QUASE

Quantitative Analysis for Self-Evaluation

Overview Report 1997
Analysis of GCSE Cohorts 1994 to 1996

Ian Schagen
Jo Morrison

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1. INTRODUCTION

The QUASE project began with a pilot study of the 1992 and 1993 GCSE cohorts and continued with its first and second operational phases, including the 1994 and 1995 GCSE cohorts. It completed its third operational phase with 123 schools supplying data on their 1996 GCSE cohorts. In addition, some schools provided retrospective data on cohorts prior to 1996, giving a very rich database of information on secondary schools, including GCSE results, prior attainment measures, attendance, destinations and a whole host of background data on both pupils and schools.

The first priority of the service is to feed back to schools detailed reports which help them to evaluate 'how they're doing' in comparison with expectations based on their backgrounds and their students' prior attainments. This is achieved through sophisticated statistical modelling, allowing only for those variables which can be consistently measured across all schools and which can be relatively objectively assessed.

A second priority of QUASE is to carry out further analysis of the data collected to gain understanding of the relationships between Year 11 performance and the complete array of background variables collected as part of the process. In this analysis, we may make use of a much wider range of variables, including some which are more subjective and less easy to quantify than those included in the school feedback reports.

In previous years, we have produced a technical report, which has given a more detailed set of analyses of the relationships between outcomes and background data than is available as part of the feedback service to schools. For this report, rather than repeat the same set of analyses as previously, we have concentrated on certain areas which have not been explored before, but which can be investigated using QUASE data.

The analyses detailed in this report cover:

- the seven overall performance indicators, controlling for all available background variables at both the pupil and school levels;
- performance in the main 15 broad subject groupings, controlling for both overall GCSE scores and prior attainment measures, as well as pupil-level factors;
- the apparent relationships between GCSE outcomes and studying arts-related subjects;
- pupil and parent attitude questionnaires, and factors derived from these;
- alternative models for subject grades as a function of overall performance;
- an investigation of contextual effects — whether pupils' performance is influenced by the overall performance level of their school.

2. THE QUASE SCHOOLS

Before discussing the results obtained from the analysis of the QUASE data, it is worth seeing to what extent the schools involved are representative of secondary schools in general. Table 2.1 shows values of different school-level variables for QUASE schools and for the entire population.

Table 2.1: QUASE schools compared with population, 1996

	QUASE schools		Population
	%	Number	%
Total	100%	122	100%
Type of school			
Comprehensive (to 16)	39%	47	39%
Comprehensive (to 18)	47%	57	50%
Selective (including independent)	15%	18	11%
Type of LEA			
Metropolitan	40%	49	34%
Non-metropolitan	60%	73	66%
Region			
North	34%	42	29%
Midlands	13%	16	24%
South	51%	62	41%
Wales	2%	2	7%
1995 GCSE Results — % A-C			
25% or lower	35%	43	23%
26-35%	19%	23	18%
36-45%	16%	20	18%
46-55%	11%	13	15%
Over 55%	14%	17	17%
Not given	5%	6	8%

(Since percentages are rounded to the nearest integer, they may not always sum to 100.)

Consideration of the above table shows that the types of schools in QUASE are very similar to the national distribution. Looking at 1995 GCSE results, it seems that lower-attaining schools are over-represented, although there are schools in all bands up to the highest. The comparisons show that the range of schools in QUASE is not restricted in any way, and that any findings from the analysis will not be negated because only a limited set of schools was included.

3. QUASE INTAKE MEASURES RELATED TO GCSE OUTCOMES

Table 3.1 shows the correlations between the 21 'first division' tests and the four 'second division' groups used as prior attainment measures in QUASE, and three of the GCSE outcomes: total score (TOTSCORE), mathematics score (MATHS) and English score (ENG).

Table 3.1: QUASE intake measures related to GCSE outcomes, 1996

Test	Number	Corr. with TOTSCORE	Corr. with MATHS	Corr. with ENG
CAT — Verbal	6328	.6966	.6633	.6567
CAT — Non-Verbal	5614	.5841	.6403	.5112
CAT — Quantitative	5580	.6790	.7237	.6083
NFER-NELSON NVR (DH)	4984	.6092	.6195	.5267
NFER-NELSON VR	3281	.6761	.7138	.6292
Richmond — Vocabulary	1913	.6234	.6159	.5686
Richmond — Reading Comp.	2834	.6261	.6243	.5862
Richmond — Maths Concepts	2225	.6264	.6952	.5579
Richmond — Problem Solving	858	.5636	.6215	.4881
Suffolk Reading Scale	518	.6129	.5803	.6063
NFER-NELSON Reading Comp.	1943	.6854	.5641	.6518
London Reading Test	1341	.5328	.4841	.5431
Edinburgh Reading Test	704	.7000	.6711	.6482
NFER-NELSON Maths	1892	.7153	.7390	.6657
Richmond — Unknown subject	628	.6506	.6864	.5901
Profile of Maths Skills	111	.6659	.6605	.5801
Widespan Reading	403	.6644	.5860	.6172
N-N English Progress Tests	810	.7793	.7595	.7249
Moray House Verbal Reasoning	402	.7247	.7219	.7743
SPAR	98	.6438	.5718	.6745
Schonell English	159	.5900	.6035	.5251
2nd div: VR/NVR bands	2044	.4613	.4934	.4394
2nd div: Eng. reading	11,582	.4983	.8960	.4790
2nd div: Eng. spelling	3045	.3881	.4166	.3828
2nd div: Maths	2253	.6813	.7262	.6208

In the above table, correlations based on small numbers of cases should be regarded as subject to a fair degree of uncertainty. Those based on around 1,000 cases or more may be treated as reasonably reliable.

4. OVERALL PERFORMANCE INDICATORS

Inevitably, the focus of analysis in QUASE, as in so much of 'value-added' research, has been on GCSE results as outcomes. They are fairly universally available, relatively consistent across the country, easily quantifiable and have a high perceived status in terms of secondary school performance. However, since each individual student can receive a range of grades in each of up to about ten subjects, it is not clear how this essentially multidimensional data should be translated into a single numerical indicator which expresses unambiguously the performance of a student and, by aggregation, that of a school.

The present government's favoured measure for school league tables is percentage of students gaining five or more A to C grades (also a component of National Targets for Education and Training). This has various disadvantages, not least that it loses more information from the student-level data than is necessary. Additionally, it may tend to encourage schools to concentrate effort on pupils at the C/D borderline, to improve their league table positions, while neglecting the very high– or low–attaining pupils. The truth is that there is no single 'right' measure for analysing school performance, especially since schools have variable policies on entering students for GCSE. We defined a set of seven outcome measures based on GCSE results, which altogether should give a good overall perspective on student and school outcomes. These are all based on a simple GCSE grade to score conversion (A* = 8, A = 7, B = 6, C = 5, D = 4, E = 3, F = 2, G = 1, U etc. = 0), and are defined as:

1. Total GCSE score (TOTSCORE), summed over all subjects attempted
2. Average GCSE score (AVSCORE), averaged over subjects attempted
3. Mathematics score (MATHS)
4. English score (ENG), averaged over language/literature, if necessary
5. Science score as a **total** (SCI), summed over Single/Double Award or separate subject
6. Number of A to C grades achieved (NATOC)
7. Number of A to G grades achieved (NATOG).

It is important to note that the science score used as an overall performance indicator is based on the total score over all the science subjects entered. In this it differs from the scores for mathematics or English, which are averages. The aim is to account for the total amount of science achieved, and to differentiate between schools offering Single science, Double science, and three separate sciences. When it comes to the analysis of subject areas, however, the science score used is an average over subjects entered. It is important to bear this distinction in mind when considering the results.

Table 4.1: Variables used in multilevel modelling

Name	Min.	Max.	Description
DESNO			School DfEE number
YEAR	94	96	Year group
ID	0	96138	Pupil identifier
SEX	0	2	Sex (0 = male, 2 = female)
FSM	0	1	Entitled to free school meal
ESL	0	1	English second language?
SEN	0	6	Special educational needs level
BLACK	0	1	Black ethnic group
ASIAN	0	1	Asian ethnic group
OTHER	0	1	Other non-white ethnic group
AVATT	1	100	Average attendance
TOTSCORE	0	94	Total GCSE score
AVSCORE	0	8	Average GCSE score
MATHS	0	8	Maths GCSE score
ENG	0	8	English GCSE score (av.)
SCI	0	30	Science GCSE score (total)
NATOC	0	13	No. GCSEs A*-C
NATOG	0	13	No. GCSEs A*-G
SUBA1	0	8	Subject area A : Science
SUBA2	0	8	Subject area B : Maths
SUBA3	0	8	Subject area C : Computing & IT
SUBA4	0	8	Subject area D : Technology
SUBA5	0	8	Subject area E : Art etc.
SUBA6	0	8	Subject area F : Geography
SUBA7	0	8	Subject area G : History
SUBA8	0	8	Subject area H : Humanities
SUBA9	0	8	Subject area I : English
SUBA10	0	8	Subject area J : Welsh
SUBA11	0	8	Subject area K : Languages
SUBA12	0	8	Subject area L : Music etc.
SUBA13	0	8	Subject area M : PE etc.
SUBA14	0	8	Subject area N : Misc. Vocational
SUBA15	0	8	Subject area P : General Studies
XCOMP2	-64	45	Composite intake measure (all)
GM	0	1	Grant maintained school
IND	0	1	Independent school
VOL	0	1	Voluntary aided or controlled school
GIRLSCH	0	1	Girls' school
BOYSCH	0	1	Boys' school
ALEV	0	1	School with sixth form

Table 4.1 (continued)

Name	Min.	Max.	Description
CATCH	0	4	Catchment area (0 = inner city, up to 4 = rural)
STREAM	0	1	Groups streamed by ability
MIXAB	0	1	Mixed ability throughout
TURNOVER	0	2	Staff turnover (0 = low, 1 = medium, 2 = high)
SUPPLY	0	2	Use of supply cover (0 = low, .. 2 = high)
UNFILLED	0	2	Unfilled staff vacancies (0 = low, .. 2 = high)
PARATT	0	2	Parental attendance at meetings (0 = low, .. 2 = high)
Y11SIZE	66	351	Size of Year 11 cohort
PCFSM	1	90	% free school meals
PCSEN	-1	68	% special educational needs
PCESL	-1	53	% English as a second language
IN94	0	1	In 1994 GCSE cohort
IN95	0	1	In 1995 GCSE cohort
AGE	16	16.92	Age at 1/9 of exam year (Year 11)
GMINT	-23	29	Interaction GM by prior attainment
VOLINT	-56	30	Interaction Voluntary by prior attainment
INDINT	-11	45	Interaction Independent by prior attainment
ARTSPC	0	67	% of arts-related subjects
ART	0	1	At least one art GCSE studied
DRAMA	0	1	At least one drama GCSE studied
MUSIC	0	1	At least one music GCSE studied

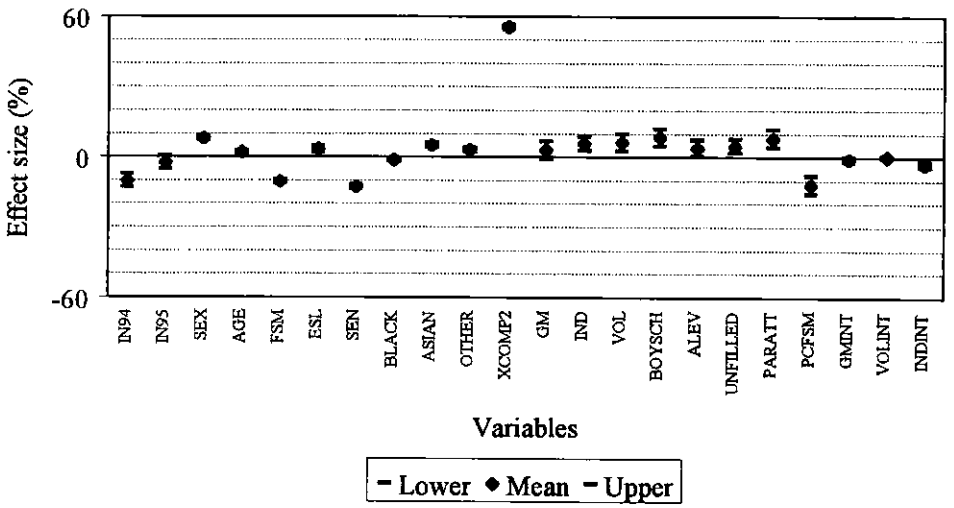
A total of 30,488 pupils with prior attainment measures in 152 schools were included in the multilevel analysis of the overall performance indicators. Results were extremely consistent with previous years, and are therefore not quoted in detail. Figure 4.1 shows an 'effect size' plot for background variables which were found to be significantly (or close to significantly) related to total GCSE score (TOTSCORE). The 'effect size' for a given background variable is independent of units and represents the change in the outcome measure, as a percentage of its standard deviation, associated with a change in the background variable of one standard deviation. It may be regarded as equivalent to the correlation between the two variables when other factors in the model are also taken into account.

