CANDIDATES' PERFORMANCE IN PUBLIC EXAMINATIONS IN MATHEMATICS AND SCIENCE

C.T. Fitz-Gibbon and L. Vincent

A report commissioned by SCAA from the
Curriculum, Evaluation and Management Centre
University of Newcastle Upon Tyne

SEPTEMBER 1994

ISBN: 1 85838 060 X

First published 1994

The School Curriculum and Assessment Authority is an exempt charity under the Charities Act 1960.

School Curriculum and Assessment Authority, Newcombe House, 45 Notting Hill Gate, London W11 3JB

Chairman: Sir Ron Dearing CB

Copies of this document may be purchased using the SCAA Publications List and Order form or by contacting: SCAA Publications, PO Box 590, London SE5 7EF, telephone 0171-701 6064. When ordering, please quote title and reference number.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

SCAA is seeking information on factors which may affect students' willingness to study science and mathematics at A level and beyond. This report makes a contribution to debate on this issue by considering whether or not there is a basis for the perception that science and mathematics are "difficult" subjects at A level. The answer appears to be yes, and foreign languages are also difficult.

The term "difficult" cannot be taken as meaning *necessarily* or *intrinsically* difficult. Rather, subjects are said to be either "difficult" or "severely graded" if the grades awarded are generally lower than might have been reasonably expected on the basis of adequate statistics.

Adequate statistics were available from the A level Information System (ALIS). Datasets from the A level examinations taken in the summer of 1993 were used. These datasets also contained each student's 1991 GCSE grades.

Four methods were used to estimate the grades that might have been expected for each student in each subject, if all subjects were of equal difficulty.

1) **GRADE PAIRS (Grades obtained by the same student in a mathematics-science subject and in a non-science subject).** If subjects were of equivalent difficulties these grades could be expected not to differ significantly.

The grades did differ significantly, indicating that Physics, Chemistry, Mathematics and Biology were more difficult than all non-science subjects with the exception of the foreign languages included in the dataset (French, German and Spanish) and General Studies. Physics was approximately a grade more difficult and Chemistry, Mathematics and Biology approximately three-quarters of a grade more difficult according to this method of analysis.

2) **CORRECTION FACTORS.** Instead of taking into account only one other subject, all grades obtained by a student were taken as a guide to the student's academic achievement level. A procedure used by the Scottish Examination Board was applied to estimate "correction factors" for each subject. The correction factor is the proportion of a grade which would need to be added to, or subtracted from, grades in A level subjects in order to equate the subjects for difficulty. (See Figure A, page v.)

As in the Grade Pairs analysis, Physics, Chemistry, Mathematics and Biology (in that order) were shown to be of above average difficulty, along with Foreign Languages and General Studies.

3) **VALUE ADDED with respect to GCSE.** It might be expected that students starting from a similar base of achievement at GCSE would achieve similar A level grades. (See Figures B(i)-(iii), page iv)

The study showed that students taking mathematics and/or science subjects at A level tended to have higher levels of prior achievement as measured by their average grade in GCSE examinations. Their A level grades were also higher, but not by an amount commensurate with the differences in average GCSE scores. In other words, the mathematics-science subjects at A level showed lower "Value Added" indicating either their greater "difficulty" or that they were more "severely graded" at A level.

The Value Added method was also used to look at gender differences. Girls showed lower Value Added in all the mathematics-science subjects, especially Physics. This could be viewed as higher than expected achievement by girls at GCSE or lower than expected at A level. The pattern tends to be common to all schools and colleges.

4) **VALUE ADDED with respect to a reference test.** In the A level Information System (ALIS) students take the International Test of Developed Abilities under standardised conditions. The Value Added against this baseline provided yet another estimate of subject difficulties, with much the same results. Mathematics-science students tended to show higher academic aptitudes on this test, both on the mathematical component and also on the verbal component, than did students choosing other A levels.

DISCUSSION. The subject difficulties found here are typical of many examination systems and might arise simply because of the tendency for more able students to choose science, mathematics and foreign languages. Standards of difficulty cannot be equated without either an explicit strategy for taking account of the prior achievement levels or a post hoc adjustment of grades using the "Correction factors" approach pioneered in Scotland (Method 2 above).

The differences in subject difficulties ranged from about a third of a grade up to a grade and a quarter. These represented average differences found among *individuals.* If the grades are added across an A level group in a school or college the net effect could be substantial. In particular, the publication of School Performance Tables in which there is no differentiation by subject type (e.g. arts, mixed, or sciences) could encourage schools to suggest to students that they avoid the difficult subjects. The extent to which this occurs is not known. There are, however, very large differences between particular schools and colleges in the proportions of students attracted into the mathematics-science subjects.

Further debate on candidates' performance in mathematics and science might consider

- Leaving the situation as it is but making information about subject difficulties more widely available
- Making grading standards for A level subjects more equivalent in difficulty
- Making more substantial changes through syllabus revisions and/or broadening A levels

Research is needed in a number of areas, particularly case studies of institutions which attract disproportionately large numbers of science and mathematics students into A level sciences, and studies of the long term impact of subject choices made at A levels. As more A levels adopt a modular structure the effects on subject difficulties should be monitored. The effects of having the candidate's name and school on the examination paper during the marking process needs consideration. The uses made of GCSE and A level grades by admissions officers, employers, careers personnel and others needs investigation along with the impact of the School Performance Tables.

Fitz-Gibbon & Vincent, 1994.
CEM Centre, ALIS project
University of Newcastle Upon Tyne
NE1 7RU

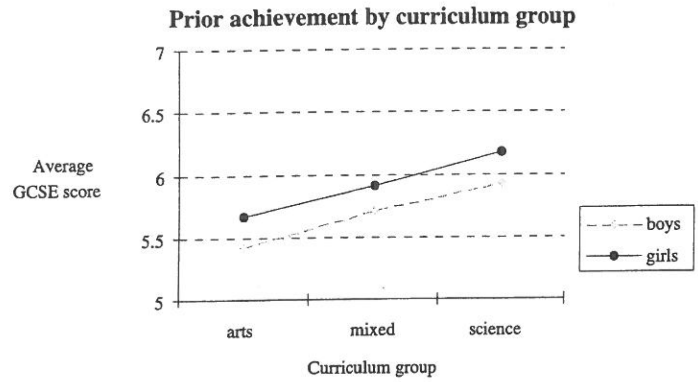


Figure B(i)

Among both boys and girls, those who had attained a higher average GCSE score tended to opt for science subjects*. Girls had higher levels of prior achievement (GCSE scores) but were less likely than boys of the same academic ability to opt for sciences.

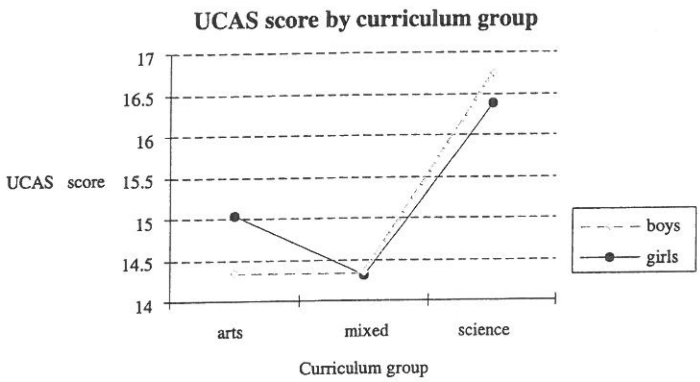


Figure B(ii)

The University Central Admissions System (UCAS) uses a scale of 10 points for an "A" grade, 8 points for a "B" etc. The "UCAS" score is the total points based on grades in the subjects taken at A level. The graph is based on students who took exactly three A levels. The higher UCAS scores were obtained by students taking mathematics-science A levels. Were these as high as should be expected considering the higher ability of the intake? That question is answered by the Value Added graph (Figure B(iii)) which records the relative progress made. Zero represents average progress for the whole sample.

