predictors in the classroom included whole class teaching mode, complex calculator use and independent work. It is likely that these are teaching strategies that work particularly well with higher achieving pupils. It cannot be said which is the direction of causality, however. It may be that pupils who are achieving highly are encouraged to use these modes of working to a greater extent, rather than that these modes of working lead to higher achievement.
- Significant positive predictors outside the classroom included number of books at home, resources at home, aspirations in education, and 'out of school activities 2' (read books for enjoyment, do homework, play musical instruments). Conversely, 'out of school activities 1' (television watching, playing computer games, playing with friends, internet usage, listening to music) was negatively associated with grade 8 science attainment. Again, it cannot be stated with certainty what the direction of causality is for these findings.

## Grade 8 mathematics

Models were run for the five mathematics plausible values. All available variables, including prior attainment measures, were used in the initial models and those that remained significant (at the 10 per cent level) for all five initial models were selected for the interim models. The final model was derived by averaging the outcomes of the five interim models.

**Exhibit A3.20 Quasi effect sizes for grade 8 mathematics**



- Taking no background variables into account, the class-level variance was greater than both the pupil-level and school-level variances. This reflects the policy of many schools (96 per cent of the schools surveyed) to place pupils in sets according to their ability for mathematics.
- However, when background variables were controlled for, in all five interim models (and hence the final model), pupil-level variance was greater than both school-level and class-level variances. The background variables explained 80 per cent of the class-level variance, but only 30 per cent of the pupil-level variance.
- Taking other background variables into account, the strongest negative predictors of attainment in mathematics were unmotivated pupils and wide range (in terms of ability, special needs, economic and language backgrounds, etc.) of pupils in the mathematics class.
- Other weaker, but still significant, negative predictors were the extent of bullying in the school, use of computer for schoolwork, frequency of number and routine problem solving activities in the mathematics class (teacher reported), and the mathematics teacher being a mathematics education specialist. The latter result is borderline and may be influenced by other variables in the model and, as such, might be spurious.
- On the other hand, significant positive predictors in the classroom included whole class teaching mode (pupil reported), complex calculator use and activities in data, geometry and algebra (teacher reported). As was the case for science attainment, these may be teaching strategies that work particularly well with higher achieving pupils. As before, it is not possible to assign direction of causality.
- Prior attainments (in both mathematics and science scores at KS2) were strong positive predictors, as expected, of mathematics attainment.
- Confidence in mathematics was also a strong positive predictor of mathematics attainment. Boys were significantly more confident in mathematics than girls, but gender was not a significant predictor of mathematics attainment. Since these variables are related, the effect of confidence may be masking the effect of gender.
- Enjoyment of mathematics was not significant for any of the mathematics attainment models, but was a strong positive predictor of confidence in mathematics (see the attitude models outlined earlier in this appendix).
- Other significant positive predictors included number of books at home and pupils' aspiration in education ('How far in education do you expect to go?').
- 'Out of school activities 2' (book reading for enjoyment, doing homework and playing a musical instrument) was positively associated with grade 8 mathematics attainment whereas 'Out of school activities 1' (television watching, playing computer games, playing with friends, internet usage, listening to music) was a negative predictor. Again, it cannot be stated with certainty what the direction of causality is for these findings.

## Grade 8 attitude models

Models were run for each of the three factors derived from the student questionnaire factor analysis:

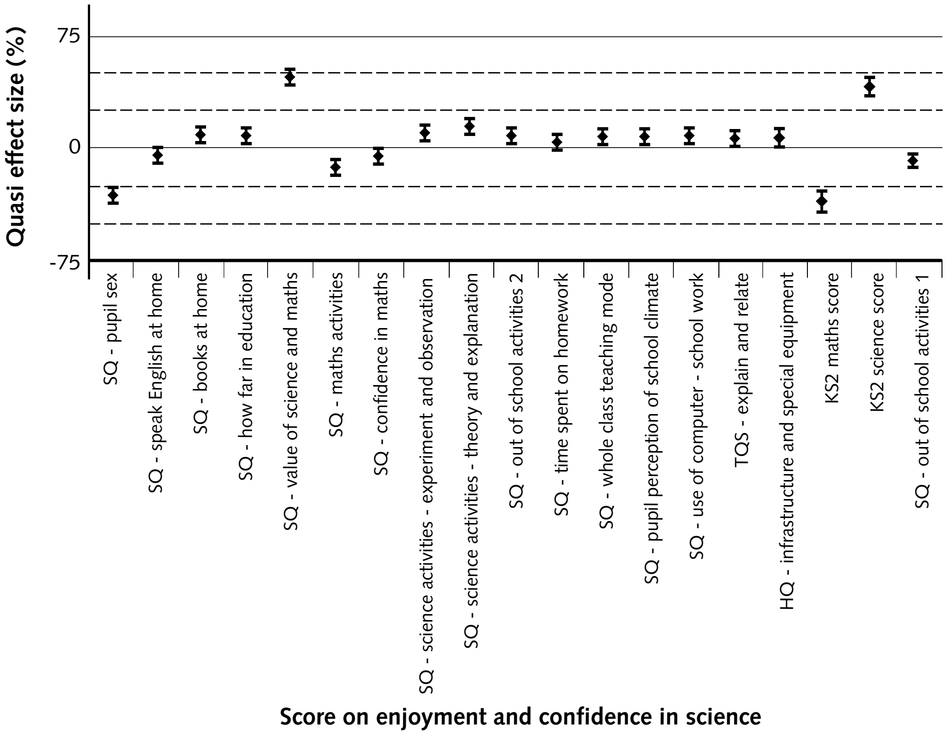
- enjoyment and confidence in science
- enjoyment of mathematics
- confidence in mathematics.