Figure 4.1 illustrates these effect sizes graphically, with each symbol representing a 95 per cent confidence interval. Those which do not touch the zero baseline can be considered significantly different from zero, i.e. those variables appear to be significantly related to total GCSE score, when other variables are taken into account.

Looking at the results for all seven outcome measures, it seems that the variables which are significant in all of them are sex, prior attainment (XCOMP2), free school meals (at the student level — FSM), special educational needs, ethnic background,

parental attendance and percentage of free school meals (PCFSM). Performance in 1994 seems consistently lower than in 1996 (when other background variables are taken into account). Sex has a positive coefficient (girls outperforming boys) for five of the outcomes, and it is negative (boys outperforming girls) in mathematics and science. Considering ethnic background, Asian and other non-white pupils do significantly better than would be predicted, while for most outcomes black pupils under-perform relative to whites. **Prior attainment is very positively related to outcomes throughout, and the school-level variable PCFSM is strongly negatively related. These two are the main predictors of GCSE performance at student and school levels.** The individual free school meal variable is also strongly related (negatively) to outcomes.

Figure 4.1: Effect sizes for background variables relative to total GCSE score



Another important result of the multilevel analysis was the amount of apparent variation between schools and between pupils which could be 'explained' by the background variables fitted. For total GCSE score (TOTSCORE), 91 per cent of the school-level variance and 43 per cent of the pupil-level variances was eliminated by the background variables — similar results were found for other outcomes. This shows that differences between schools based on 'raw' GCSE results depend to a very large degree on pupil and school background factors, and not on the quality of the school itself.

Part of the multilevel model was a set of 'interaction terms', which attempted to assess the extent to which different school types had different relationships between prior attainment and GCSE outcomes. The interaction term INDINT was significantly negative in all cases, while its corresponding variable IND was significantly positive. The latter means that pupils in independent schools do better than expected on average, while the former implies that the relationship between prior attainment and GCSE results is 'flatter' than for other school types.

Grant-maintained schools show no overall difference (the variable GM is not significant in any case), but the interaction term GMINT is significantly negative in five

Grant-maintained schools show no overall difference (the variable GM is not significant in any case), but the interaction term GMINT is significantly negative in five cases. This implies that the GM schools in the study are tending to have a less strong relationship between prior attainment and GCSE outcomes.

The voluntary schools variable (VOL) has a significantly positive effect in four cases, corresponding to better than expected performance overall in those schools. The interaction term (VOLINT) is positive on three occasions (total score, science, and number of A* to C grades) but negative in two cases (English and number of A* to G grades). In the former cases there is therefore a stronger relationship than would be expected between prior attainment and the GCSE outcomes, while the reverse is true in the latter two cases.

In Figure 4.2, we can see the relationships between prior attainment and GCSE total score for all the schools. Each school is represented by a vertical line, whose midpoint is the estimated slope value and whose length measures the 95 per cent confidence interval. The steepest slopes are almost 50 per cent above the average, while the shallowest are approaching zero. The data from QUASE seems to indicate quite clearly that different schools do have different relationships between prior attainment and GCSE performance.

Figure 4.2: Total GCSE Score versus prior attainment slope for each school, showing 95% confidence intervals

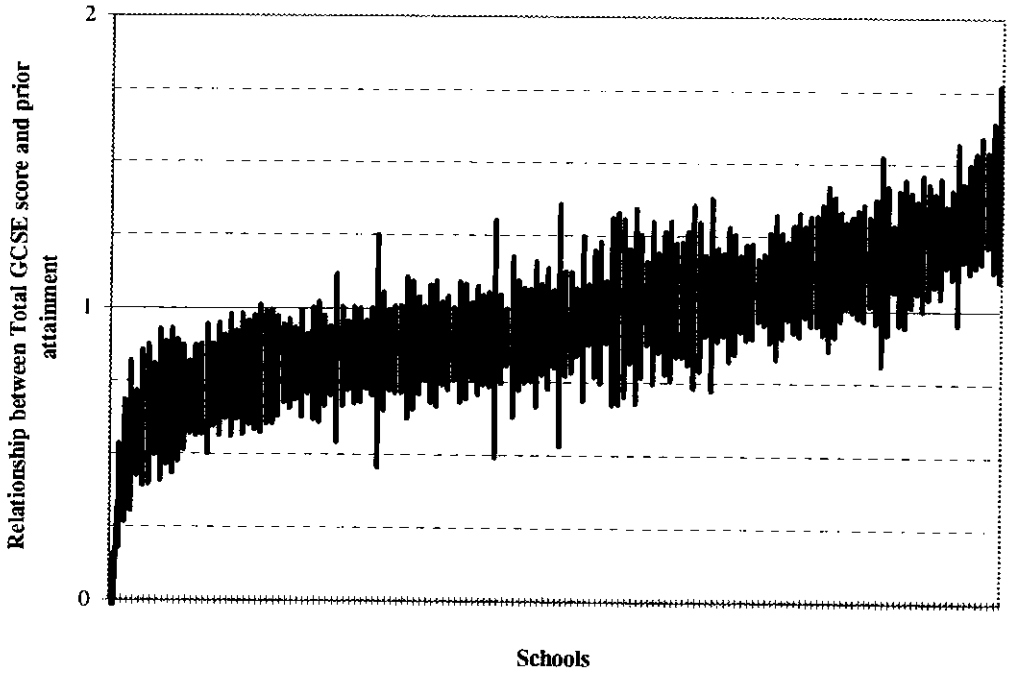


Figure 4.3: Total GCSE Score differential performance between girls and boys for each school, showing 95% confidence intervals

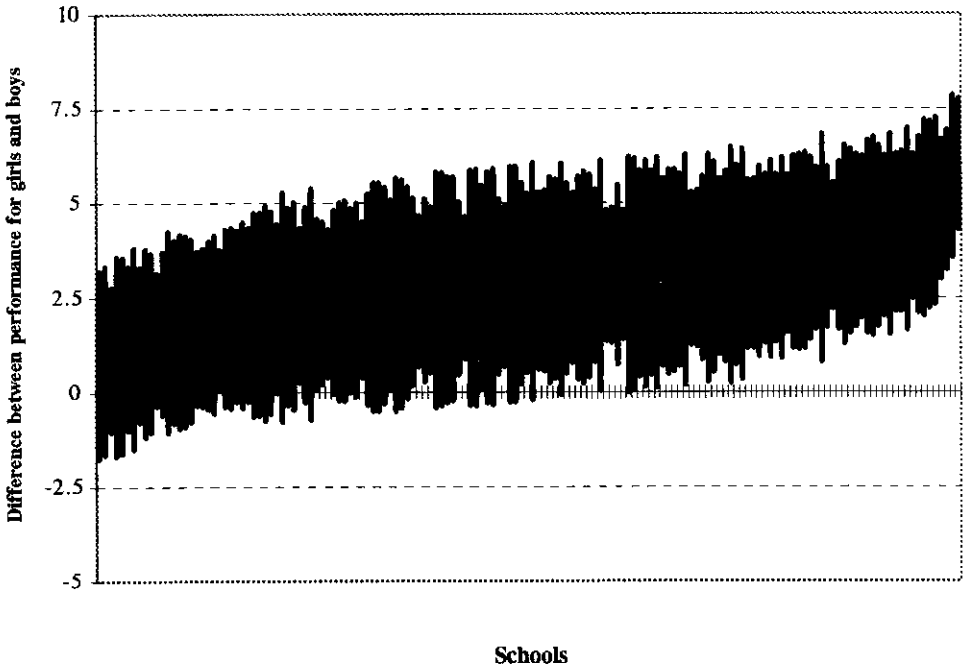


Figure 4.3 shows the difference in performance (measured by TOTSCORE) between girls and boys for each school in the study, as estimated by the multilevel model with random coefficients. It is clear that about one-third of schools have female/male differences which are not significantly different from zero, while the others are all showing significant advantages to the females. These can go up to over five GCSE points (one grade C) in some schools.

5. SUBJECT AREA SCORES

Thirteen of the 15 subject areas as defined by the National Consortium for Examination Results (NCER) coding were each analysed in two different ways:

- by comparison with each student's overall performance in GCSE, measured in this case by total GCSE score (TOTSCORE);
- by comparison with each student's measure of prior attainment (XCOMP2 — where available).

This kind of analysis has the advantage that it does not depend on estimating relative difficulties between subject — each is analysed separately, relative to total GCSE score or to prior attainment. In the first case, we are looking at subject results relative to a contemporary measure of overall attainment. In the second, the main contextualising variable is a measure of prior attainment at or near the start of secondary schooling. This latter allows us to assess 'progress' or 'value added' for different groups of pupils in different subjects.

The other variables taken into account were the 1994 and 1995 cohort indicators, sex and ethnicity. Results are shown in Table 5.1, in terms of the effect sizes for each background variable relative to each subject area (while controlling for total GCSE score). Only effects which are significant at the 5 per cent level are shown.

Table 5.1: Subject area results, in terms of effect sizes of background variables while controlling for total GCSE score

Subject area	No. of cases	IN94	IN95	SEX	AGE	BLACK	ASIAN	OTHER	TOT-SCORE
1: Science	30942			-11		-1	-1		78
2: Maths	31103			-9	1	-1	-1		78
3: Computing	3205	-7	-2		4	1		0	65
4: Technology	24755		-5	5		-1			75
5: Art etc.	11576			6		1		1	53
6: Geography	14614		-3	-3	1	-2	-1	-1	89
7: History	11260					1			90
8: Humanities	10733			8		1	1		83
9: English	31601	-3		8	1	1	-1	-2	70
11: Languages	24101			7	-1	-1	3	2	72
12: Music etc.	2211						-4		68
13: PE etc.	4279	-11		-12	2	2	-5		71
14: Misc. Voc.	1705			5			-3		77

Table 5.2 shows similar results, controlling for prior attainment (XCOMP2) rather than total GCSE score.