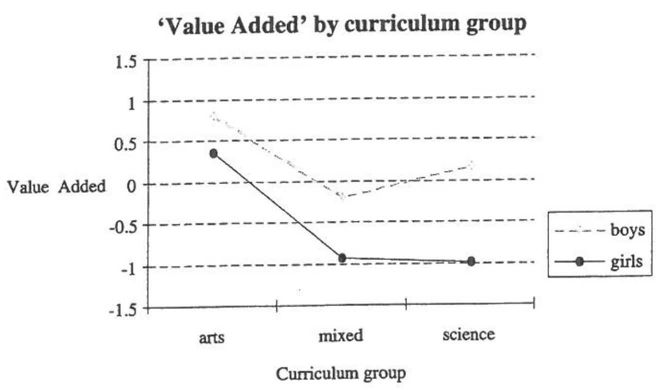


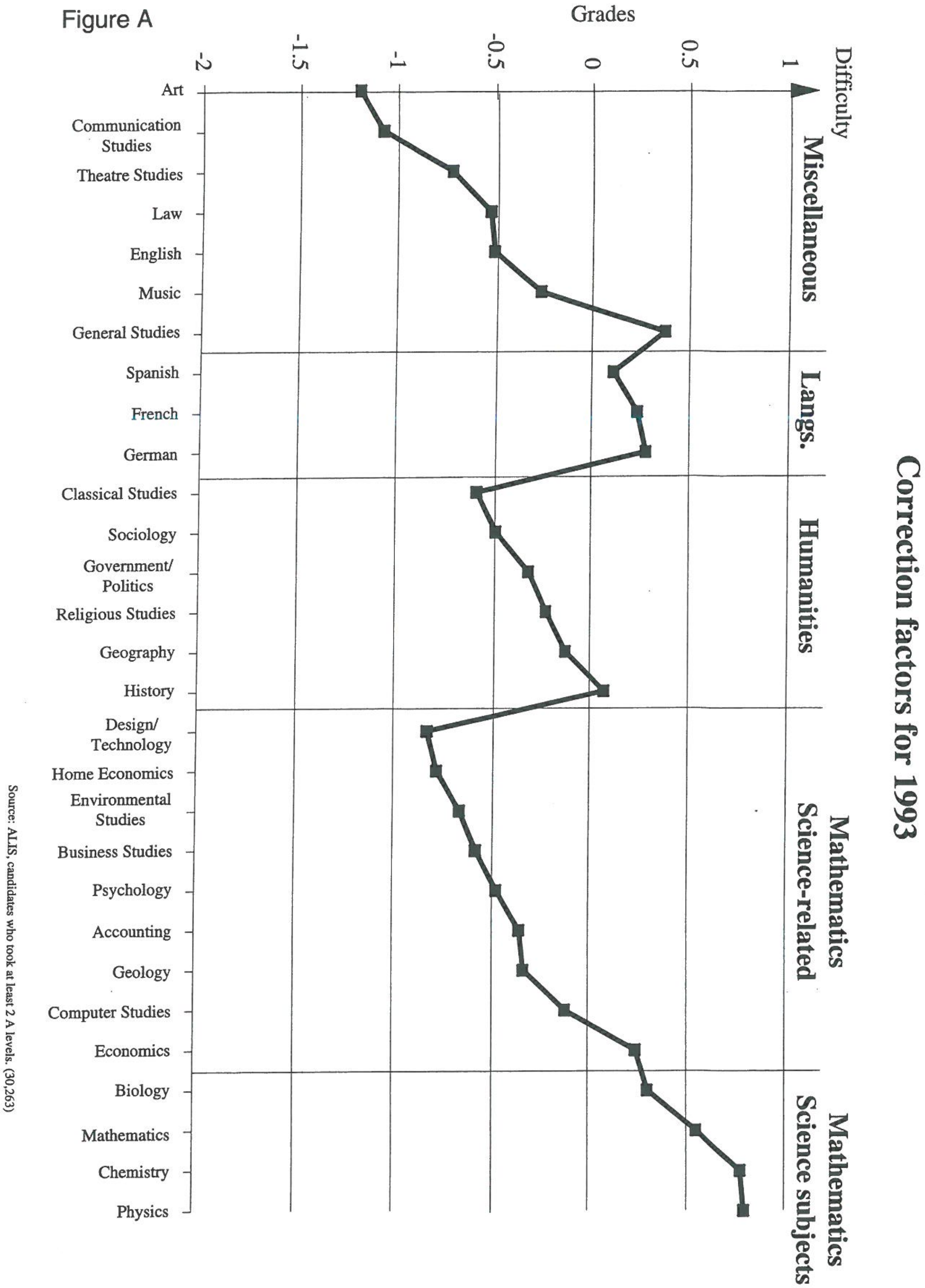
Figure B(iii)

The Value Added scores show that

- Boys made greater progress than girls.
- Maximum Value Added scores were obtained in the arts subjects.

*Mathematics, Physics, Chemistry and Biology were identified as the main science subjects. Environmental Studies, Geology and Psychology were specified as counting as science A levels *if taken in conjunction with the main science subjects*. These combinations defined the "Science" curriculum group. Other combinations that contained at least one of the four main science subjects were classified as "Mixed" and other combinations were labelled "Arts".

Figure A


Correction factors for 1993
Grades
Difficulty
-2
-1.5
-1
-0.5
0
0.5
1
Miscellaneous
Langs.
Humanities
Mathematics Science-related
Mathematics Science subjects
Art
Communication Studies
Theatre Studies
Law
English
Music
General Studies
Spanish
French
German
Classical Studies
Sociology
Government/ Politics
Religious Studies
Geography
History
Design/ Technology
Home Economics
Environmental Studies
Business Studies
Psychology
Accounting
Geology
Computer Studies
Economics
Biology
Mathematics
Chemistry
Physics
Source: ALIS, candidates who took at least 2 A levels. (30,263)

1. INTRODUCTION

1.1 Is there a basis for the perception that science and mathematics are "difficult" subjects at A Level? If so, then to what extent are they difficult, are they all equally difficult and are there any other subjects that are as difficult?

1.2 Answers to these questions may be important in seeking explanations for the lack of growth in post-16 enrolments in mathematics-science subjects. It may also be important to consider the issue of subject difficulties in relation to the use of School Performance Tables. There has been little public documentation or acknowledgement of differences in difficulty and little in the way of guidance provided for employers, admissions officers or other members of the public who may make decisions on the basis of examination results. Furthermore, the work of teachers may be unfairly appraised if there are differences in the difficulties of subjects.

1.3 In this report we consider first the terminology needed to discuss the evidence (Section 2) and four methods of measuring subject difficulties (Section 3). The dataset available from the A level examinations taken in the summer of 1993 is then described (Section 4) and the four methods of analysis are applied to this data (Section 5). A summary of the quantitative findings is provided in Section 6. The report concludes with a discussion of the results and of the need for further studies (Sections 7 and 8). Tables and figures are at the end of Section 8, following the references.

1.4 In addition to this main report there is an **Executive Summary**.

2. TERMINOLOGY

2.1 Four terms used in this report require some explanation. The terms are "difficulty", "aptitude", "Value Added", and "curriculum group".

Levels of Difficulty

2.2 What does it mean to say that a subject is difficult or easy? Can we compare English with Mathematics at A Level? We *can* in terms of the grades achieved because grades are to some extent regarded as common currency. University places are often offered initially on the basis of points achieved at A Level. Employers may look at grades, considering each A Level subject to be of equivalent difficulty. Indicators of performance are frequently based on grades without any distinction being drawn between one subject and another. Whether or not it makes sense to compare grades across subjects, it is common practice to do so.

2.3 If pupils of the same prior achievement consistently score lower on one subject at A Level than on another subject this suggests that there is a difference in "difficulty" or in the "severity" of the marking. But we must be sure to compare equivalent groups of students. Students must be equivalent in terms of characteristics which relate to their performance at A Level. The single best available predictor of A Level performance is the average GCSE score. This is an excellent measure of general academic aptitude and achievement. It represents many hours of testing and the effects of many different teachers. Tests are taken on different days so that the problems inherent in single sittings are avoided. There is a broad range of subjects tested, covering both the quantitative and verbal aptitudes which are used in most A Level subjects. There is a variety of assessment practices, including coursework. It is a basic measurement principle that, as a general rule, the longer the test the more reliable the outcome measure. The average GCSE score achieved by a student represents, essentially, a measure derived from a long series of tests.