All available variables, including prior attainment measures, were used in the initial models and those that remained significant (at the 5 per cent level) were selected for the final models.

In all three models, the pupil-level variance was greater than the class-level and school-level variances, indicating that the differences between individual pupils were larger compared with those between pupils in different classes or schools.

## Enjoyment and confidence in science

**Exhibit A3.21 Quasi effect sizes for grade 8 enjoyment and confidence in science**

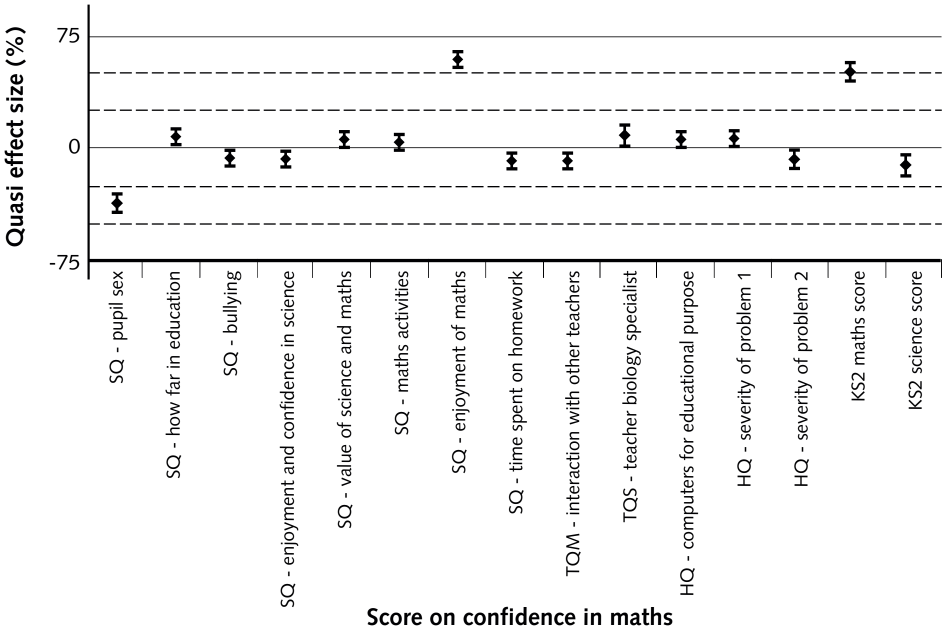



- The strongest positive predictors of enjoyment and confidence in science were pupils' KS2 science score and the extent to which pupils valued mathematics and science.
- KS2 mathematics score turned out to be the strongest negative predictor. This may be a spurious result caused by the correlation between KS2 science and mathematics scores.

- The next strongest predictor was a pupil's gender, with boys scoring higher in confidence and enjoyment of science compared with girls.
- Confidence in mathematics turned out to be a significant negative predictor of enjoyment and confidence in science, but the quasi-effect size was small and this was a borderline effect that can be treated as potentially spurious.
- Activities in the classroom with a significant positive effect on enjoyment and confidence in science included 'experiments and observation', 'theory and explanation', 'explaining and relating to daily life', whole class teaching mode and use of computer for school work. Each of these was derived from the student questionnaire except for 'explaining and relating to daily life', which was drawn from the science teacher questionnaire. The more that pupils experience each of these activities, the greater their enjoyment and confidence in science.
- On the contrary, the frequency of mathematics activities in the mathematics class was a negative predictor of enjoyment and confidence in science.
- At the school level, infrastructure and special equipment acted as a significant positive predictor, as did pupils' perception of school climate. If pupils enjoy school, want to do well and feel that their teachers want them to do well, they will tend to enjoy their science lessons more and be more confident in them. The same applies if their schools are regarded by the headteacher as being well resourced in terms of infrastructure and special equipment.
- Outside the school gate, the number of books at home, a pupil's aspiration in education, time spent on homework, and 'out of school activities 2' (read books, do homework, play musical instruments) were all significant positive predictors of enjoyment and confidence in science. However, 'out of school activities 1' (television watching, playing computer games, playing with friends, internet usage, listening to music) was a negative predictor. Again, it cannot be stated with certainty what the direction of causality is for each of these findings.
- Interestingly, frequency of English usage at home was a negative predictor - the more often a pupil spoke English at home, the lower their score on enjoyment and confidence in science. The vast majority of pupils reported speaking English at home always or almost always. Thus, this finding might simply reflect a higher level of motivation for education among pupils who have recently arrived, or whose families have relatively recently arrived, in England and who are in the earlier stages of acquiring English.