Table 5.2: Subject area results, in terms of effect sizes of background variables while controlling for Prior Attainment

Subject area	No. of cases	IN94	IN95	SEX	AGE	BLACK	ASIAN	OTHER	XCOMP -2
1: Science	27497	-10	-3	-4	2	-2	3	2	48
2: Maths	27821	-11	-4	-3	3	-2	5	3	55
3: Computing	2737				3		5	3	34
4: Technology	22295	-8	-5	11	3	-3	4	2	37
5: Art etc.	9977	-6		11	3		3	3	26
6: Geography	13318	-8	-5	4	4	-3	4	2	49
7: History	10364	-11		7	4		5	2	50
8: Humanities	8085			15	4		7	3	46
9: English	28093	-14		13	3		4	1	44
11: Languages	21426	-9		13	2	-1	7	3	43
12: Music etc.	1879	-9		7		-4			35
13: PE etc.	3505	-16		-5	5	2			36
14: Misc. Voc.	1229			14					42

Although there are certain similarities between these two analyses, there are also some interesting differences:

- There is a stronger relationship between subject scores and the total score (TOTSCORE) than with the prior attainment measure (XCOMP2). For the former, the effect sizes range from 53 per cent (art) up to 90 per cent (history), while for the latter the range is from 26 per cent (art) up to 55 per cent (mathematics). This is not surprising, as TOTSCORE is a contemporary measure of overall attainment, while XCOMP2 was measured up to around five years earlier.
- The effects of background variables appear stronger in the latter case than the former, again not very surprisingly.
- Controlling for prior attainment, the 1994 data indicator is significantly negative in most cases. This implies that results in most subjects relative to prior attainment are higher on average in 1996 than in 1994.
- Girls appear to be making more progress than boys in most subjects except science, mathematics and PE.
- Older pupils within the year group are making more progress than others in most subjects.
- Pupils of Asian or other non-white ethnic background are making more progress than whites in most subjects, while black pupils make less progress in most subjects, with PE being an exception.

6. RELATIONSHIPS BETWEEN GCSE PERFORMANCE AND STUDYING ARTS-BASED SUBJECTS

In order to study the possible relationships between studying arts-related GCSE subjects and overall performance at GCSE, some secondary analysis has been carried out on QUASE data. The three subject areas whose impact was to be studied were:

- art;
- drama;
- music.

In addition to the standard QUASE variables related to sex, age, ethnicity, prior attainment, etc., some new indicators were developed for students who had studied arts-related subjects.

ART	takes the value 1 if the student has entered at least one GCSE in the subject area of art, 0 otherwise.
DRAMA	takes the value 1 if the student has entered at least one GCSE in the subject area of drama, 0 otherwise.
MUSIC	takes the value 1 if the student has entered at least one GCSE in the subject area of music, 0 otherwise.

Some care had to be taken, however, in including these variables as they stand in the multilevel model. There are a significant number of students in the model with no GCSEs at all, as well as many with just one or two. Each of the above indicators is more likely to be positive for students taking a non-zero number of GCSEs, and therefore their effect is likely to be confounded with the overall effect of just taking one or more GCSEs. To get round this, the analysis was carried out on a subset of students who had attempted three or more GCSEs.

As well as examining possible direct relationships between studying each of these subjects and GCSE performance, the opportunity was taken to investigate two other aspects of these relationships: 'interactions' and 'random slopes'. An interaction between studying a subject (say art) and another background variable (say sex) would imply that the relationship between art and GCSE performance was different for males and females. As well as considering possible sex interactions, the study also looked at interactions with prior attainment, so that hypothetically pupils with lower initial attainment might do more or less well if they studied one of the arts-based subjects.

Such interaction terms were included in the multilevel analysis by defining extra 'interaction variables':

ARTSEX	Interaction between studying art and sex
DRAMSEX	Interaction between studying drama and sex
MUSSEX	Interaction between studying music and sex
ARTXINT	Interaction between studying art and prior attainment
DRAMXINT	Interaction between studying drama and prior attainment
MUSXINT	Interaction between studying music and prior attainment.

The concept of 'random slopes' is based on the idea that the relationship between studying an arts-based subject and GCSE performance may not be the same across all schools, but may vary from school to school. The size of the school-level variance gives us an indication of the extent to which the 'arts-based subject effect' is consistent from school to school. One further variable was developed, which was intended to represent the overall tendency of students to take arts-related subjects:

ARTSPC is the sum of the above three indicators, as a percentage of the total number of GCSEs attempted.

The multilevel analysis was carried out on the following measures of GCSE performance:

ENG Average English score
MATHS Average maths score
SCI Total science score
AVREST Average score on non-arts subjects.

None of the other performance indicators which sum or average over all subjects was suitable, as they would include the arts subjects themselves.

The multilevel analysis of QUASE data was carried out with three levels in the model: school, cohort and pupil. Background variables at the school and pupil levels were included, including prior attainment in Year 7. Once these basic models had been set up, the arts-related variables and the interaction terms were included. The variable ARTSPC, which measured the overall proportion of GCSEs which were arts-related, was included at a later stage. Figures 6.1 to 6.4 show the effect sizes for each outcome measure.

Figure 6.1: Effect sizes of arts-related variables on average English score

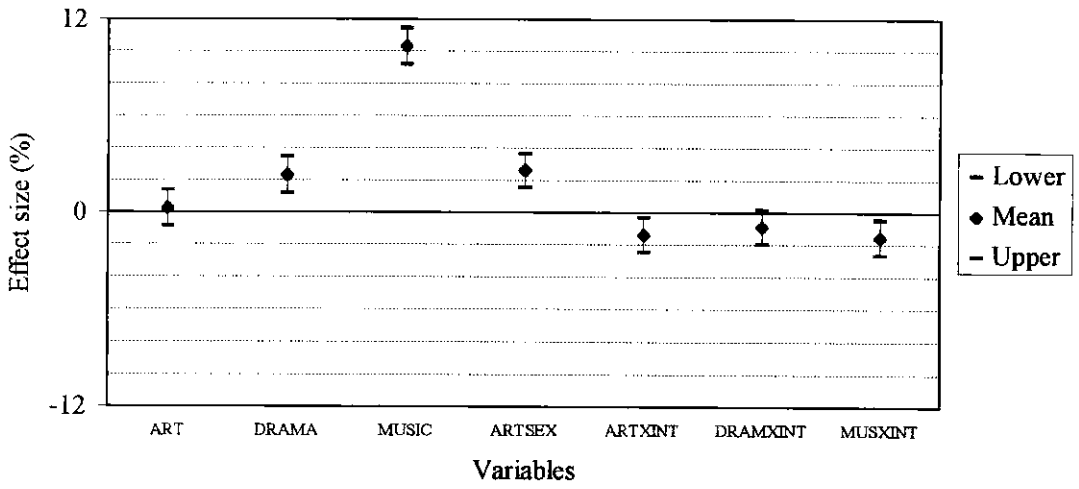


Figure 6.2: Effect sizes of arts-related variables on average maths score

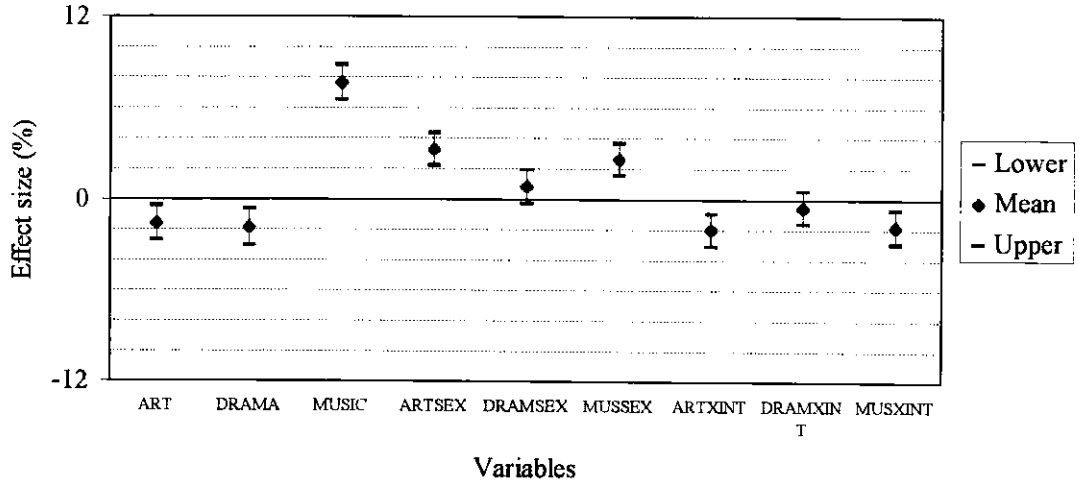


Figure 6.3: Effect sizes of arts-related variables on total science score

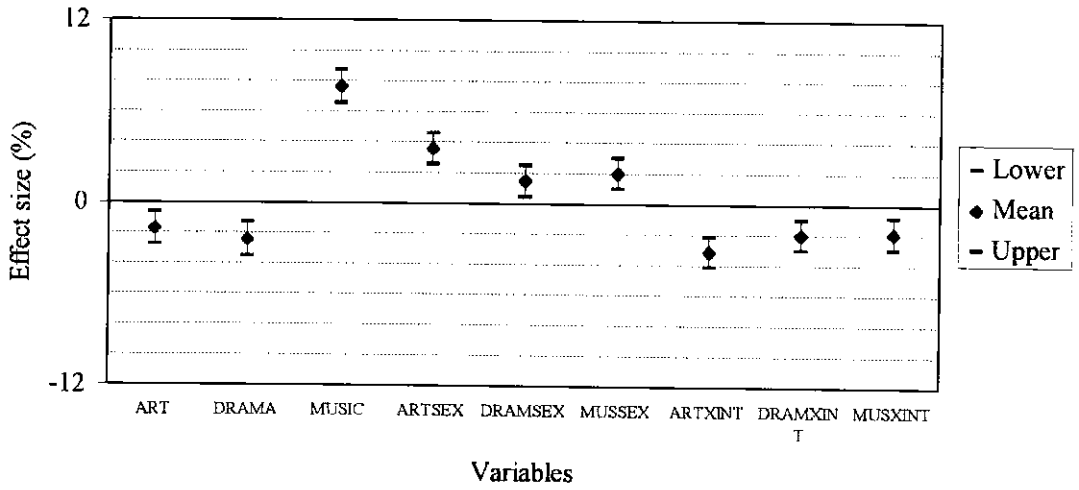
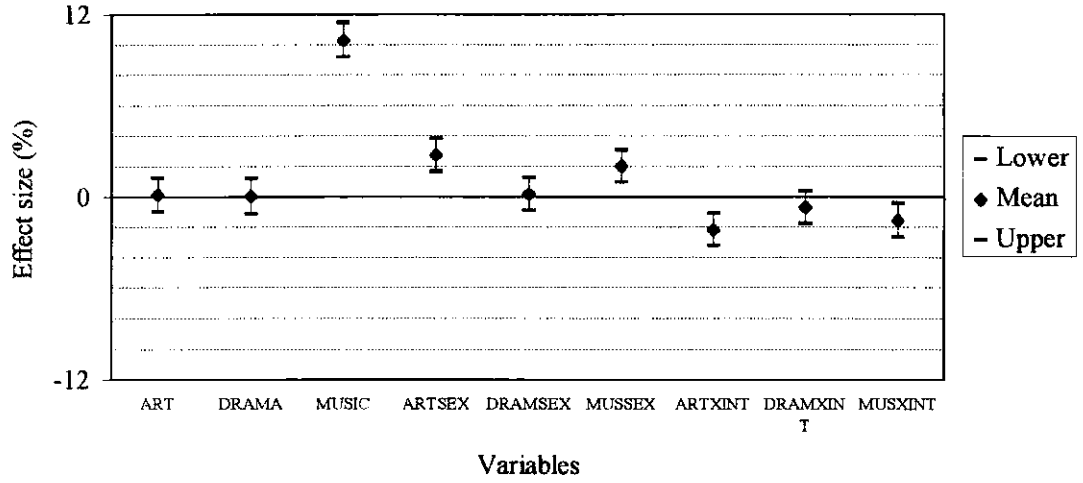
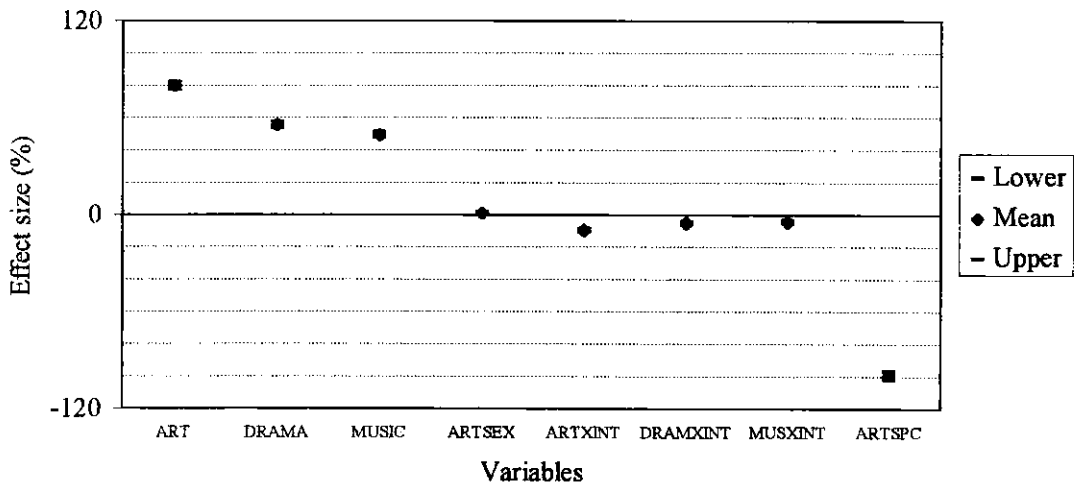