2.4 In short the term "difficult" applied to a subject is equivalent to the term "severely graded". Conversely an "easy" subject could equally well be called a "leniently graded" subject. For simplicity we will simply use the term "difficulty".

Abilities or Aptitudes

2.5 The term "aptitude" is used here simply as the statistical representation of the observation that students who do well on one cognitive measure tend to do well on others. The terms *aptitude* or *ability* are used here primarily in contradistinction to *achievement*. Achievement is measured by examinations related to the curriculum taught and might be attributable to the student's efforts, the school's teaching and other factors additional to the effect of the student's developed aptitudes.

2.6 Tests of developed aptitudes (tests not directly related to what has been taught in school) provide an alternative way of comparing students. This we can do in this study by use of the International Test of Developed Abilities (ITDA). This test consists of a measure of acquired mathematical abilities and a verbal scale based on reading passages and answering comprehension items about the passages. Both because of their general content and the fact that the tests are timed so that most students do not complete them, the tests measure aptitudes rather than achievement. The ITDA was developed at the Educational Testing Service, Princeton, New Jersey as a measure suitable for college-entrants around the world (Ottobre and Turnbull, 1987). It was chosen for the ALIS project in 1988 after two other tests (the AH6 and Raven's Advanced Progressive Matrices) had been tried in previous years and found wanting. Combined with a specially written vocabulary test, in which a synonym has to be picked from among various possibilities, the ITDA has been found to give reasonable predictions for both arts and science A levels (correlations ranging from about 0.2 to 0.5 depending upon the subject). As a measure of "developed ability", not taking into account the perseverance, memory and knowledge required for examination performance, correlations are not expected to be as high as those with prior achievement (which typically range from 0.5 to 0.7).

Value Added

2.7 The progress made by some students is greater than that made by others. The difference is called "Value Added". A positive Value Added represents greater than average progress (or an easy subject or lenient grading) and a negative Value Added implies less progress (or a difficult subject, or severe grading).

Curriculum Group: "Arts" "Mixed" or "Science"

2.8 For the purposes of this study the School Curriculum and Assessment Authority (SCAA) designated Mathematics, Physics, Chemistry and Biology as subjects of prime concern, the "target subjects". Three other subjects were specified as counting as science A levels *if taken in conjunction with mathematics-science subjects.* These were Environmental Studies, Geology and Psychology. These combinations defined the "Science" curriculum group. Other combinations that contained at least one of the target subjects were classified as "Mixed" and other combinations were labelled "Arts".

3. FOUR METHODS OF COMPARING DIFFICULTIES

3.1 Quantitative measures of subject difficulties can readily be developed if the relevant data is available. In this report we draw on data from the A level Information System (ALIS) run by the Curriculum, Evaluation and Management Centre (CEM Centre) at the University of Newcastle upon Tyne. Examination data is matched, on a student-by-student basis, with data from specially administered aptitude tests and questionnaires. The tests and questionnaires are completed by students under carefully controlled conditions. Trained data collectors are generally used along with an audio tape. The tape ensures that students hear the same explanations, using the same words, at the same speed, in the same tone of voice, in every institution. Data entry is undertaken by the University's Data Entry Service and data analysis is undertaken in the CEM Centre. Schools and colleges receive detailed feedback, including measures of student progress ("Value Added"). The ALIS project has been running since 1983.

The four methods of analysis to be applied to the data are briefly described below.

3.2 **GRADE PAIRS (Simple comparisons).** If a candidate has taken both a mathematics-science subject and a non-science subject a direct comparison can be made of the grades the same candidate obtained in each subject.

3.3 **CORRECTION FACTORS (Full data comparisons).** Using all the grades obtained in all subjects by all candidates, the extent to which some subjects were more difficult than others can be calculated as a "Correction Factor", a procedure developed in Scotland. (Please see Section 5 below).

3.4 **VALUE ADDED with respect to GCSE (i.e. prior achievement).** A level grades can be compared with the grades obtained by students at GCSE. If there was a general tendency for students with the same GCSE performance to get lower grades in mathematics-science subjects than in other subjects, then this would suggest that mathematics-science subjects were more difficult at A level.

3.5 **VALUE ADDED with respect to a "Reference Test".** If there was a general tendency for students with the same scores on tests of aptitudes (such as comprehension, vocabulary and numeracy) to get lower grades in mathematics-science subjects than in other subjects, then this would suggest that mathematics-science subjects were more difficult.

3.6 Each method of assessing difficulties has its strengths and weaknesses. If the results from all methods point in the same direction then there is considerable confidence in the findings. Each method demands different data and different samples and it would not be valid to expect that the numerical indicators from each method would be the same. Different statistical questions will produce precise and different numerical answers. However, the general trends and orders of magnitude should be consistent.

3.7 The methods are described in greater detail in the FINDINGS section. First we must consider the extent to which the data available can be seen as nationally representative to a degree that justifies confidence in the analyses.

4. THE REPRESENTATIVENESS OF THE SAMPLE

4.1 Examination data from the summer of 1993 held by the *A level Information System* (ALIS) was used for the analyses. The size of the sample was substantial. In the major Correction Factors analysis, the average number of entries per subject was 2,800. The smallest number in any one subject was 242 in Environmental Studies and the subject with the largest number of entries was English with 10,782 candidates (Table 1).

4.2 The following major subjects were included:

Accounting	Art	Biology
Business Studies	Chemistry	Classical Studies
Communication Studies	Computer Studies	Design & Technology
Economics	English	French

Environmental Studies	General Studies	Geography
Geology	German	Government/Politics
History	Home Economics	Law
Mathematics	Music	Physics
Psychology	Religious Studies	Sociology
Spanish	Theatre Studies	

The remaining paragraphs in this section consider the extent to which this dataset was representative of types of institution, Examination Boards, the pattern of subject entries and the grades awarded.

Representativeness by type of institution

4.3 Since participation in the ALIS project is voluntary it might be thought that only certain types of schools and colleges would choose to participate and that the data would not be nationally representative. An analysis of data from two datasets (Figure 1) indicated that variations in the type of institution are not a major issue. Furthermore, there is strong evidence from previous years that the Value Added does not vary substantially between types of institution (Tymms, 1992; Audit Commission, 1993).

Representativeness by Board

4.4 The distribution of the ALIS data by Examination Board (Table 2) shows that all Boards are represented although entries from the Welsh and Northern Ireland Boards were below 1,000. However, any under-representation would only be serious if the difficulties of subjects differed substantially between Boards. There is considerable evidence that Boards generally maintain similar standards *within each subject* (Tymms and Fitz-Gibbon, 1990; Fitz-Gibbon, Tymms and Vincent, 1994; Tymms and Vincent, 1994). Minor differences in standards are unlikely to be sufficiently large as to alter the patterns of difficulty seen in samples as diverse as those used here.

Representativeness by the patterns of subject entries

4.5 The proportions entering each subject were compared with the national proportions. The match with national data was very acceptable, being within a percentage point or two except where there were differences in the subject classifications used by SCAA and ALIS (Figure 2).

Representativeness by grades awarded

4.6 A comparison of ALIS and national data showed that there was a slight under-representation of "A" grades in ALIS but the percentage achieving each grade was generally very close (Table 3).

4.7 In summary the ALIS data for 1993 seemed an adequate basis from which to investigate subject difficulties.

5. FINDINGS

5.1 In this section each method is described in more detail than previously and then the findings from the method are discussed.

GRADE PAIRS (Simple comparisons)

5.2 In this method the grade obtained by the student in one subject is compared with the grade the same student actually obtained in another subject taken at A Level. If the student received a B in English and a D in Mathematics this would suggest that mathematics was more severely graded than English since the same student obtained a lower grade. Of course in the case of one student the difference could be explained away. If the difference was indicative of a pattern across all students, however, it would suggest a difference in the difficulty of the subjects.