## Confidence in mathematics

**Exhibit A3.22 Quasi effect sizes for grade 8 confidence in mathematics**

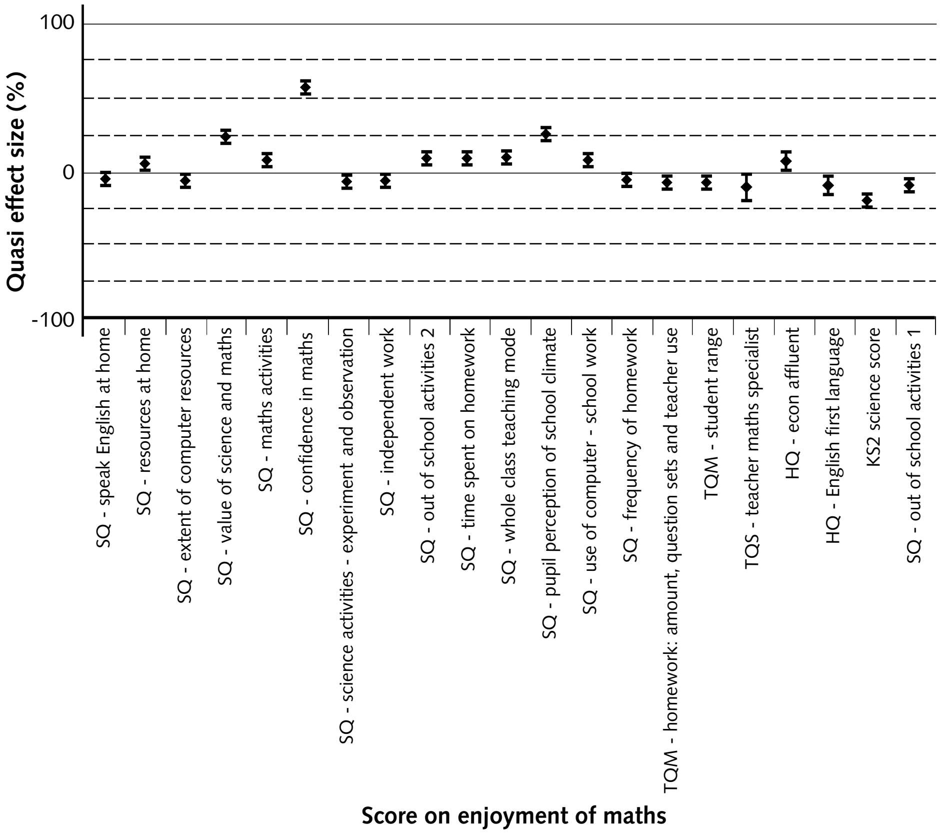



- The strongest positive predictor for confidence in mathematics was enjoyment of mathematics. On the contrary, enjoyment and confidence in science was a significant negative predictor, but this effect was smaller and borderline. These variables might have interacted to produce these findings.
- The second strongest positive predictor of confidence in mathematics was KS2 mathematics score. KS2 science score turned out to be a significant negative predictor. This may be a spurious result caused by the correlation between KS2 science and mathematics scores.
- Pupil's gender again turned out to be a strong predictor. Controlling for other variables, boys were more confident in mathematics than girls, although there was no significant difference in their overall performance in it.
- The value placed by pupils on science and mathematics was a significant positive predictor of confidence in mathematics, as was frequency of mathematics activities in class: the more pupils carried out the range of activities listed, the more confident they were in mathematics.
- At the school level, sufficiency of computers for education purposes was a significant positive predictor of confidence in mathematics. There was evidence to suggest that the science teacher being a biology specialist could have a positive effect on attitudes to mathematics, too. Professional interaction between teachers, however, was negative. Both of these were slight borderline effects and can probably be treated as spurious.
- Being bullied was a negative predictor of confidence in mathematics, as was the 'severity of problem 2' (serious behavioural problems) in the school: the more serious the headteachers felt behaviour problems were, the less confident pupils were in their mathematics abilities. Surprisingly, the factor 'severity of problem 1' (minor behavioural problems) was a positive predictor of confidence in mathematics. It is possible that schools with only the more minor behaviour problems are seen as being generally positive learning environments, thus promoting confidence in learning.