Figure 6.4: Effect sizes of arts-related variables on average score for other subjects



When, in addition to the above background variables, we also controlled for the variable ARTSPC, the percentage of the GCSE subjects entered which were arts-related, a dramatic change was observed. This is illustrated in Figure 6.5 for English, but it carried over into the analyses for all the outcome variables. The apparent effects of each of the original background variables become much stronger, but counterbalanced by an even stronger negative effect of ARTSPC.

Figure 6.5: Effect sizes controlling for ARTSPC on average English score



As discussed earlier, the extent to which these relationships vary from school to school was investigated by making the coefficients for the three variables ART, DRAMA and MUSIC random at the school level. In all cases, this random effect was statistically significant, even when the overall relationship was not apparently significant. This implies that in certain schools there are strong positive relationships between arts-based subjects and GCSE performance, while in others they may be non-existent or

even negative. Table 6.1 shows the standard deviation between schools in the apparent change in GCSE performance associated with each arts-based subject.

Table 6.1: Standard deviations in slopes between different schools for GCSE results versus arts-based subjects

	ART	DRAMA	MUSIC
Average English score	0.31	0.45	0.40
Average Maths score	0.33	0.45	0.67
Total Science score	0.88	1.08	0.95
Average score for others	0.34	0.43	0.37

Commentary on results

Turning first to Figure 6.1, which shows the relationships between the individual subject indicators and the English GCSE score, it appears that drama and music are significantly related to success in English. Looking at interactions, art is the only significant one for sex, and the result implies that the effect of studying art is more positive for girls than for boys. Interactions with prior attainment show a stronger positive effect for art and music on those with lower levels of prior attainment.

Looking at Figure 6.2 (Mathematics) we can see that music again (and traditionally), is positively related to mathematics, while students of art and drama appear to under-perform. Art and music are more positive for girls than for boys, and both have a stronger positive effect for pupils of lower prior attainment.

Figure 6.3 (Science) shows a similar picture to Figure 2, with music positive overall and art and drama negatively related to science. All three are more strongly positive for girls and for those of lower prior attainment.

Figure 6.4 shows the relationships with the average score on non-arts subjects, and shows a similar picture to the others. Only Music has a significant positive effect overall, while the other two are not significant. Once again, art and music are more positive for girls than for boys, and both have a stronger positive effect for pupils of lower prior attainment.

When we include the overall proportion of arts-based subjects, ARTSPC, there is a dramatic change (see Figure 6.5). The apparent effects of the individual subjects become much stronger, but these are counter balanced by an even stronger negative effect of ARTSPC. What does this mean? One possibility is that each arts subject by itself may have some beneficial impact on performance in core subjects, but that students who tend to concentrate on arts subjects to the exclusion of others may have reduced attainment. None of the analysis carried out here gives any indications of causality, of course.

Analysis with 'random slopes' has shown a very strong variation between schools in the relationship between GCSE performance and studying arts-based subjects. This

holds true even when the apparent overall effect is not significant. The implication is that the impact of studying these subjects on pupils' performance is affected by one or more school-level factors.

7. PUPIL AND PARENT ATTITUDE QUESTIONNAIRES

Introduction

One of the optional elements of the QUASE service to schools is the provision and analysis of questionnaires to pupils in Year 11, and also to their parents. Over the past three years, a relatively large set of data based on these questionnaires has accumulated, which contains the potential to give insights into factors affecting the attitudes of pupils and their parents at this crucial stage of their careers.

For reasons of confidentiality, it is not possible to match questionnaire responses and examination results at the pupil level, and the best that can be done is to match aggregated data at the level of the school cohort. However, with this limitation, some extensive analysis has been carried out on this data, with the following aims in view:

- to reduce the large number of questions in each questionnaire to a smaller set of underlying factors which can be interpreted more easily;
- to study the relationships between these factors and background variables at the school and pupil levels.

To achieve the first aim, the technique known as *factor analysis* was used; the second was approached using *multilevel modelling*. Details of the results of these analyses are given in the following sections.

Results of factor analysis

Over the three years of data, the pupil questionnaire had 9,106 respondents from 46 schools, and the parents' questionnaire had 4,078 respondents from 35 schools. The questionnaires had 42 and 34 questions respectively which could be converted to numerical values, significantly more than can be grasped and interpreted by the unaided human brain.

Factor analysis is a technique which is widely used in dealing with large numbers of measurements made on different individuals or objects, many of which may be strongly correlated with each other. In factor analysis, we attempt to define a smaller set of underlying factors which are related to the variables measured, and which explain or represent most of the correlation structure of the data. The set of factors we define in this way is not unique, and the final set used can be chosen according to a number of criteria. The process of finding the 'best' or simplest factor solution is known as factor rotation.

An important issue to be addressed is the number of factors to be extracted from a given set of variables: too many, and there is no gain in ease of understanding; too few, and the position is over-simplified. Techniques involving plotting 'eigenvalues' can be used to answer this question, but in some cases the optimal number of factors is a matter of judgement.

Having defined the factors, we may compute 'factor scores' for each respondent, based on the actual values they have for the relevant variables. These scores enable us to

characterise each respondent on each dimension of performance represented by the factors.

Initial investigation of the number of factors to be extracted led to the decision to choose four for the pupil questionnaire and three for the parents'. Factor rotation was then carried out to ensure, as far as possible, that each factor's relationship with each questionnaire variable was either large or quite small. This enables us to assign descriptions to each of the extracted factors.

Tables 7.1 and 7.2 show the factor 'loadings' for each factor against each questionnaire variable. Only values greater than 0.35 are printed, to show more clearly the way in which factors are associated with variables. The final row shows the percentage of the total variance in the questionnaire variables 'explained by', or associated with, each of the factors. From these tables, the following provisional descriptions of the factors were derived:

- **Pupil factor 1 (PUPFAC1):** Perception of school as a 'good school'
- **Pupil factor 2 (PUPFAC2):** Personal reaction to school and schooling in general
- **Pupil factor 3 (PUPFAC3):** Pupil's perception of parental attitude to school
- **Pupil factor 4 (PUPFAC4):** Bullying (higher values associated with less bullying)

- **Parent factor 1 (PARFAC1):** Child-specific — information, progress, etc.
- **Parent factor 2 (PARFAC2):** General view of education in Year 11
- **Parent factor 3 (PARFAC3):** Personal reaction to school and schooling in general.

For each of the above factors, it is possible to estimate a 'factor score' for each respondent, based on the values of the questionnaire variables. These factor scores were scaled to have a mean of 100 and standard deviation of 15, and could then be used as outcome variables in multilevel modelling to determine the relationships between these scores and a range of background variables. Note that each score is arranged such that higher values refer to 'good' or positive responses, while lower values are related to 'poor' or negative responses.

Results of multilevel modelling

The background variables which could be fitted were restricted to the following:

- pupil- or parent-level variables actually derived from the questionnaire (sex and ethnicity);
- aggregated GCSE results at the school cohort level;
- school-level context data from the context questionnaire.

The variables and their names are given below:

IN94	1 if data collected with 1994 GCSE data
IN95	1 if data collected with 1995 GCSE data
SEX	0 = male, 2 = female, 1 = not known
BLACK	1 = black ethnic group, 0 otherwise
ASIAN	1 = Asian ethnic group, 0 otherwise
OTHER	1 = other non-white ethnic group, 0 otherwise
MEANTOT	School average total GCSE score
MEANAV	School average of average GCSE score per entry
GIRLSCH	1 if girls-only school., 0 otherwise
BOYSCH	1 if boys-only school, 0 otherwise
ALEV	1 if school has sixth form, 0 otherwise
CATCH	Catchment area, on scale 0-4, rural to inner-city
TURNOVER	Staff turnover rate, on scale 0 to 2
SUPPLY	Use of supply cover, on scale 0 to 2
UNFILLED	Unfilled teaching posts, on scale 0 to 2
PARATT	Parental attendance at governors' meetings (0 to 2)
Y11SIZE	Size of Year 11
PCFSM	Percentage of pupils eligible for free school meals.

For each of the derived factor scores, multilevel analysis was carried out including all the pupil-level background variables (IN94 to OTHER) plus those of the school-level variables which appeared to be significant or close to significant. Figures 7.1 to 7.4 show the results for the four pupil factors, in terms of 'effect sizes' for each background variable.