5.3 This approach is similar to the "Subject Pairs" analyses used by the Examination Boards and it suffers from the same major problem: the students who chose to do both Mathematics and English, for example, may not be representative of students taking English nor of students taking Mathematics. To use simple comparisons may be to base inferences on subsets of rather unusual students, those who chose to bridge the arts-science divide. It must be noted however, that there has been considerable growth in enrolments for "mixed A Levels" combining both arts and science subjects and that as a consequence the comparisons become more valid with greater numbers and greater representativeness.

5.4 The main advantage of this method is that it is straightforward, clear and readily understood.

5.5 Results of the analysis show that the grades did differ significantly, indicating that Physics, Chemistry, Mathematics and Biology were more difficult than all non-science subjects with the exception of the foreign languages included in the dataset (French, German and Spanish) and General Studies. Physics was approximately a grade more difficult and Chemistry, Mathematics and Biology approximately three-quarters of a grade more difficult according to this method of analysis (Tables 4a to 4d).

CORRECTION FACTORS (Full data comparisons)

5.6 In the Correction Factors approach the grades obtained in each subject are considered against the grades obtained in all the other subjects for each candidate. That is, a full matrix of candidates and subjects is analysed. The average grade obtained by a student is taken as being indicative of that student's general level of achievement at A Level. The procedure yields a set of Correction Factors (Kelly, 1976) showing the amount by which grades in a subject should be increased or decreased in order to bring the subject into line with the difficulties of all other subjects in the analysis. Thus a Correction Factor of 0.5 implies that half a grade should be added to the obtained grade to bring the subject into line with the average difficulty of other subjects. A Correction Factor of -1 would imply that a grade should be taken off the obtained grade.

5.7 The results from the analysis show that Art, Communication Studies, Design and Technology, Home Economics and Theatre Studies were the easier subjects and Physics, Chemistry, Mathematics and Biology appeared as the most difficult subjects, along with foreign languages and General Studies (Figure 3 and Table 1).

5.8 The sample was divided into three achievement groups (based on students' average GCSE scores). For students with the lowest prior achievement, the subjects that were most difficult were mathematics-science subjects, French, German and General Studies. For the most able, only Physics, Chemistry and Mathematics stood out as relatively difficult subjects. Thus there appeared to be slight differences in difficulties associated with the student's general level of achievement as well as differences from subject to subject (Figure 3 and Table 1).

VALUE ADDED with respect to GCSE (i.e. prior achievement)

5.9 Prior achievement is the best single predictor of subsequent achievement. An instance of this general rule is that GCSE results are the best predictors of achievements at A Level. Using data on many thousands of students and knowing for each student the average grade he or she obtained on the GCSE examinations we can predict the grade likely to have been obtained in each of the A Level subjects.

5.10 An analysis of the performance of 16,351 students, each taking three A levels showed, for both male and female students taking Arts subjects, greater Value Added than for those in mixed or science A level curriculum groups. For girls in both mixed and science groups, the Value Added was almost 1.5 grades less than for girls in arts subjects. For boys the comparable difference averaged to about 1 grade. These represented grade differences added across *three* A levels. (Figures 4a to 4c)

5.11 Analyses of the individual A level subjects showed that gender differences in the Value Added measures were less than half a grade in Biology, Mathematics and Chemistry but approached three quarters of a grade in Physics.

VALUE ADDED with respect to a "Reference Test"

5.12 The first three methods relied on measures of a student's *achievement* to indicate what might be expected in a given subject. An alternative approach is to use a test of *developed ability*. Candidates of similar ability should achieve similar standards at A Level, on average, if subjects were of equivalent difficulty. In the A Level Information System, at the discretion of the school or college, students may take the International Test of Developed Abilities (ITDA). The nature of the test was described in section 2.6.

5.13 The average Value Added scores *taking account of the students' ITDA scores* were analysed for the three curriculum groups: arts, mixed and science (Figure 5). The analysis shows that the average Value Added for arts subjects was higher than for mixed subjects and science subjects. However, for all three curriculum groups the girls had higher residuals than the boys. This strengthens the suggestion that girls' "under achievement" at A level may be viewed as "over achievement" at GCSE. Against this reference test, girls had made as much or more progress than boys. This finding needs further investigation. In 1993, the ITDA was taken by students in the *second* year of two year A level courses whereas now schools and colleges are being encouraged to administer the test to students on entry to the courses. It will be important to check 1994 data to see if the pattern found here is repeated and whether or not it varies with the timing of the test.

6. SUMMARY OF FINDINGS

6.1 The four methods outlined above are all valid approaches to studying difficulties of A Level subjects. Since the results from all the analyses based on prior or concurrent achievement pointed in the same direction there can be considerable confidence in stating that mathematics-science difficulties are high in comparison with measures of students' academic achievement in other subjects. The evidence strongly suggests that, in 1993, Physics was the most difficult A level followed by Chemistry, Mathematics and Biology. Foreign Languages and General Studies were similarly difficult. The picture is slightly complicated when results are considered in terms of a reference test, the ITDA. Whether the time of administration of the test affects the outcomes needs investigation.

6.2 The data showed that students opting for A levels in mathematics or science subjects tended to be of higher academic aptitude or achievement than those opting for arts subjects at A level. The total points scored at A levels were subsequently higher in mathematics and science but not to the extent that would be expected from the differences in intake. Thus the Value Added scores, measuring progress made, were lower both for students taking mixed A levels and for those taking mathematics-science subjects only. For 1993 A level data, the apparent "cost" of including a science subject at A level, in terms of total points scored across three subjects, was about 1.5 grades for girls (or 3 points on the UCAS scale in which each grade is 2 points) and about 1 grade for boys (or 2 points on the UCAS scale).

6.3 Among the four target subjects the differences in subject difficulties ranged from about a third of a grade up to a grade and a quarter. Physics and Chemistry were the most difficult, Mathematics somewhat difficult and Biology very slightly difficult. Girls showed lower Value Added measures than boys, i.e., they appeared to make less progress between GCSE and A level. This was particularly true in Physics. The differences observed in the 1993 dataset paralleled those found in 1989 (Fitz-Gibbon, 1991).

6.4 Foreign Languages and General Studies were also found to be as difficult as Biology and Mathematics.

6.5 Mathematics results from modular courses showed higher grades than those from non-modular courses (Table 5). This fact may account to some extent for the apparent decrease in the relative difficulty of mathematics in 1993 compared with that found in earlier ALIS samples. The differences in grade distributions were particularly discrepant at the levels of "N" and "U" grades due, no doubt, to the choices available to students as to whether or not to "cash in" or "re-sit" modules. Thus instead of a 22 per cent failure rate this was recorded as barely more than 4 per cent. The records do not show, however, how many left the courses.

7. DISCUSSION

7.1 In the first part of this discussion section an attempt is made to suggest what seems to the authors to be the simplest explanation for the differences found and to consider some other reasons which have been postulated. The final section considers possible ways forward.

What might be the explanations for differential difficulties?

7.2 How is it that science, mathematics and foreign language examinations are found to be more "difficult"? It must be noted that the general patterns of differences are so commonly found as to require a broadly applicable explanation. The patterns have been observed in age-16 examinations as well as A levels, in every Examination Board in England and Wales and also in Scotland.

7.3 How does this consistent difficulty differential occur? One possible explanation is that the difficult subjects are those that have always attracted the more able students. Wherever an element of choice arises in the curriculum, larger proportions opt for mathematics and science courses from among the more academically able than from among the less academically able. The result is that different subjects have different intakes with respect to academic aptitudes.

7.4 This difference in intakes means that examiners working in a single subject area become used to assessing quite different ranges of abilities. Between the years 1963 and 1987 there was a recommended distribution for A level grades (e.g. 10 per cent were expected to get As, 15 per cent were to get Bs, etc. The modal result was a fail, with 30 per cent being the usual figure). The routine application of this distribution in each subject would immediately make the mathematics-science areas more severely graded (more difficult). Failing the bottom 30 per cent of a very able group produces a different standard of difficulty from failing the bottom 30 per cent of a less able group.