- A pupil's aspiration in education was associated with confidence in mathematics, but time spent on homework worked in the other direction. The longer pupils spent on homework, the less confident they were. This may be because less confident pupils take longer to complete their homework.

## Enjoyment of mathematics

**Exhibit A3.23 Quasi effect sizes for grade 8 enjoyment of mathematics**




- The strongest positive predictor for enjoyment of mathematics was confidence in mathematics. Unlike the model for confidence in mathematics, enjoyment and confidence in science was not significant for enjoyment in mathematics.
- KS2 mathematics score was not significant either, implying that pupils could equally enjoy (or not enjoy) mathematics no matter how able they were in mathematics.
- Perhaps counter-intuitively, KS2 science score was the strongest negative predictor of enjoyment in mathematics. The better pupils did in their science test at key stage 2, the less they were enjoying mathematics at the end of key stage 3.
- The value pupils place on science and mathematics was a positive predictor of enjoyment in mathematics, as in all other attitude models.
- Unlike the other two attitude models, pupil gender was not significant in this case. Boys and girls enjoyed mathematics equally, although boys tended to be more confident in it.
- In the classroom, mathematics activities, whole class teaching mode and use of computers for school work were all significant positive predictors of enjoyment in mathematics. On

the other hand, science experiments and observations, independent work and wide pupil range were all negative predictors of enjoyment in mathematics. The latter two factors may tell us that pupils enjoy their learning more when working with others rather than independently, and that they enjoy their lessons more when teachers are able to focus on their needs rather than dealing with a wide range of needs in one class.

- There was evidence to suggest that the science teacher being a mathematics specialist could reduce pupils' enjoyment of mathematics, the reason for which is unclear. Again, this is a borderline effect.
- Interestingly, time spent on homework was a positive predictor of enjoyment in mathematics, while homework amount, question sets and teacher use was a negative predictor, as was homework frequency. There may be some interaction between these variables.
- At the school level, pupils' perception of school climate and percentage of pupils from economically affluent families were positive predictors of enjoyment in mathematics. Extent of computer resources was a weak but significant negative predictor: as pupils have more access to computers at home, school or elsewhere, their enjoyment of mathematics goes down. Pupils were asked about computers other than game computers. However, it is likely that some responded with gaming in mind, which might have affected the relationship described here. It is also possible that the computer variables might have interacted with the other variables discussed here, so the suggestion of computer use being associated with lower attainment might be a spurious result.
- Outside the school, resources at home and 'out of school activities 2' (read books for fun, do homework, play a musical instrument) were significant positive predictors of enjoyment in mathematics. However, 'out of school activities 1' (television watching, playing computer games, playing with friends, internet usage, listening to music) was a negative predictor. Again, it cannot be stated with certainty what the direction of causality is for these findings.
- English as the first language and speaking more English at home were both significant negative predictors of enjoyment in mathematics. The same finding was obtained for enjoyment and confidence in science and the same suggested reason might apply to enjoyment in mathematics (see the section above).

**Exhibit A3.24 Variables used in the Grade 4 models**

The variables used in the model comprise the factors described earlier in this appendix and additional variables of interest, some of which were sourced from the teacher, school and student questionnaires and some which came from the National Pupil Database. The derivation of the various factors is described in Exhibits A3.1-A3.6. Where individual questions were used from the TIMSS 2007 questionnaires, the question number is specified. For variables from the National Pupil Database, 'NPD' is stated in brackets.

| Variable |
|---|
| *SCHOOL ID* |
| *CLASS ID* |
| *STUDENT ID* |
| Constant |
| 1ST PLAUSIBLE VALUE MATHEMATICS |