Figure 7.1: Effect sizes for pupil factor 1 ('good school')

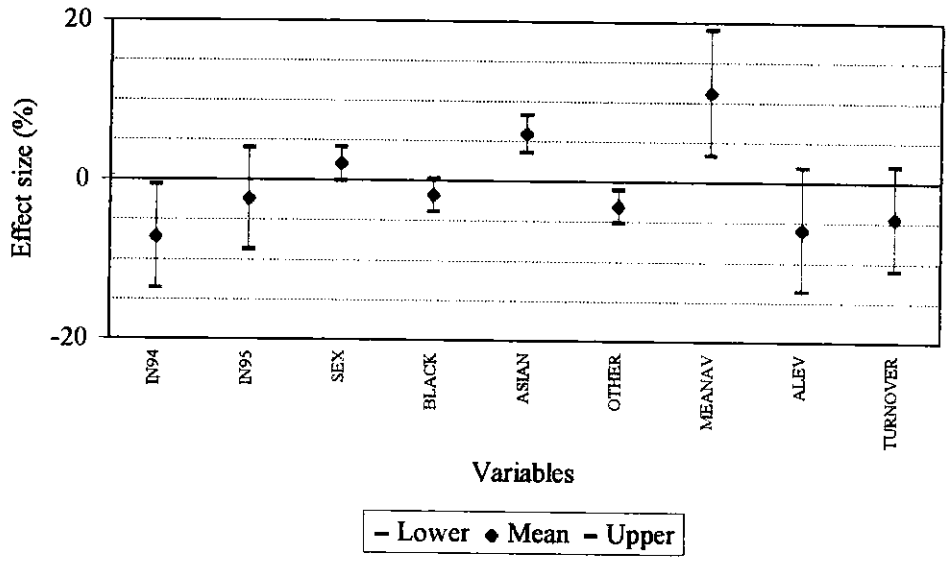


Figure 7.2: Effect sizes for pupil factor 2 (personal reaction)

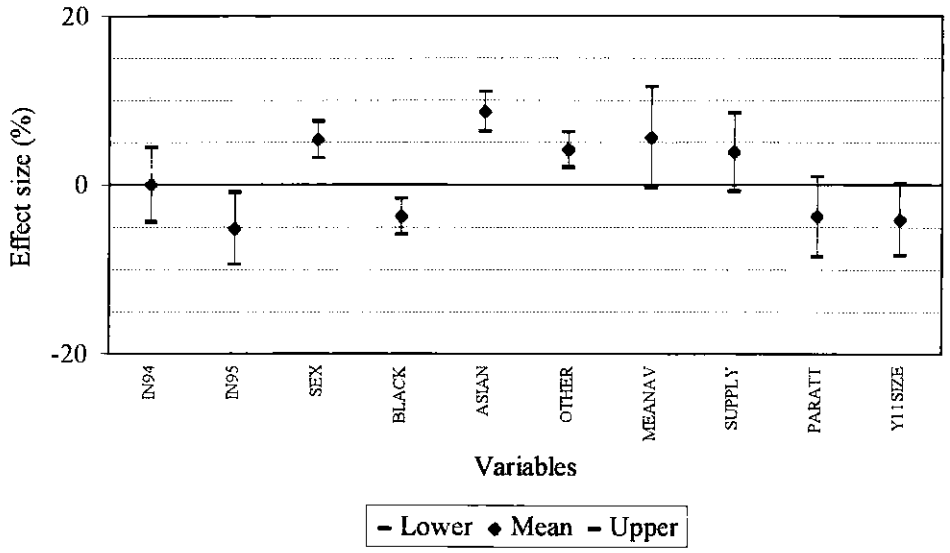


Figure 7.3: Effect sizes for pupil factor 3 (parents)

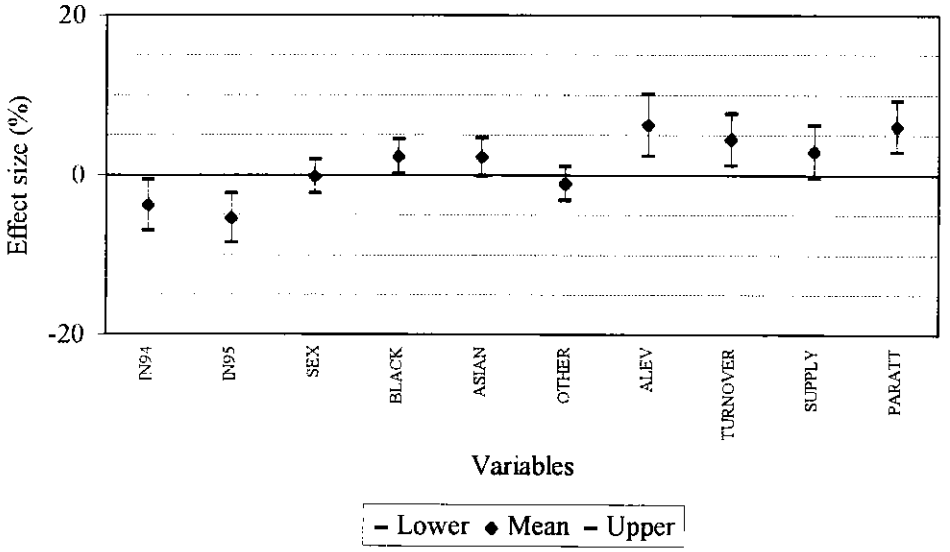
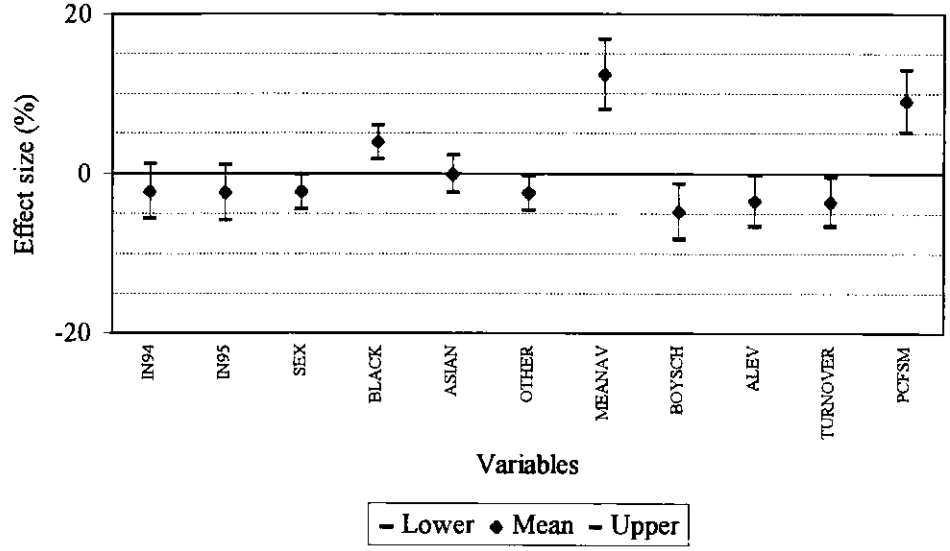


Figure 7.4: Effect sizes for pupil factor 4 (bullying)



Effect sizes for the parents' factors are shown in Figures 7.5 to 7.7.

Figure 7.5: Effect sizes for parents' factor 1 (child-specific)

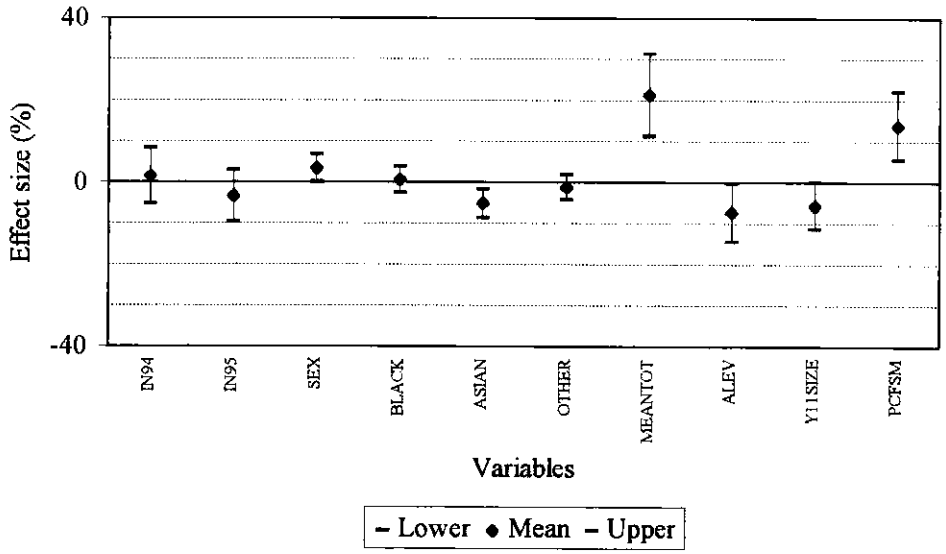


Figure 7.6: Effect sizes for parents' factor 2 (Year 11)

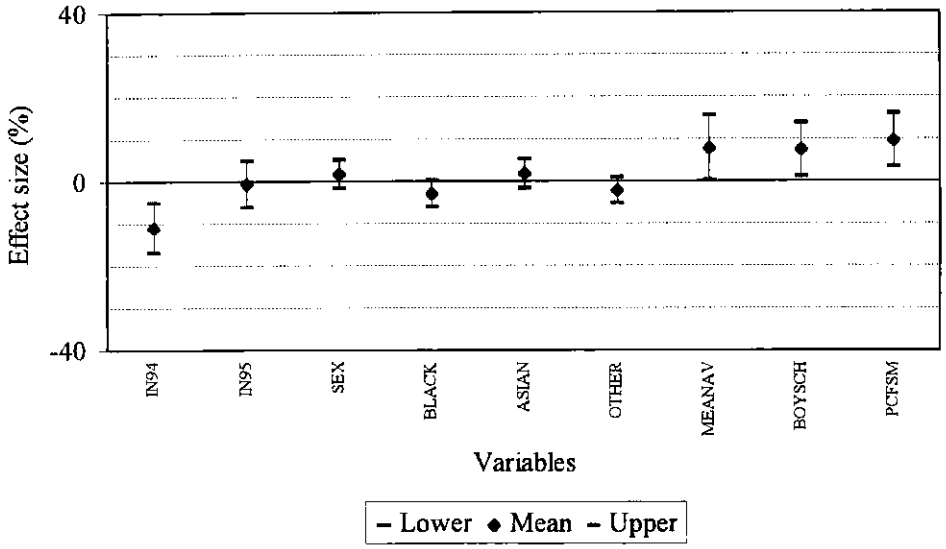
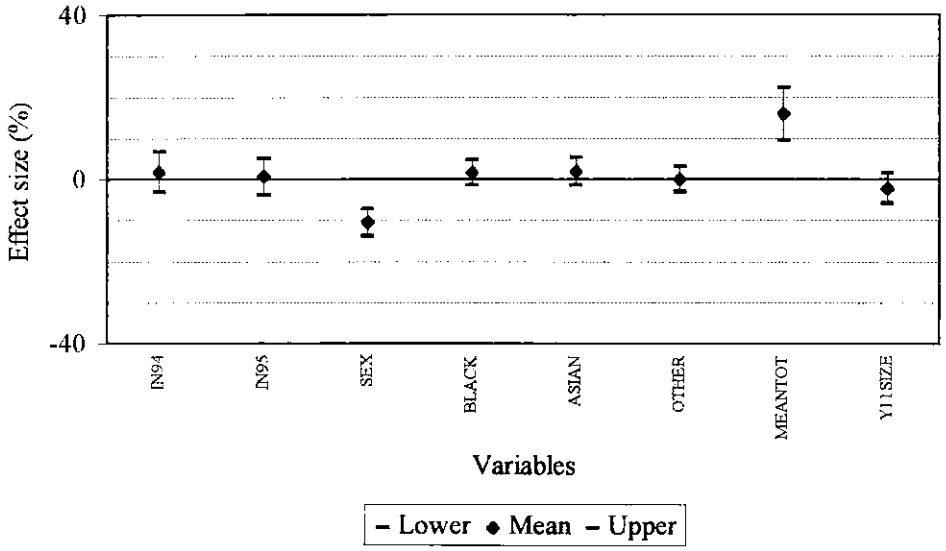


Figure 7.7: Effect sizes for parents' factor 3 (personal reaction)



In the next section, we shall discuss the interpretation of these results. In all the models described so far, the relationships between the factor scores and background variables are 'fixed', that is to say they are assumed to be the same for each school. It may be interesting to see the extent to which the relationships with the pupil-level variables are different from one school to another. For this reason, each model was rerun with the sex effect 'random' at the school level — i.e. varying from school to school.

Table 7.3 shows the results of this type of modelling on the pupil factor scores. In three out of four cases, there is a significant variation between schools in the difference between male and female factor scores, and this variation is larger than the estimated overall sex difference. It is clear in this case, therefore, that a model which only considers overall relationships is only telling part of the story. For parent factor scores, there were no significant school-level variations relative to male/female differences.

Interpreting the results

In this section, we shall attempt to summarise the findings of the multilevel analysis. First, relative to the pupil questionnaires:

- The responses to 42 of the questions could be reduced to four major factors which explained 30 per cent of the variance in the questionnaire data and summarised pupils' attitudes to school.