7.5 Whether we need to look any further than this simple explanation for the reason why the differential difficulties have arisen is not clear.

7.6 The mathematics-science students are not simply better at mathematics and science but also, on average, on verbal tests and in non-science subjects. Differences between students who passed mathematics and English A levels on several tests of aptitude have been reported elsewhere (Fitz-Gibbon 1992) and the pattern is probably international. For example, a report from the Educational Testing Service in the US noted:

".....examinees planning to major in maths, science, or engineering obtained a mean Verbal score 18 points higher than the population average and a mean Mathematics score 31 points higher. Means for specific fields varied considerably. Examinees planning to major in physics, for example, obtained a mean Mathematics score 145 points above average, while those planning to major in sociology obtained a mean 44 points below the population average." Grandy, 1989. p. 1.

7.7 It is sometimes suggested that the teaching is less effective in the difficult subjects. It seems more likely that it is as variable as in other subjects and, given the lack of evidence, the suggestion would seem to be an ill-advised criticism of a highly valued and diverse set of teachers in the mathematics-science areas. Furthermore, in international comparisons science and mathematics achievement at A level was ahead of most countries in the study (including Japan, USA, Australia, Korea and Canada) and second only to Hong Kong, which inherited the UK examination system (Smithers and Robinson, 1991, Postlethwaite and Wiley, 1991). Teaching at A level seems of high quality by this yardstick. However, if it were found that effective mathematics-science teachers were being lost from teaching — either to administration or other employment — it might be necessary to consider the remuneration they receive, particularly in later years. A report from the Institute of Physics showed a severe decrement in earning power in the later years of physicists' careers if they had stayed in teaching (Institute of Physics, 1990).

7.8 It is sometimes suggested that, perhaps due to teacher shortage, the mathematics-science subjects are taught by people with lower qualifications than those teaching in the Arts subjects. For example, mathematics-science teachers may have lower class degrees. There is a problem here in that degree classifications cannot be considered to be standardised across subjects in universities, nor across universities. (Coleman, 1994, showed large differences in standards of French competencies from different universities and comparability of standards in universities is certainly in need of more research before degree classes can be interpreted with any confidence.) Instead of considering degree class, we could simply look at the extent at which classrooms are staffed by people with a qualification beyond A level. The 1992 Secondary Staffing Survey found that only 4 per cent of Physics tuition was provided by a teacher without a qualification above A level in the subject. For all secondary subjects, 19 per cent of the tuition was from teachers without a qualification in the subject. Lack of qualifications among teachers does not seem likely to provide a sufficient explanation of the lower levels of grades awarded to students taking mathematics-science and foreign language subjects.

7.9 However, the ALIS datasets show that some schools and colleges are attracting far greater proportions of post-16 students into mathematics-science areas than are others. The extent to which these differences in 'pulling power' are related to various factors needs investigation. Factors to consider would include the nature of the teaching and learning processes employed, the teachers' degree class or levels of qualifications, the affective influences on students, the effectiveness of the teaching as indicated by high Value Added scores and more distant possible influences such as the employment patterns around the schools.

7.10 There would seem to be an urgent need to develop some in-depth case studies of institutions which have maintained, over several years, their 'pulling power' for the mathematics-science area. The same applies if there is national concern about foreign languages since institutions differ considerably in the extent to which students are attracted into foreign language study.

7.11 Although the differences in difficulties were not large for individuals, every grade counts in the eyes of the school in view of the School Performance Tables. There may be an incentive for schools to discourage students from opting for science A levels since the School Performance Tables do not differentiate between subjects.

7.12 In short, it seems clear that the perception of mathematics-science subjects as difficult is justified. The reasons for this may be diverse, but are most simply explained in terms of the widespread tendency for more able students to opt for mathematics and science subjects or foreign languages. The policy responses will, of course, need careful consideration.

8. TOPICS IN NEED OF FURTHER RESEARCH

8.1 In this brief, two month project, the questions asked have been answered but many questions remain. Research is needed in a number of areas, in particular relating to the following topics:

- (1) **Reasons for the differences in "yield" between institutions** (Using the term "yield" as the per cent of the cohort becoming qualified in mathematics-science cf. Howson, 1987) Can we find in the ALIS data (which goes back over 10 years) schools and colleges with *consistently* high yields of mathematicians-scientists? If so, why is this? How are such institutions different from other schools and colleges? Are the differences of a magnitude which, if copied, would eliminate expected shortfalls in scientists and technicians? Can the lessons learned from these institutions be transferred to other institutions? What other initiatives might be successful in increasing enrolments in mathematics-science subjects? [This study would represent a major effort and would fit in with current interests in the Department of Trade and Industry and the Department for Education (see Tarsh, 1994).] Similarly, are there Foreign Language departments which, over the years, have been consistently successful in attracting students into these difficult subjects?

- (2) **The extent to which schools do or do not guide student choices according to the likely impact of these choices on School Performance Tables**, (i.e. the extent to which curriculum balance in schools is affected by public interpretation and use of School Performance Tables).

- (3) **Long term effects of curriculum groups.** The use of longitudinal data to investigate the careers followed by students taking, and not taking, mathematics-science A levels.

- (4) **The difficulties of subjects taken at *AS level.*** Are AS levels equivalent in difficulty to the full A level in the subject? Do they show the same patterns of difficulty as are evident in A levels? What is the relationship of AS choices to curriculum groups (e.g. are they used for broadening across curriculum groups or for taking A level in stages within a curriculum group?)

- (5) **Changes over time.** To what extent do the 1994 results reflect the 1993 results in terms of difficulty levels and how have difficulties changed over time with respect to the International Test of Developed Abilities? As General National Vocational Qualifications (GNVQs) are offered in more institutions as an alternative to A levels, will enrolments on some A levels decline?

- (6) **Modular courses.** How are modular courses affecting attempts to estimate Value Added and how are they affecting subject difficulties?

- (7) **The likely impacts of adjustments to the examining system.** Some models could be developed of the likely changes in enrolment patterns if various adjustments were made to the system. Whilst these could be quantitative as well as descriptive, they would necessarily be speculative, but might inform policy discussions.

  Three possible levels of adjustment to the system could be considered:

  - Leaving the situation as it is but making information about subject difficulties more widely available.

  - Making grading standards for A level subjects more equivalent in difficulty.

  - Making more substantial changes through syllabus revisions and/or broadening A levels.

- (8) **The uses made of A level and GCSE grades by admissions officers, employers, careers personnel and others.** What is their level of knowledge of subject difficulties? What weight is given to grades achieved and to the types of subjects taken? To what extent do they use initial filtering procedures for applicants and the criteria employed when such filtering takes place (e.g. UCAS points).

- (9) **Removing candidates' names and schools from examination scripts.** From a candidate's name and school the gender, ethnicity, social class and religion are frequently obvious. Would removal of such information from examination scripts affect the grades awarded?

REFERENCES

Audit Commission and HMI (1993) Unfinished Business. Full-time Educational Courses for 16-19 Year Olds. London: HMSO.

Coleman, J.A. (1994) Degrees of proficiency: assessing the progress and achievement of university language learners. French Studies Bulletin. Spring, 50 pp 11-16.

Fitz-Gibbon, C.T. (1991) *Evaluation of School Performance in Public Examinations: A report for the Scottish Office Education Department.* Newcastle upon Tyne: CEM Centre, Department of Education.

Fitz-Gibbon, C.T. (1992) School Effects at A level: genesis of an information system? In Reynolds, D. and Cuttance, P. (Eds) *School Effectiveness, Research, Policy and Practice,* London: Cassell, pp 96-120.

Fitz-Gibbon, C.T., Tymms, P.B. and Vincent, L. (1994) *Comparing Examination Boards and Syllabuses at A level: students grades, attitudes and perceptions of classroom processes. Executive Summary:* Newcastle upon Tyne: CEM Centre, Department of Education.