**Exhibit A3.24 Variables used in the Grade 4 models** *cont'd ...*

| Variable |
|---|
| 2ND PLAUSIBLE VALUE MATHEMATICS |
| 3RD PLAUSIBLE VALUE MATHEMATICS |
| 4TH PLAUSIBLE VALUE MATHEMATICS |
| 5TH PLAUSIBLE VALUE MATHEMATICS |
| 1ST PLAUSIBLE VALUE SCIENCE |
| 2ND PLAUSIBLE VALUE SCIENCE |
| 3RD PLAUSIBLE VALUE SCIENCE |
| 4TH PLAUSIBLE VALUE SCIENCE |
| 5TH PLAUSIBLE VALUE SCIENCE |
| SQ - q7h I explain my answers (mathematics) |
| SQ - q7j I use a calculator (mathematics) |
| SQ - enjoyment and confidence in science |
| SQ - enjoyment of mathematics |
| SQ - confidence in mathematics |
| SQ - science activities |
| SQ - mathematics activities |
| SQ - out of school activities 1 |
| SQ - use of computer for school work |
| SQ - resources |
| SQ - independent work |
| SQ - time spent on homework |
| SQ - out of school activities 2 |
| SQ - pupil perception of school climate |
| SQ - extent of bullying |
| KS1 mathematics TA level (NPD) |
| KS1 science TA level (NPD) |
| IDACI_07 (Income Deprivation Affecting Children Indices, NPD) |
| FSM_07 (Pupil-level eligibility for free school meals, NPD) |
| Student gender (SQ - q2) |
| Mother born in the UK (SQ - q16a) |
| Father born in the UK (SQ - q16b) |
| Pupil born in the UK (SQ - q17) |
| How often speak English at home (SQ - q3) |
| TQ q7 - teacher interactions |
| Teacher gender (TQ - q2) |
| Teacher mathematics specialist (TQ - q6) |
| Teacher science specialist (TQ - q6) |
| TQ q16 - calculator use |
| TQ q14 - text book use in mathematics |
| TQ q35 - text book use in science |
| TQ - science - observation and investigation |
| TQ - number and explanation |
| TQ - mathematics - shape, measures and data |
| TQ - school climate - teachers |
| TQ - school climate - children and parents |
| TQ - teachers perception of safety |
| TQ - science homework |
| TQ - mathematics homework - teacher use |
| TQ - mathematics homework - class use |
| TQ - routine calculator use |
| TQ - complex calculator use |
| TQ - mathematics computer use |
| TQ - science computer use |
| TQ - mathematics and science - motivation |
| TQ - science - student range |
| TQ - mathematics - student range |

### Exhibit A3.24 Variables used in the Grade 4 models *cont'd ...*

| Variable |
|---|
| TQ - mathematics professional development |
| TQ - science professional development |
| HQ - computer/lab equipment |
| HQ - calculator availability |
| HQ - materials/budget |
| HQ - infrastructure |
| HQ - library and audio-visual resources |
| HQ - problem behaviours |
| HQ - school climate - teachers |
| HQ - severity of problem 1 |
| HQ - severity of problem 2 |
| HQ - absenteeism/lateness |
| HQ - school climate - children and parents |
| HQ - professional development |
| HQ - q20a number of computers in school |
| HQ - q3a economic disadvantage |
| HQ - q3b economic affluence |
| HQ - % EAL |
| HQ - q9 mathematics ability grouping |
| HQ - q11 science ability grouping |
| HQ - q15 difficulty filling vacancies |

### Exhibit A3.25 Variables used in the Grade 8 models

The variables used in the model comprise the factors described earlier in this appendix and additional variables of interest, some of which were sourced from the teacher, school and student questionnaires and some which came from the National Pupil Database. The derivation of the various factors is described in Exhibits A3.1-A3.6. Where individual questions were used from the TIMSS 2007 questionnaires, the question number is specified. For variables from the National Pupil Database, 'NPD' is stated in brackets.

| Variable |
|---|
| *SCHOOL ID* |
| *CLASS ID* |
| *STUDENT ID* |
| 1ST PLAUSIBLE VALUE MATHEMATICS |
| 2ND PLAUSIBLE VALUE MATHEMATICS |
| 3RD PLAUSIBLE VALUE MATHEMATICS |
| 4TH PLAUSIBLE VALUE MATHEMATICS |
| 5TH PLAUSIBLE VALUE MATHEMATICS |
| 1ST PLAUSIBLE VALUE SCIENCE |
| 2ND PLAUSIBLE VALUE SCIENCE |
| 3RD PLAUSIBLE VALUE SCIENCE |
| 4TH PLAUSIBLE VALUE SCIENCE |
| 5TH PLAUSIBLE VALUE SCIENCE |
| Constant |
| SQ - pupil gender (q2) |
| SQ - speak English at home (q3) |
| SQ - books at home (q4) |
| SQ - resources at home (q5) |
| SQ - how far in education (q7) |
| SQ - extent of computer resources (q14a, q14b) |
| SQ - bullying (q16) |
| SQ - mother born in UK (q20a) |
| SQ - father born in UK (q20b) |