- Girls had significantly more positive personal reaction to school than boys, but were more likely to mention bullying. These sex differences should be qualified by the finding that for most factors there were significant variations between schools in male/female differences.

- Black pupils tended to have more negative personal reactions to school than whites, but were significantly more positive on parental attitudes and bullying. Asian pupils were significantly positive on saying it was a 'good school' and on their personal reaction to school. Other non-white ethnic minorities appeared to be positive in identifying their school as 'good' but negative in terms of personal reaction to the school and bullying.

- Of the school-level variables, one of those most consistently identified as related to pupil attitudes was the school's overall average GCSE grade per subject entry. This was positively related to saying it was a 'good school' and to bullying (i.e. lower incidence).

- No school-level factors were quite significant in their relationship to pupils' personal reactions to school, although the size of the year group was almost significant in a negative sense (i.e. smaller schools getting better reactions).

- Pupil-reported parental attitudes appeared to be positively related to having a sixth form, higher staff turnover, and parental attendance at meetings.

- Bullying (lower incidence thereof) appeared to be positively related to overall average GCSE grade and percentage of pupils eligible for free school meals, but negatively to boys' schools, having a sixth form, and higher staff turnover.

Some of the above findings may be intuitively reasonable and others less so. It should be noted that they refer to the best models which fit the data and do not imply any form of direct causality.

Now, considering the results from the parents' questionnaires:

- Factor analysis of the 34 questions analysed resulted in three major factors being extracted, which together explained 34 per cent of the variance.

- Parents of girls tended to be more positive on the child-specific factor, and more negative on their reaction to school in general. No significant variation between schools in male–female differences were found.

- The only significant ethnic relationship found was a negative one for parents of Asian children on the child-specific factor.

- School-level GCSE performance (either mean total score or average score) was positively related to all three parental factors.

- Parents in schools with a higher percentage of free school meals had overall more positive responses on the child-specific and Year 11 education factors.

- Parents in smaller schools tended to be more positive on the child-specific factor, whereas those in schools with sixth forms tended to be more negative on the same factor.

- Parents in boys' schools tended to be more positive on the Year 11 education factor.

Again, those relationships highlighted above should not be taken to imply any form of causality.

Table 7.1: Factor loadings for pupil questionnaire

	F1	F2	F3	F4	Description
Q1.1		0.54			I like being at school
Q1.2		-0.52			I don't want to go to school
Q1.3		0.40			School work is worth doing
Q1.4		0.44			School has sensible rules
Q1.5	0.40				People think it is a good school
Q1.6	0.43				School is clean & attractive
Q1.7		0.43			Homework is important
Q1.8					Doesn't help get job
Q1.9	0.47				Would recommend school
Q2.1		0.41			I work as hard as I can
Q2.2		-0.44			Often count minutes to end
Q2.3		-0.58			I am bored in lessons
Q2.4		-0.49			Lesson work waste of time
Q2.5	0.36	0.50			Lesson work interesting
Q3.1			0.57		Parents: Important to do well
Q3.2			0.67		Parents: Interested in how I do
Q3.3			0.46		Parents: Come to parents' evenings
Q3.4			0.57		Parents: Make sure I do homework
Q3.5			-0.36		Parents: School waste of time
Q3.6			0.48		Parents: Should behave well
Q4A.1	0.46				Teachers: Make sure homework done
Q4A.2	0.49				Teachers: Clear how to behave
Q4A.3	0.51				Teachers: Take action on breaking rules
Q4A.4	0.47				Teachers: Praise for good work
Q4A.5	0.41	0.49			Teachers: Like them
Q4A.6	0.51				Teachers: Can keep order
Q4B	0.42				Teachers: Level of work
Q4C	0.41				Teachers: Marking work
Q4D.1					Personal talk with form teacher
Q4D.2					Personal talk with other teacher
Q5A		-0.44			Discipline
Q5B		-0.45			Number of rules
Q5C.1		0.36			Last year behaviour of self & friends
Q5C.2		0.40			This year behaviour of self & friends
Q5D.1				0.79	Bullying last year
Q5D.2				0.78	Bullying this year
Q6A.1	0.46				Covered wide range of subjects
Q6A.2	0.47				Good balance of subjects
Q6A.3	0.53				Equipped with right skills
Q6A.4	0.52				Prepared for adult & working life
Q6A.5	0.54				Suitable for individual needs
Q6B	0.36				Careers guidance
% Var.	11.19	9.64	5.50	3.23	Percentage of total variance explained

Table 7.2: Factor loadings for parents' questionnaire

	F1	F2	F3	Description
Q2.1			0.52	Child likes being at school
Q2.2			-0.47	Child doesn't want to go to school
Q2.3			0.48	School work is worth doing
Q2.4			0.61	School has sensible rules
Q2.5			0.49	People think it is a good school
Q2.6			0.38	School is clean & attractive
Q2.7			0.48	Homework is important
Q2.8			-0.33	Doesn't help get job
Q2.9	0.35		0.54	Would recommend school to others
Q3.1	0.48			Enough info on subjects studying?
Q3.2	0.34			Enough info on choices post-Yr 11?
Q3.3	0.53			Enough info on progress?
Q3.4	0.50			Enough info on difficulties?
Q3.5				Enough info on rules & regs?
Q4.1	0.58	0.35		How child being taught
Q4.2	0.50			Progress in maths
Q4.3	0.47			Progress in science
Q4.4	0.46			Progress in English
Q4.5	0.64			Kind of homework
Q4.6	0.58			Amount of homework
Q4.7	0.42		0.39	How treated by teachers
Q4.8				How treated by students
Q4.9				Religious & moral teaching
Q4.10	0.40			Exam results
Q4.11		0.36		Equipment & resources
Q4.12		0.35		Opportunities for sports
Q4.13				Opportunities for music, drama, etc.
Q5.1		0.63		Covers wide range of subjects
Q5.2		0.68		Good balance of gen. & spec. subjects
Q5.3		0.72		Equipped with right skills & knowledge
Q5.4		0.65		Prepared for further ed/training
Q5.5		0.66		Prepared for adult & working life
Q5.6		0.64		Suitable for individual needs
Q7				Careers guidance
% Var.	12.63	12.22	9.21	Percentage of total variance explained

Table 7.3: School-level variations in male/female differences in pupil factor scores

Outcome factor score	Overall male/female difference	Standard deviation of male/female difference between schools	School variation significant?
PUPFAC1	0.61	1.65	No
PUPFAC2	1.74	2.57	Yes
PUPFAC3	0.27	2.49	Yes
PUPFAC4	-1.23	1.90	Yes

8. NON-LINEAR RELATIONSHIPS FOR SUBJECT GRADES

One of the features of QUASE's feedback to schools is the set of scatterplots produced for individual subjects, showing pupils' attainment in the subject as a function of their total GCSE score. Most importantly, the plots show not just the results for the pupils at a given school, but also a 'prediction line' which aims to show the average performance in the subject relative to total score, based on all the QUASE data. To date, these prediction lines have been straight lines, based on simple linear regression, but there are logical difficulties with this model at either end of the range.

- At the low end of the ability range, when total score approaches zero, the linear predictor may give a non-zero result (either positive or negative) for the subject score.

- At the high end of the ability range, the linear predictor tends to extrapolate a subject score above the maximum value of 8 (equals A*).

A better and more logical model for the relationship between total score and subject score would have the following properties:

- It would predict a value of zero when total score was zero.
- From zero it would rise fairly sharply, flattening off at higher values of total score.
- As total score increased, it would asymptotically approach the value 8.

In an attempt to satisfy these requirements, a 'mixed model' has been developed.

Let S = subject score (range 0 to 8);
T = total score (range 0 to ?);
S^* = maximum subject score (= 8);
T^* = nominal maximum total score.

For low values of T, let

$$S = a\sqrt{T} + bT \qquad (1)$$

For high values of T, let

$$S = S^* \qquad (2)$$

The 'mixed model' combines the above two equations using a weighting factor T/T^*:

$$S = (a\sqrt{T} + bT)(1 - T/T^*) + S^*T/T^* \qquad (3)$$

This model has the desired properties outlined above. Some suitable manipulation allows it to be fitted to data values using linear regression to estimate the parameters a and b.

As an example of the use of this model, data from five subjects in QUASE has been used, and three models have been fitted to each:

1. A linear model
2. A cubic polynomial model
3. The 'mixed model' described above.

The five subjects chosen were:

- science (mean score over single, double, and separate subjects);
- mathematics;
- art;
- English (mean of language and literature);
- modern languages.

Figures 8.1 to 8.5 show the results of this model-fitting for each subject, plus the mean score for the actual individual data, averaged over bands of total scores of width five points each.

For the mixed model, the values $S^* = 8$ and $T^* = 100$ were used.