Grandy, J. (1989) *Trends in SAT scores and other characteristics of examinees planning to major in mathematics, science, or engineering.* Princeton, NJ: Educational Testing Service.

Howson, G. (1987) *Challenge and Change.* Inaugural lecture given at the University of Southampton, January 1987. Faculty of Mathematical Studies.

Institute of Physics (1990) *Statistics relating to Education and Physics,* London: Education Department, Institute of Physics.

Kelly, A. (1976) A study of the comparability of external examinations in different subjects. *Research in Education,* 16, pp 50-63.

Ottobre, F.M. and W.W. Turnbull (1987): *The International Test of Developed Abilities: A report on the feasibility study.* Report for the International Association for Educational Assessment, Princeton, New Jersey 08541 .

Postlethwaite, D.N and Wiley, D.E. (1991) *Science Achievement in Twenty Three Countries,* Oxford: Pergammon.

Smithers, A. and Robinson, P. (1991) *Beyond Compulsory Schooling: a numerical picture.* London: The Council for Industry and Higher Education.

Tarsh, J. (1984) *Science and Maths. A consultation paper on the supply and demand of newly qualified young people.* London: Department for Education.

Tymms, P.B. and C.T. Fitz-Gibbon. (1990) A comparison of exam boards: "A" levels. *Oxford Review of Education,* 17 (1): 17-32.

Tymms, P.B. (1992) The Relative Success of Post 16 Institutions in England (Including "Assisted Places Schools"). *British Educational Research Journal,* 18 (2): 175-192.

Tymms, P.B. and Vincent, L. (1994) *Comparing Examination Boards and Syllabuses at A level: students grades, attitudes and perceptions of classroom processes. Technical Report for the Standing Research Advisory Committee of the GCE Boards.* The CEM Centre, the University of Newcastle upon Tyne.

TABLES and FIGURES

Correction factors for 1993, overall and by prior achievement with percentages in each band

Prior achievement	Overall 30,263 Candidates		AVGCSE ≤ 5.2 30.1% of Candidates		5.2 < AVGCSE ≤ 6.1 38.7% of Candidates		6.1 < AVGCSE 31.2% of Candidates	
Subject	n	Correction factor	%	Correction factor	%	Correction factor	%	Correction factor
Art	3,114	-1.19	37.0	-1.49	41.2	-1.15	21.9	-0.65
Communication Studies	790	-1.07	49.6	-0.87	38.2	-1.20	12.2	-1.09
Theatre Studies	1,020	-0.72	38.3	-0.65	40.2	-0.77	21.5	-0.64
Law	678	-0.53	50.0	-0.44	38.5	-0.47	11.5	-0.50
English	10,865	-0.51	30.4	-0.41	40.7	-0.56	28.9	-0.48
Music	580	-0.27	21.0	-0.31	40.0	-0.40	39.0	-0.15
General Studies	6,309	0.38	26.6	0.53	37.5	0.41	36.0	0.20
Spanish	573	0.11	15.0	-0.06	40.1	0.09	44.9	0.14
French	3,766	0.23	11.3	0.38	36.6	0.35	52.0	0.04
German	1,500	0.28	11.7	0.38	35.5	0.33	52.9	0.14
Classical Studies	555	-0.58	37.8	-0.35	37.5	-0.68	24.7	-0.67
Sociology	3,607	-0.49	45.5	-0.19	39.5	-0.63	15.0	-0.67
Government / Politics	1,436	-0.32	34.7	-0.30	39.5	-0.31	25.8	-0.24
Religious Studies	1,008	-0.23	36.8	0.08	42.6	-0.32	20.6	-0.43
Geography	5,728	-0.12	30.5	0.21	42.9	-0.14	26.6	-0.42
History	5,839	0.07	26.3	0.22	40.8	0.10	32.9	-0.06
Design / Technology	1,348	-0.82	44.4	-0.80	39.7	-0.85	15.9	-0.65
Home Economics	463	-0.78	49.5	-0.37	41.9	-1.04	8.6	-1.02
Environmental Studies	244	-0.66	47.5	-0.48	38.1	-0.78	14.3	-0.50
Business Studies	3,353	-0.58	45.7	-0.44	39.9	-0.58	14.3	-0.60
Psychology	1,687	-0.47	43.3	-0.27	41.0	-0.48	15.8	-0.66
Accounting	390	-0.35	49.0	-0.16	36.9	-0.40	14.1	-0.37
Geology	479	-0.33	34.9	-0.12	42.2	-0.29	23.0	-0.56
Computer Studies	1,476	-0.12	43.4	0.02	40.3	-0.06	16.3	-0.27
Economics	4,343	0.24	28.7	0.55	39.8	0.23	31.5	-0.01
Biology	5,931	0.30	23.3	0.55	40.3	0.42	36.4	-0.02
Mathematics	8,336	0.55	15.9	0.74	35.6	0.65	48.5	0.32
Chemistry	5,226	0.78	16.2	0.90	33.5	0.95	50.3	0.50
Physics	5,049	0.79	17.8	0.99	36.0	0.92	46.2	0.54

Representativeness by Examination Board

Board	Number of Candidates	ALIS percentage
AEB	15,339	21.5%
UCLES	10,633	14.8%
ULEAC	17,468	24.6%
NEAB	15,476	21.6%
NICCEA	877	1.2%
OCSEB	5,355	7.5%
UODLE	5,444	7.6%
WJEC	858	1.2%

Sample: ALIS, n = 71,450

Comparison of ALIS with UK (1993)

Percentage of candidates in ALIS gaining grade
(National figures in parentheses)

	A	B	C	D	E	N	U	Number Graded A-U
Art & Design subjects*	15.3 (13.3)	16.9 (18.4)	23.1 (22.7)	20.7 (21.2)	14.7 (14.9)	6.5 (7.0)	2.9 (2.5)	4,936 (35,330)
Biology	10.9 (13.0)	14.4 (15.4)	15.8 (15.7)	18.6 (17.2)	18.1 (16.1)	12.2 (11.5)	9.8 (11.1)	6,131 (47,320)
Business Studies	6.6 (6.1)	15.9 (14.6)	21.0 (18.9)	22.7 (22.0)	19.2 (18.4)	8.4 (10.4)	6.2 (9.6)	3,599 (22,559)
Chemistry	14.7 (16.7)	18.1 (18.2)	16.2 (16.0)	16.8 (15.6)	14.4 (13.2)	10.1 (9.9)	9.8 (10.4)	5,297 (40,772)
Classical subjects*	14.0 (20.0)	19.8 (22.9)	24.1 (22.0)	17.4 (15.9)	14.0 (9.8)	4.5 (4.9)	6.2 (4.5)	580 (8,199)
Computing	10.8 (9.4)	13.6 (13.1)	16.3 (16.6)	21.0 (20.0)	17.5 (18.5)	10.7 (12.4)	9.9 (10.0)	1,568 (9,695)
Economics	13.2 (11.8)	15.8 (14.6)	15.9 (15.2)	16.9 (17.3)	16.1 (16.3)	11.0 (11.9)	11.0 (12.9)	4,409 (36,217)
English	12.9 (12.9)	18.3 (18.0)	20.8 (20.2)	21.8 (21.0)	15.7 (15.3)	6.7 (7.6)	3.7 (5.0)	11,345 (88,739)
French	15.5 (18.5)	15.7 (17.3)	18.9 (19.4)	19.1 (18.6)	16.5 (13.7)	8.8 (7.6)	5.5 (4.9)	3,835 (29,637)
General Studies	9.8 (10.5)	17.1 (16.9)	13.9 (13.6)	16.6 (15.6)	14.8 (15.4)	12.4 (12.0)	15.5 (16.0)	6,361 (54,788)
Geography	11.3 (11.8)	16.7 (16.7)	16.6 (17.6)	20.3 (19.1)	15.7 (15.7)	10.1 (10.0)	9.2 (9.1)	5,929 (46,399)
German	16.1 (21.0)	16.4 (19.3)	18.9 (18.8)	18.5 (16.4)	16.0 (12.2	9.0 (7.5)	5.1 (4.8)	1,515 (10,830)
History	12.2 (12.5)	17.9 (16.9)	20.1 (19.2)	19.4 (19.4)	15.4 (14.9)	8.0 (8.7)	7.0 (8.4)	5,963 (46,096)
Home Economics	6.8 (9.4)	14.2 (14.2)	18.4 (20.3)	21.6 (22.9)	18.4 (16.5)	10.0 (8.5)	10.6 (8.2)	500 (3,487)
Mathematics	20.3 (24.3)	16.2 (17.0)	15.8 (15.6)	16.0 (13.8)	12.5 (11.3)	9.2 (8.0)	10.0 (10.0)	8,467 (64,676)
Physics	15.2 (16.7)	15.0 (16.0)	17.4 (16.2)	17.8 (16.9)	15.2 (14.3)	10.9 (10.3)	8.5 (9.6)	5,142 (37,349)
Religious Studies	10.7 (12.6)	13.9 (14.3)	17.4 (19.7)	22.0 (20.9)	16.3 (13.7)	6.9 (8.0)	12.9 (10.8)	1,046 (8,550)
Social Science subjects*	12.4 (9.7)	19.3 (15.2)	16.0 (16.4)	14.9 (17.0)	14.2 (15.0)	9.6 (10.5)	13.6 (16.2)	3,788 (75,716)
Spanish	16.1 (21.0)	17.8 (19.9)	19.2 (18.8)	19.4 (16.9)	13.2 (11.7)	7.0 (6.6)	7.3 (5.1)	589 (4,845)
Technology Subjects*	12.8 (10.2)	17.3 (13.5)	19.7 (20.5)	22.3 (21.4)	14.4 (17.0)	7.2 (10.2)	6.3 (7.2)	1,094 (10,931)