**Exhibit A3.25 Variables used in the Grade 8 models** *cont'd ...*

| Variable |
|---|
| SQ - pupil born in UK (q21a) |
| SQ - time since coming to UK (q21b) |
| SQ - enjoyment and confidence in science |
| SQ - value of science and mathematics |
| SQ - mathematics activities |
| SQ - enjoyment of mathematics |
| SQ - confidence in mathematics |
| SQ - science activities - experiment and observation |
| SQ - independent work |
| SQ - science activities - theory and explanation |
| SQ - out of school activities 1 |
| SQ - out of school activities 2 |
| SQ - time spent on homework |
| SQ - whole class teaching mode |
| SQ - pupil perception of school climate |
| SQ - use of computer - school work |
| SQ - frequency of homework |
| SQ - check homework in class |
| TQM - maths teacher gender (q2) |
| TQM - teacher mathematics specialist (q5a) |
| TQM - teacher mathematics education specialist (q5b) |
| TQM - teacher science specialist (q5c) |
| TQM - teacher science education specialist (q5d) |
| TQM - teacher general education specialist (q5e) |
| TQM - teacher other specialist (q5f) |
| TQM - textbook use (q15) |
| TQM - problem solving & explanation |
| TQM - data, geometry, algebra |
| TQM - number & routine problem solving |
| TQM - school climate: children and parents |
| TQM - school climate: teachers |
| TQM - teacher perception of safety |
| TQM - homework: amount, question sets and teacher use |
| TQM - homework: class use |
| TQM - homework type: active |
| TQM - computer use |
| TQM - routine calculator use |
| TQM - complex calculator use |
| TQM - teaching resources |
| TQM - computer resources |
| TQM - student motivation |
| TQM - student range |
| TQM - professional development |
| TQM - interaction with other teachers |
| TQS - science teacher sex (q2) |
| TQS - teacher biology specialist (q5a) |
| TQS - teacher physics specialist (q5b) |
| TQS - teacher chemistry specialist (q5c) |
| TQS - teacher earth science specialist (q5d) |
| TQS - teacher science education specialist (q5e) |
| TQS - teacher mathematics specialist (q5f) |
| TQS - teacher mathematics education specialist (q5g) |
| TQS - teacher general education specialist (q5h) |
| TQS - teacher other specialist (q5i) |
| TQS - textbook use (q15) |
| TQS - observe/ investigate |
| TQS - explain and relate |

**Exhibit A3.25 Variables used in the Grade 8 models** *cont'd ...*

| Variable |
| --- |
| TQS - passive learning |
| TQS - school climate: children and parents |
| TQS - school climate: teachers |
| TQS - teacher perception of safety |
| TQS - homework: amount, question sets and teacher use |
| TQS - homework: other types and class use |
| TQS - computer use |
| TQS - teaching resources |
| TQS - computer resources |
| TQS - student motivation |
| TQS - student range |
| TQS - professional development |
| TQS - interaction with other teachers |
| HQ - economic disadvantage (q3a) |
| HQ - economic affluence (q3b) |
| HQ - English first language (q4) |
| HQ - pupils grouped by mathematics ability (q9) |
| HQ - pupils grouped by science ability (q11) |
| HQ - computers for educational purpose (q21a) |
| HQ - computers for educational purpose missing (q21a) |
| HQ - budget, materials and staff |
| HQ - library and audio-visual resources |
| HQ - computers and software |
| HQ - infrastructure and special equipment |
| HQ - recruitment incentives |
| HQ - difficulty filling vacancies |
| HQ - professional development |
| HQ - problem behaviours 2 |
| HQ - problem behaviours 1 |
| HQ - school climate: teachers and students |
| HQ - school climate: parents |
| HQ - severity of problem 1 |
| HQ - severity of problem 2 |
| Eligibility for free school meals (NPD) |
| IDACI_07 (Income Deprivation Affecting Children Indices, NPD) |
| KS2 mathematics score (NPD) |
| KS2 science score (NPD) |

**Exhibit A3.26 Quasi effect sizes for science attainment, grade 4**

| | Variables | Effect sizes |
|---|---|---|
| 1 | KS1 mathematics TA level | 36.7 |
| 2 | Pupil born UK | 27.1 |
| 3 | SQ - confidence in maths | 24.1 |
| 4 | SQ - resources | 23.5 |
| 5 | KS1 science TA level | 22.9 |
| 6 | SQ - enjoyment of maths | -20.6 |
| 7 | SQ - enjoyment and confidence in science | 17.3 |
| 8 | HQ - q3a economic disadvantage | -15.9 |
| 9 | SQ - out of school activities 1 | -10.9 |
| 10 | Teacher maths specialist | 9.8 |
| 11 | SQ - use of computer for school work | -9.6 |
| 12 | SQ - maths activities | -9.3 |
| 13 | SQ - extent of bullying | -8.7 |
| 14 | SQ - independent work | 8.6 |
| 15 | FSM_07 | -7.6 |
| 16 | HQ - calculator availability | -5.7 |
| 17 | TQ - maths homework - class use | -5.1 |
| 18 | SQ - out of school activities 2 | 4.8 |