Figure 8.1: Prediction of Science GCSE Scores from Total GCSE Score

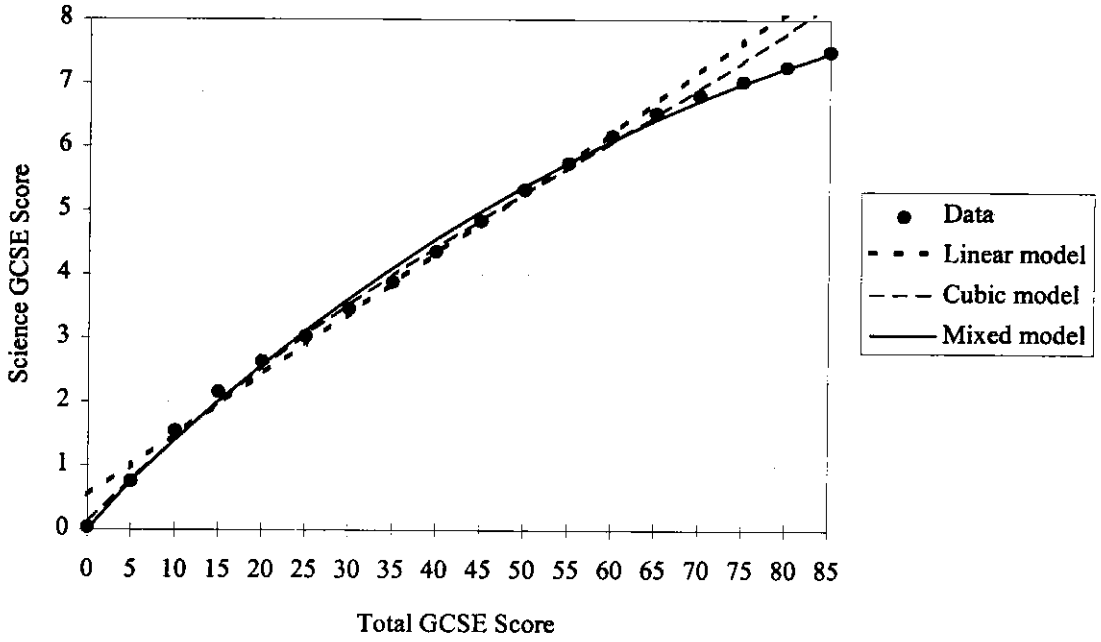


Figure 8.2: Prediction of Mathematics GCSE Scores from Total GCSE Score

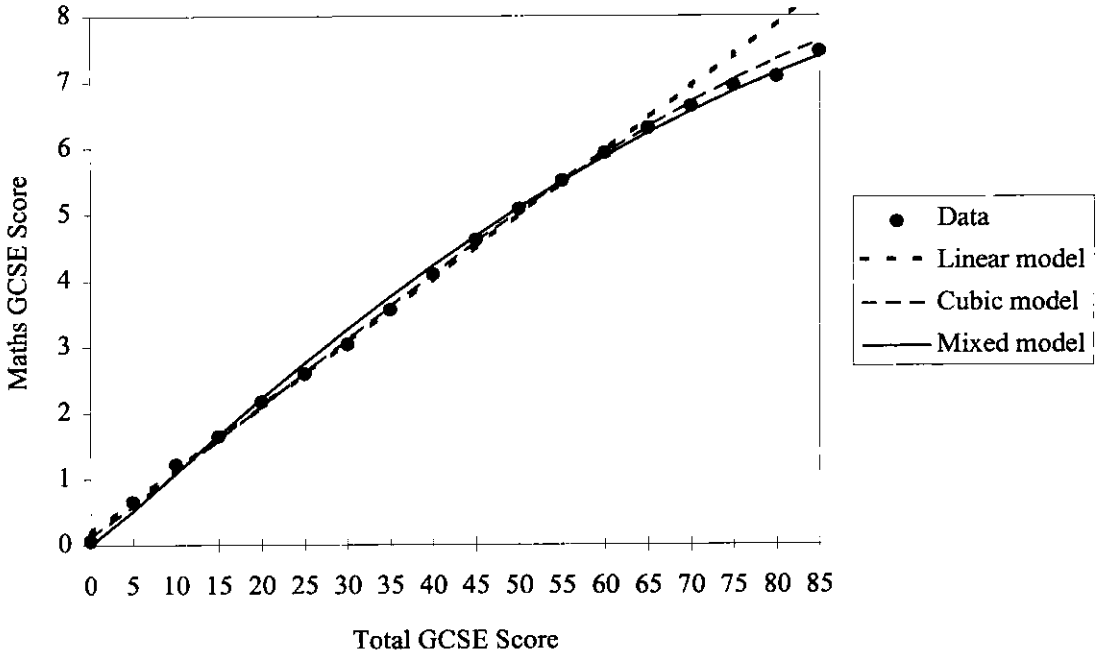


Figure 8.3: Prediction of Art GCSE Scores from Total GCSE Score

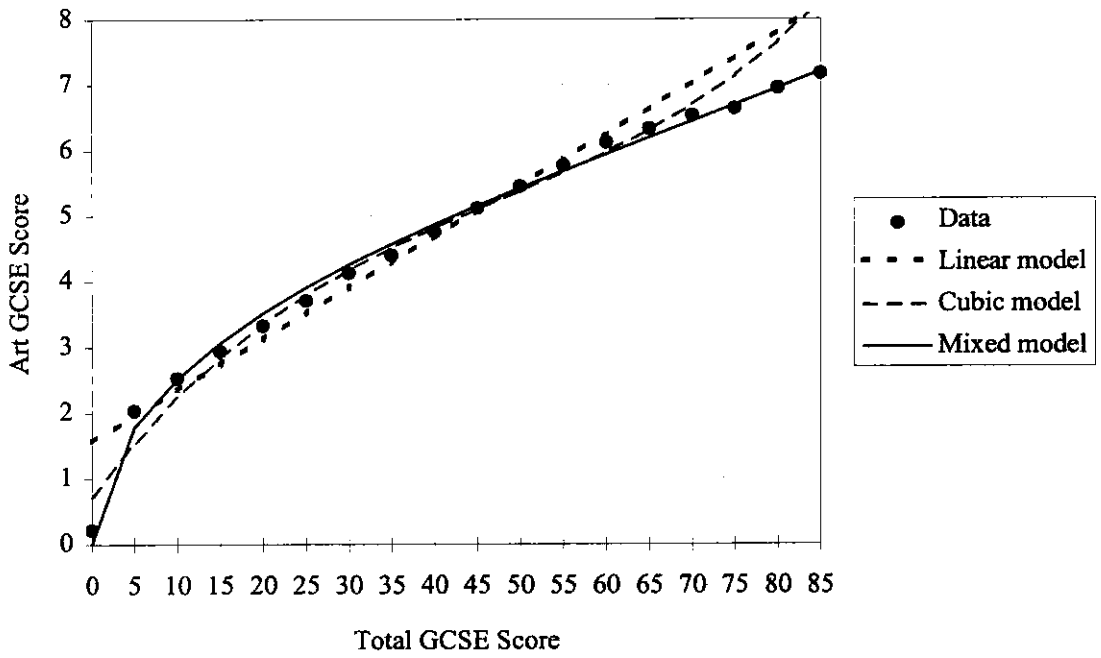


Figure 8.4: Prediction of English GCSE Scores from Total GCSE Score

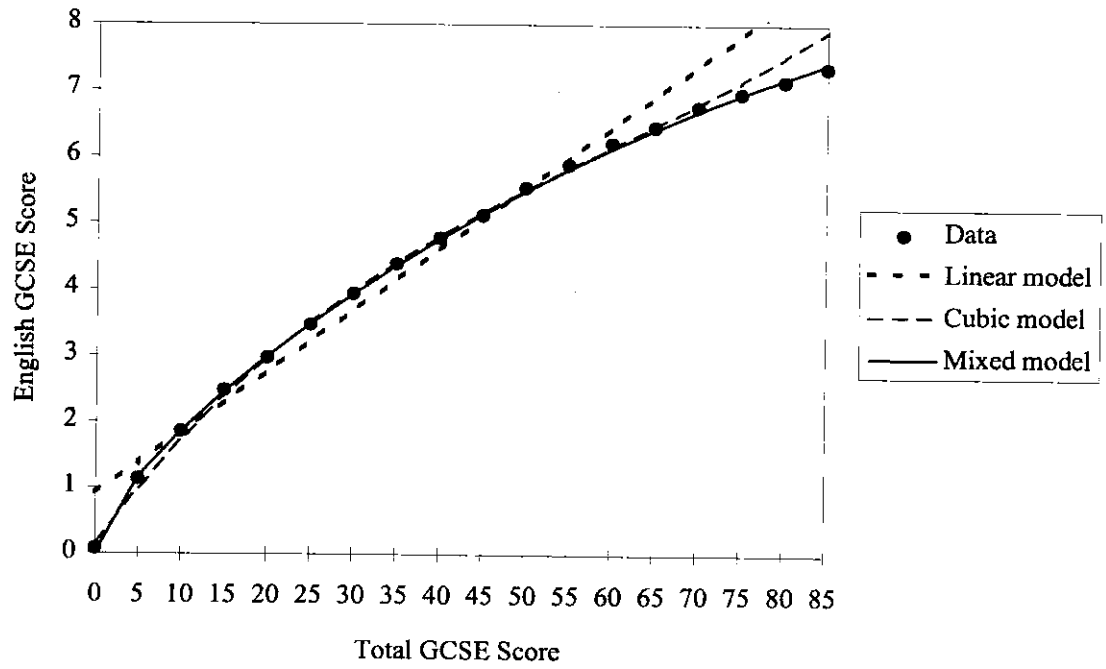
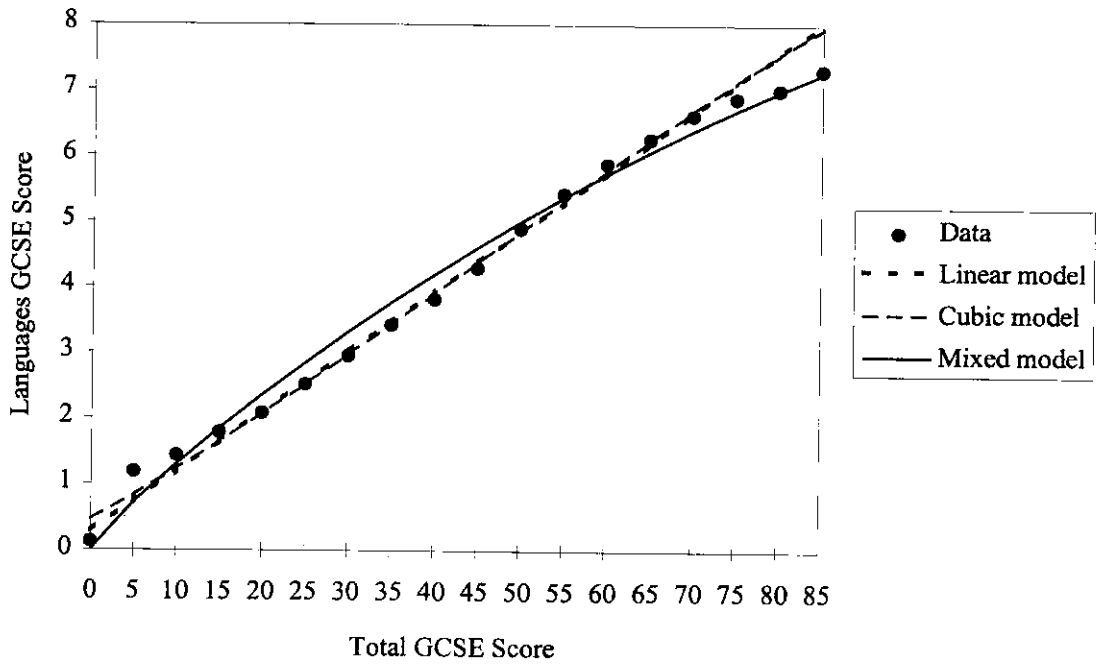


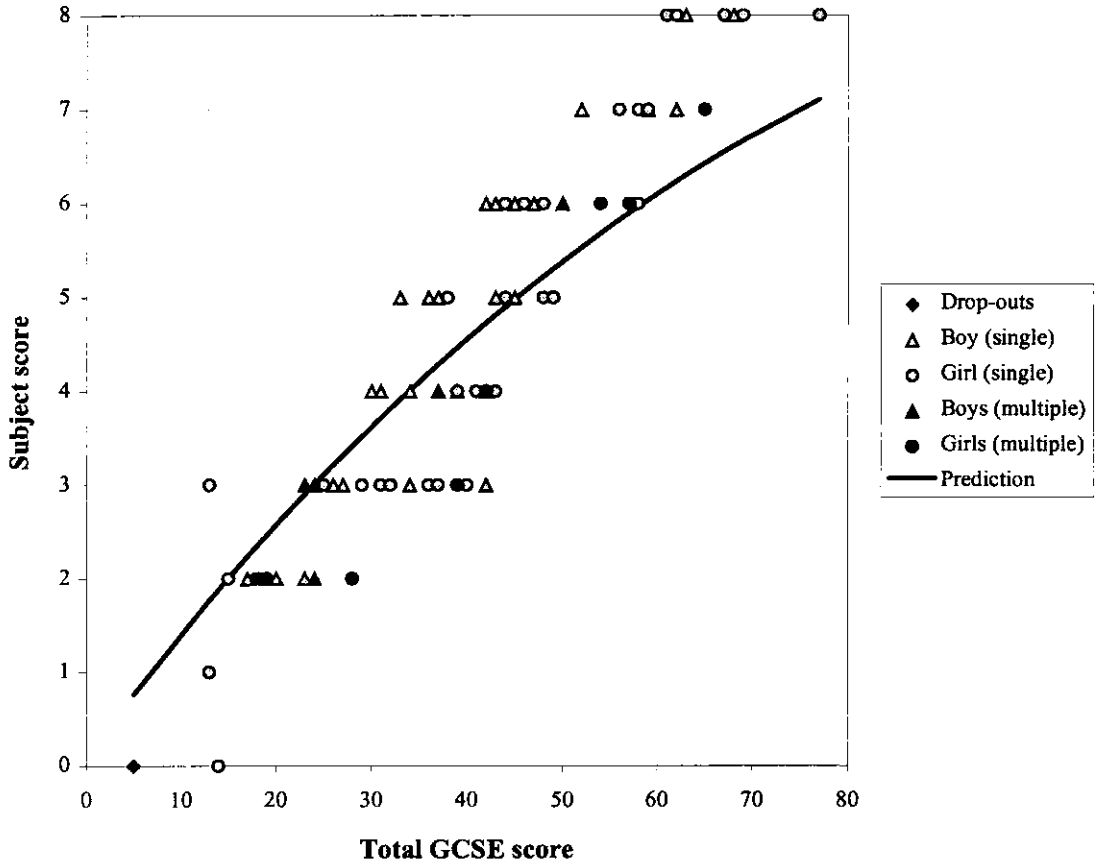
Figure 8.5: Prediction of Modern Languages GCSE Scores from Total GCSE Score



It is clear from the above figures that in some cases, the linear or cubic model fits the data best over the mid-range of ability, while in other cases the new mixed model fits better in the middle of the total score range. In all cases, however, the mixed model gives sensible predictions at either end of the range, with values going to zero at a total score of zero and rising smoothly to a maximum of 8 at the high end.