NB. Provisional National results for 1993. (SCAA)
Source: ALIS, n = 82,094

* These titles cover a range of subjects.

If a student took Biology and also another subject, how did their grades compare?

The table below shows the average difference between a student's grade in another subject and that achieved in Biology. Positive differences imply that, on average, students found Biology more difficult than the other subject.

...the other subject	Difference in Grades	Number of Candidates	Sig.	Comment
Mathematics	-0.48	1,476	**	Biology was easier than Mathematics, Chemistry and especially Physics.
Chemistry	-0.57	2,710	**	
Physics	-0.96	784	**	
Design / Technology	1.40	64	**	All these subjects were easier than Biology, i.e. the same candidates attained higher grades than in Biology.
Home Economics	0.98	127	**	
Environmental Studies	1.24	74	**	
Business Studies	1.13	210	**	
Psychology	1.07	285	**	
Accounting	0.75	20	**	
Geology	0.59	152	**	
Computer Studies	0.69	71	**	
Economics	0.26	311	**	
Spanish	0.15	32		Candidates studying foreign languages as well as Biology attained similar grades in each.
French	0.11	328		
German	0.16	108		
Classical Civilisation / Studies	1.05	37	**	All these subjects were easier than Biology. A candidate's Sociology result was on average one grade higher than Biology.
Sociology	1.10	370	**	
Government / Politics	1.10	47	**	
Religious Studies	0.75	115	**	
History	0.63	1,142	**	
Geography	0.65	473	**	
Art	1.26	299	**	All these subjects were easier than Biology with the exception of General Studies.
Communication Studies	1.38	35	**	
Theatre Studies	1.21	63	**	
Law	0.61	26		
English	1.00	1,076	**	
Music	0.49	45		
General Studies	-0.23	1,187	**	

* $p < .05$ ** $p < .01$

Example: There was a grade difference on average between a candidate's English and Biology result, for the 1,076 candidates who took that combination, suggesting Biology was a grade more difficult than English.

Comment: Biology was more difficult than all subjects with the exception of the other sciences and General Studies.

If a student took Chemistry and also another subject, how did their grades compare?

The table below shows the average difference between a student's grade in another subject and that achieved in Chemistry. Positive differences imply that, on average, students found Chemistry more difficult than the other subject.

...the other subject	Difference in Grades	Number of Candidates	Sig.	Comment
Biology	0.56	2,710	**	Chemistry was on average about half a grade more difficult than Biology.
Mathematics	0.11	2,884	**	
Physics	-0.06	2,330	*	
Design / Technology	1.50	32	**	Chemistry was found to be more difficult than any of the science-related subjects. Often the difference found in these paired comparisons was as much as a grade.
Home Economics	2.00	30	**	
Environmental Studies	2.18	16	**	
Business Studies	1.14	65	**	
Psychology	1.47	55	**	
Accounting	0.61	13		
Geology	1.09	100	**	
Computer Studies	1.00	89	**	
Economics	0.79	177	**	
Spanish	1.00	15		Chemistry was found to be over half a grade more difficult than French and German.
French	0.61	147	**	
German	0.75	65	**	
Classical Civilisation / Studies	1.77	9	**	Once again, consistent with the findings from relative ratings, Chemistry was found to be more difficult than the subjects in the social science and humanities category.
Sociology	1.00	59	**	
Government / Politics	0.53	17		
Religious Studies	1.44	9	*	
History	1.15	431	**	
Geography	0.75	153	**	
Art	1.49	87	**	Chemistry was more difficult than any of the subjects in the miscellaneous category of which General Studies was the most difficult.
Communication Studies	1.00	8	*	
Theatre Studies	1.20	10	**	
Law	1.16	6		
English	1.37	270	**	
Music	0.30	30		
General Studies	0.26	1,194	**	

* $p < .05$ ** $p < .01$

If a student took Mathematics and also another subject, how did their grades compare?

The table below shows the average difference between a student's grade in another subject and that achieved in Mathematics. Positive differences imply that, on average, students found Mathematics more difficult than the other subject.

...the other subject	Difference in Grades	Number of Candidates	Sig.	Comment
Biology	0.48	1,476	**	Biology was easier than Mathematics, but Chemistry and Physics were harder.
Chemistry	-0.10	2,884	**	
Physics	-0.15	3,707	**	
Design / Technology	1.11	358	**	All these subjects were easier than Mathematics, i.e. the same students obtained higher grades than in Mathematics. Environmental Studies was easiest.
Home Economics	1.19	13	*	
Environmental Studies	1.50	20	**	
Business Studies	0.79	504	**	
Psychology	0.90	114	**	
Accounting	0.83	123	**	
Geology	1.08	77	**	
Computer Studies	0.67	587	**	
Economics	0.38	1,404	**	
Spanish	-0.08	63		Students taking Languages as well as Mathematics obtained similar grades in each.
French	0.29	615		
German	-0.12	254		
Classical Civilisation / Studies	0.38	24		Government /Politics grades were lower but all other grades were higher than Maths. There were only small numbers in Religious Studies and Classical studies.
Sociology	0.80	136	**	
Government / Politics	0.66	112	**	
Religious Studies	0.30	37		
Geography	0.82	1,005	**	
History	0.33	535	**	
Art	1.25	305	**	All these subjects were easier than Mathematics.
Communication Studies	1.03	33	**	
Theatre Studies	1.27	34	**	
Law	0.94	49	**	
English	0.77	833	**	
Music	0.30	104		
General Studies	0.29	1,952	**	

* $p < .05$ ** $p < .01$

Example: 1,476 students took both Biology and A level Mathematics. The difference, Biology grade minus Mathematics grade, averaged 0.48. Therefore it appears that, for those students who took both subjects, Mathematics was about half a grade more difficult than Biology.

If a student took Physics and also another subject, how did their grades compare?

The table below shows the average difference between a student's grade in another subject and that achieved in Physics. Positive differences imply that, on average, students found Physics more difficult than the other subject.