**Exhibit A3.27 Quasi effect sizes for mathematics attainment, grade 4**

| | Variables | Effect sizes |
|---|---|---|
| 1 | KS1 mathematics TA level | 42.9 |
| 2 | SQ - confidence in maths | 37.1 |
| 3 | Pupil born UK | 30.1 |
| 4 | SQ - resources | 21.0 |
| 5 | KS1 science TA level | 21.0 |
| 6 | HQ - q3a economic disadvantage | -11.7 |
| 7 | Teacher maths specialist | 11.2 |
| 8 | SQ - use of computer for school work | -9.8 |
| 9 | SQ - extent of bullying | -8.4 |
| 10 | SQ - independent work | 8.4 |
| 11 | TQ - school climate - teachers | 8.3 |
| 12 | FSM_07 | -7.8 |
| 13 | SQ - maths activities | -6.8 |
| 14 | SQ - out of school activities 1 | -6.2 |
| 15 | SQ - enjoyment of maths | -5.8 |

**Exhibit A3.28 Quasi effect sizes for enjoyment and confidence in science, grade 4**

| | Variables | Effect sizes |
|---|---|---|
| 1 | SQ - pupil perception of school climate | 24.5 |
| 2 | Student gender | -23.1 |
| 3 | SQ - science activities | 19.6 |
| 4 | SQ - out of school activities 2 | 18.1 |
| 5 | SQ - out of school activities 1 | -13.9 |
| 6 | TQ - teachers' perception of safety | -13.0 |
| 7 | SQ - resources | 12.9 |
| 8 | SQ - independent work | 12.2 |
| 9 | SQ - q7h I explain my answers | 7.3 |
| 10 | SQ - q7j I use a calculator | -7.2 |
| 11 | SQ - extent of bullying | -6.6 |

**Exhibit A3.29 Quasi effect sizes for confidence in mathematics, grade 4**

| | Variables | Effect sizes |
|---|---|---|
| 1 | SQ - enjoyment of maths | 60.7 |
| 2 | KS1 mathematics TA level | 28.1 |
| 3 | Student gender | -18.0 |
| 4 | SQ - resources | 15.3 |
| 5 | SQ - q7h I explain my answers | 14.8 |
| 6 | KS1 science TA level | 11.2 |
| 7 | FSM_07 | 10.8 |
| 8 | SQ - independent work | 10.7 |
| 9 | SQ - q7j I use a calculator | -10.4 |
| 10 | SQ - extent of bullying | -7.7 |
| 11 | HQ - % EAL | -7.0 |
| 12 | HQ - materials/budget | 6.3 |
| 13 | SQ - pupil perception of school climate | -6.2 |
| 14 | TQ q14 - text book use in maths | -5.7 |
| 15 | SQ - maths activities | 5.5 |
| 16 | SQ - out of school activities 2 | -4.5 |

**Exhibit A3.30 Quasi effect sizes for enjoyment in mathematics, grade 4**

| | Variables | Effect sizes |
|---|---|---|
| 1 | SQ - confidence in maths | 59.6 |
| 2 | SQ - pupil perception of school climate | 39.6 |
| 3 | FSM_07 | 14.6 |
| 4 | KS1 science TA level | -13.8 |
| 5 | HQ - severity of problem 2 | -13.6 |
| 6 | SQ - out of school activities 2 | 11.7 |
| 7 | Student gender | -10.9 |
| 8 | HQ - problem behaviours | 10.6 |
| 9 | SQ - maths activities | 9.9 |
| 10 | SQ - out of school activities 1 | -9.7 |
| 11 | SQ - resources | -6.6 |
| 12 | SQ - use of computer for school work | 6.5 |
| 13 | SQ - extent of bullying | 5.6 |
| 14 | SQ - science activities | -4.0 |

**Exhibit A3.31 Quasi effect sizes for science attainment, grade 8**

| | Variables | Effect sizes |
|---|---|---|
| 1 | KS2 science score | 37.1 |
| 2 | SQ - enjoyment and confidence in science | 25.5 |
| 3 | KS2 maths score | 20.7 |
| 4 | TQM - student motivation | -16.3 |
| 5 | TQM - complex calculator use | 11.4 |
| 6 | TQM - teacher maths education specialist | -9.9 |
| 7 | SQ - out of school activities 2 | 9.9 |
| 8 | SQ - books at home | 9.3 |
| 9 | TQM - student range | -8.7 |
| 10 | SQ - whole class teaching mode | 7.9 |
| 11 | SQ - confidence in maths | 7.7 |
| 12 | SQ - how far in education | 7.4 |
| 13 | SQ - enjoyment of maths | -7.0 |
| 14 | SQ - maths activities | -6.2 |
| 15 | SQ - resources at home | 5.3 |
| 16 | SQ - science activities - experiment and observation | -4.0 |
| 17 | SQ - independent work | 3.9 |
| 18 | SQ - out of school activities 1 | -3.8 |
| 19 | SQ - use of computer - school work | -3.7 |