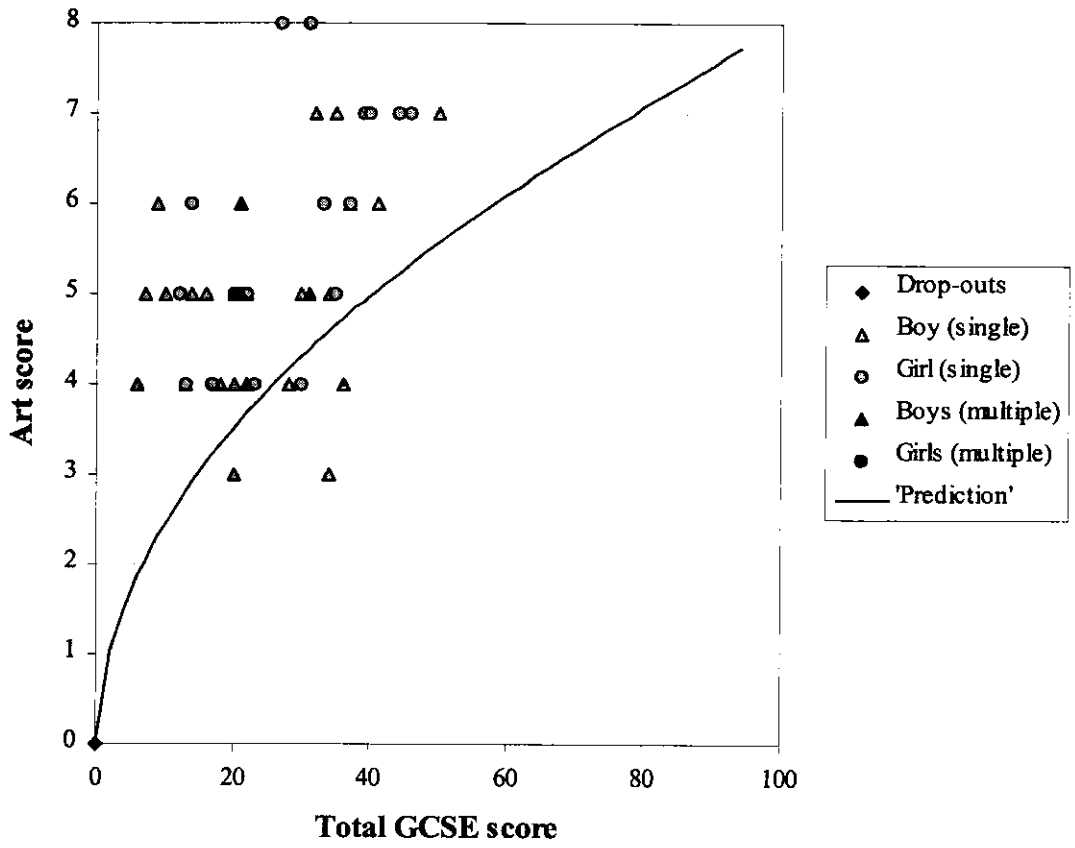
In Figure 8.6 below we see an example of the kind of scatterplot that might be returned to schools using this model of subject performance. In this case, the subject is science, and the plot shows individual performance for boys and girls against the expected results from the nonlinear model. It is clear in this case that the school's science results are good for pupils with higher ability, but less so for those at the bottom end of the total score range.

Figure 8.6: Example of school scatterplot for science using nonlinear prediction



Another example scatterplot is given in Figure 8.7, this time for art. The effect of the nonlinear model is more noticeable here, and it is clear that the school's results for art are generally higher than would be predicted from total GCSE scores.

Figure 8.7: Example of school scatterplot for art using nonlinear prediction



9. EFFECTS OF SCHOOL AVERAGE INTAKE LEVELS

The question has been raised about the possible relationship between pupils' results and the average school intake level, over and above the clear relationship between an individual's prior attainment measure and their GCSE results. There are two possible ways in which results may be related to average school prior attainment, when controlling for individual prior attainment:

- A **positive** relationship between results and average intake measure. This could be interpreted as meaning that pupils in schools with higher-performing intakes do better than might be expected. Another way of looking at this would be as evidence for a 'dragging-up' or 'dragging-down' effect of the peer group for each pupil.

- A **negative** relationship between results and average intake measure, which could be interpreted as implying that pupils in the top ability range for a school do better than expected, while those at the bottom do worse, regardless of the school's own average intake level.

In QUASE, it would seem that we have the data to study this question, but the main problem that remains is the issue of which background variables to control for. Average school intake level is clearly related to a number of other school-level variables which are also included in QUASE. Two models were therefore fitted for each outcome variable:

1. Model with pupil-level variables only (including prior attainment)
2. Model with pupil-level and school context variables.

In each case the school-level average prior attainment measure was computed and included in the model. Four outcome measures were used:

1. Total GCSE score (TOTSCORE)
2. Average GCSE score (AVSCORE)
3. Mathematics score (MATHS)
4. English score (ENG).

Table 9.1 shows the effect sizes estimated from the models for the school-level average prior attainment measure, with pupil-level variables only and with both pupil and school variables included in the model.

Table 9.1: Effect sizes for school-level average prior attainment

Outcome measure	With pupil variables only	With pupil and school variables
TOTSCORE	7.89 *	-4.60 *
AVSCORE	6.18 *	-5.83 *
MATHS	3.67	-9.82 *
ENG	4.42	-6.98 *

(* significant at the 5% level)

These results are intriguing. It seems that with pupil-level variables only taken into account there is a significant positive relationship between GCSE results and average school intake level. In other words, as a parent, it could be sensible to send your child to the school with the highest possible prior attainment scores, in the assumption that their results will be 'dragged up' by their peers.

On the other hand, when we allow for school context (in particular things like percentage free school meals) it appears that the relationship is negative. This could mean that, within a given type of school in a given context, pupils do better than expected if they are higher than the school average in terms of prior attainment.

These results are not as inconsistent as they appear — they refer to subtly but importantly different ways of looking at the data. If, as a parent, you choose a school with the highest possible prior attainment for your child, then the chances are that it will have a different context (free school meals etc.) from schools with lower attainment. The actual mechanisms which operate within schools to make pupils move up or down relative to their peers cannot be determined by statistical modelling, however interesting the results may be.

10. SUMMARY OF RESULTS

In this section of the overview report, we will attempt to summarise the main findings from the secondary analysis of QUASE data collected over the GCSE cohorts 1994 to 1996.

- Although the schools taking part in QUASE are not perfectly representative of the national population of secondary schols, they cover all types, regions and ability ranges. The findings from QUASE analysis will not be compromised because only a limited set of schools was included.

- Correlations between prior attainment measures and GCSE results range up to about 0.7 for the best tests. This implies that about 50 per cent of the variation between individual pupils in their GCSE results can be attributed to existing differences in attainment on entry to secondary school.

- Multilevel analysis of data from 30,488 pupils with prior attainment in 152 schools and up to three year-groups showed the following relationships between background variables and GCSE performance (all background variables taken into account together):

    - prior attainment is strongly related to GCSE performance;
    - girls outperform boys for five of the outcome measures, while boys do better than girls for mathematics and science;
    - pupils eligible for free school meals do less well than others
    - pupils with special educational needs do less well than others;
    - black pupils under-perform relative to whites for most outcome measures;
    - Asian and other non-white pupils do better than would be predicted relative to whites;
    - performance in 1994 was significantly lower than in 1996;
    - older pupils within the cohort have slightly better results;
    - schools with a higher percentage of pupils eligible for free school meals do significantly less well than expected in terms of GCSE results;
    - about 90 pe cent of the variation between schools and about 40 per cent of the variation between pupils can be explained by fitting background variables.

- There is a significant variation between schools in the relationship between prior attainment and GCSE results. This varies from almost zero to schools almost 50 per cent above the average relationship. Independent schools show a less steep relationship between prior attainment and GCSE performance than other types of school.

- There is a significant variation between schools in the difference in performance between boys and girls. About one-third of schools have no significant difference, while the rest show significant advantages to the females. These differences can go up to over five GCSE points (one grade C) in some schools.

- Results for individual subject areas are more strongly related to total GCSE score (a contemporary measure of attainment) than to prior attainment measures, which may be up to five years previous.

- There is some evidence that studying certain arts-based subjects (art, music or drama) may be positively related to results in other subjects. However, it seems that students who take a high percentage of such arts-based subjects at GCSE perform less well overall.

- Factor analysis of pupil attitude questionnaires allowed a large proportion of the variation in the responses to be explained by four factors. Significant differences between factor scores were found for boys and girls, and for ethnic minorities. The overall average GCSE grade obtained by the school was associated with improved pupil attitudes and lower reported bullying.

- Factor analysis of the parent attitude questionnaire allowed three major factors to be extracted. Again, overall school GCSE performance was positively related to parental approval factors.

- A nonlinear model of the relationship between total GCSE score and individual subject grades has been developed and fitted to different QUASE datasets. This model gives a more realistic portrayal of the relationship, and can be used more effectively to compare individual schools' results with predicted patterns than the previous simple linear model.

- Multilevel modelling including average prior attainment scores at the school level has given some interesting results. Controlling only for pupil-level background variables, there is some evidence that pupils do better in schools with higher overall prior attainment (in other words, they are 'dragged up' or 'dragged down' by their peers). On the other hand, if we also control for other school factors (such as free school meals), it appears that, within a given type of school in a given context, pupils do better than expected if they are higher than the school average in terms of prior attainment.

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QUASE
Overview Report 1997
Analysis of GCSE Cohorts 1994 to 1996

This report gives answers to a lot of questions about performance in secondary schools at the end of Year 11 (age 15-16). These questions include:

- How do attainment tests at the start of secondary school relate to GCSE performance?
- How are contextual factors for both pupils and schools related to GCSE results?
- How do the differences in performance between boys and girls vary from school to school?
- How does the relationship between prior attainment and GCSE results vary from school to school?
- What are the relationships between different subject results and pupil background factors (sex, age, ethnicity), taking into account either prior attainment or overall GCSE performance?
- What are the apparent relationships between GCSE performance and studying arts-related subjects (music, drama or art)?
- How are pupils' and parents' attitudes related to school and pupil background factors?
- What is the best model for predicting individual subject GCSE results from total GCSE score?
- What is the apparent impact of average school GCSE performance on the results of individual students?

Data from over 30,000 pupils with prior attainment measures in 152 schools over three cohorts has been assembled as part of the QUASE (Quantitative Analysis for Self-Evaluation) service to schools. This unique dataset has been thoroughly analysed by sophisticated statistical techniques to provide answers to the above questions.

The QUASE service thus continues to be of value not only to the schools who receive detailed reports on their own performance, but also to all those who are concerned about the factors which appear to influence secondary school performance.

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