### Exhibit A3.32 Quasi effect sizes for mathematics attainment, grade 8

| | Variables | Effect sizes |
|---|---|---|
| 1 | KS2 maths score | 27.3 |
| 2 | SQ - confidence in maths | 23.1 |
| 3 | TQM - student motivation | -19.2 |
| 4 | KS2 science score | 18.0 |
| 5 | TQM - complex calculator use | 15.6 |
| 6 | TQM - student range | -15.4 |
| 7 | TQM - data, geometry, algebra | 14.4 |
| 8 | TQM - teacher maths education specialist | -12.5 |
| 9 | TQM - number and routine problem solving | -8.8 |
| 10 | SQ - books at home | 8.5 |
| 11 | SQ - whole class teaching mode | 5.2 |
| 12 | SQ - how far in education | 5.0 |
| 13 | SQ - use of computer - school work | -5.0 |
| 14 | SQ - out of school activities 2 | 4.4 |
| 15 | SQ - out of school activities 1 | -3.3 |
| 16 | SQ - bullying | -3.1 |

### Exhibit A3.33 Quasi effect sizes for enjoyment and confidence in science, grade 8

| | Variables | Effect sizes |
|---|---|---|
| 1 | SQ - value of science and maths | 47.3 |
| 2 | KS2 science score | 41.2 |
| 3 | KS2 maths score | -35.3 |
| 4 | SQ - pupil gender | -30.9 |
| 5 | SQ - science activities - theory and explanation | 15.5 |
| 6 | SQ - maths activities | -12.7 |
| 7 | SQ - science activities - experiment and observation | 10.1 |
| 8 | SQ - out of school activities 2 | 9.6 |
| 9 | SQ - how far in education | 8.5 |
| 10 | SQ - books at home | 8.3 |
| 11 | SQ - use of computer - school work | 8.3 |
| 12 | SQ - out of school activities 1 | -8.1 |
| 13 | SQ - pupil perception of school climate | 7.8 |
| 14 | SQ - whole class teaching mode | 7.2 |
| 15 | HQ - infrastucture and special equipment | 7.0 |
| 16 | TQS - explain and relate | 6.8 |
| 17 | SQ - speak English at home | -6.3 |
| 18 | SQ - confidence in maths | -5.6 |
| 19 | SQ - time spent on homework | 5.1 |

## Exhibit A3.34 Quasi effect sizes for confidence in mathematics, grade 8

| | Variables | Effect sizes |
|---|---|---|
| 1 | SQ - enjoyment of maths | 60.2 |
| 2 | KS2 maths score | 51.7 |
| 3 | SQ - pupil gender | -35.5 |
| 4 | KS2 science score | -10.0 |
| 5 | TQS - teacher biology specialist | 8.0 |
| 6 | SQ - how far in education | 7.8 |
| 7 | TQM - interaction with other teachers | -7.2 |
| 8 | HQ - severity of problem 1 | 7.1 |
| 9 | HQ - computers for educational purpose | 6.6 |
| 10 | SQ - enjoyment and confidence in science | -6.4 |
| 11 | SQ - maths activities | 6.3 |
| 12 | SQ - value of science and maths | 6.2 |
| 13 | SQ - time spent on homework | -6.2 |
| 14 | HQ - severity of problem 2 | -6.2 |
| 15 | SQ - bullying | -5.6 |

## Exhibit A3.35 Quasi effect sizes for enjoyment in mathematics, grade 8

| | Variables | Effect sizes |
|---|---|---|
| 1 | SQ - confidence in maths | 57.5 |
| 2 | SQ - pupil perception of school climate | 25.8 |
| 3 | SQ - value of science and maths | 24.2 |
| 4 | KS2 science score | -21.0 |
| 5 | TQS - teacher maths specialist | -11.6 |
| 6 | SQ - whole class teaching mode | 9.3 |
| 7 | HQ - English first language | -9.1 |
| 8 | SQ - time spent on homework | 8.8 |
| 9 | SQ - out of school activities 1 | 8.6 |
| 10 | SQ - out of school activities 2 | 8.3 |
| 11 | HQ - economic affluence | 8.3 |
| 12 | SQ - maths activities | 7.9 |
| 13 | TQM - student range | -7.8 |
| 14 | SQ - use of computer - school work | 7.7 |
| 15 | TQM - homework: amount, question sets and teacher use | -7.1 |
| 16 | SQ - science activities - experiment and observation | -6.6 |
| 17 | SQ - resources at home | 6.0 |
| 18 | SQ - frequency of homework | -6.0 |
| 19 | SQ - independent work | -5.9 |
| 20 | SQ - speak English at home | -4.4 |
| 21 | SQ - extent of computer resources | -4.0 |