...the other subject	Difference in Grades	Number of Candidates	Sig.	Comment
Biology	0.96	784	**	On average a candidate gained one grade higher in Biology than in Physics.
Mathematics	0.15	3,707	**	
Chemistry	0.07	2,330	*	
Design / Technology	1.35	365	**	Physics was harder than all the science-related subjects. On average, in the well represented combinations, candidates achieved about one grade higher in their other subject than they did in Physics.
Home Economics	1.00	3		
Environmental Studies	2.00	4		
Business Studies	1.10	121	**	
Psychology	2.00	16	*	
Accounting	2.20	14	**	
Geology	0.99	59	*	
Computer Studies	1.00	364	**	
Economics	0.62	362	**	
Spanish	0.91	11		There were no significant differences between grades candidates achieved in Physics and the foreign languages.
French	0.01	102		
German	0.42	57		
Classical Civilisation / Studies	1.00	3		Grades candidates achieved in Physics, on average, were about a grade lower than they attained in the social science / humanities subject they took in combination with it.
Sociology	1.64	14	**	
Government / Politics	1.22	18	*	
Religious Studies	1.00	4		
History	1.01	409	**	
Geography	0.75	120	**	
Art	1.50	152	**	All these subjects were easier than Physics (except Theatre Studies, which only seven students took in combination with Physics).
Communication Studies	1.29	7	*	
Theatre Studies	0.00	7		
Law	1.00	9		
English	0.99	177	**	
Music	0.54	54	*	
General Studies	0.70	1,161	**	

* $p < .05$ ** $p < .01$

Comment: Physics was found to be the most difficult subject using Relative Ratings. This finding is confirmed in this table, where all the difference are positive, indicating that, on average candidates achieved lower grades in Physics than they did in their other A levels, often by as much as a grade.

Grade Distributions in Modular and Non-Modular Mathematics courses

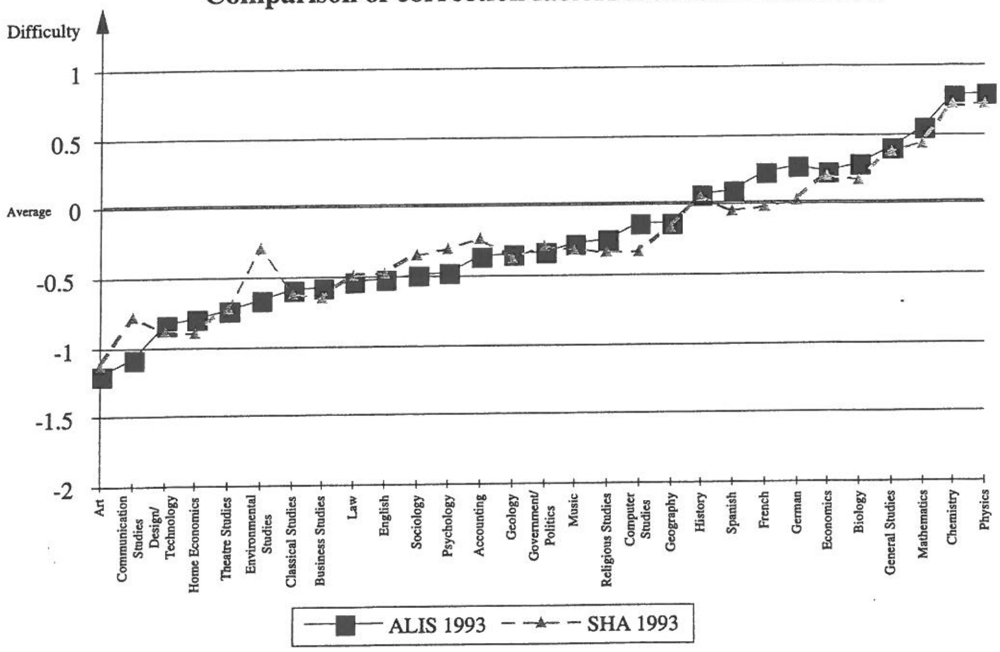
Type of Mathematics Courses	Modular	Non-Modular
Grade	% awarded grade	% awarded grade
A	25	19
B	21	15
C	19	15
D	18	16
E	10	13
N	4	10
U	0.015	12
Total entry	1,087	6,041
Average GCSE score	5.96	5.96
Average UCCA Points	6.29	4.67
Average Mathematics Grade	C	D

Does Type of Institution have any effect on the relative difficulty of subjects?

Types of Institution in SHA and ALIS

	SHA		ALIS	
Type of Institution	Frequency	%	Frequency	%
Secondary Modern	3	0.8		
Grammar	41	10.9	3	0.8
Comprehensive 11-18	109	29.0	154	43.3
Other Secondary	1	0.3		
City Technology College	1	0.3		
Independent	111	29.5	4	1.1
Grant Maintained Secondary	52	13.8	27	7.6
Comprehensive Upper School	30	8.0	59	16.6
Comprehensive Senior School	5	1.3	6	1.7
Sixth Form College	23	6.1	103	28.9
Total	376		356	

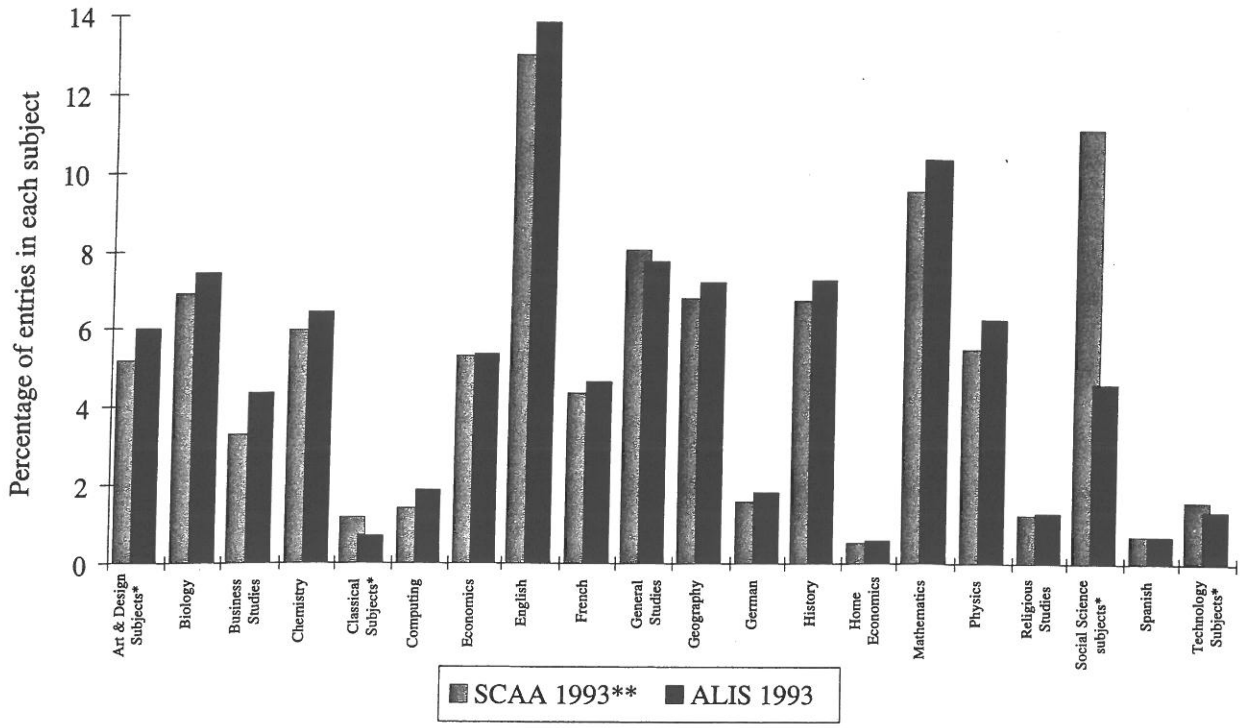
Comparison of correction factors from SHA and ALIS



Source: ALIS 30,263 Candidates taking at least two A levels.
SHA 28,247 Candidates taking at least two A levels.

Comment: 29.5% of the SHA sample consisted of independent schools as compared to only 1.1% of the ALIS sample. Nevertheless, the correction factors followed the same pattern.

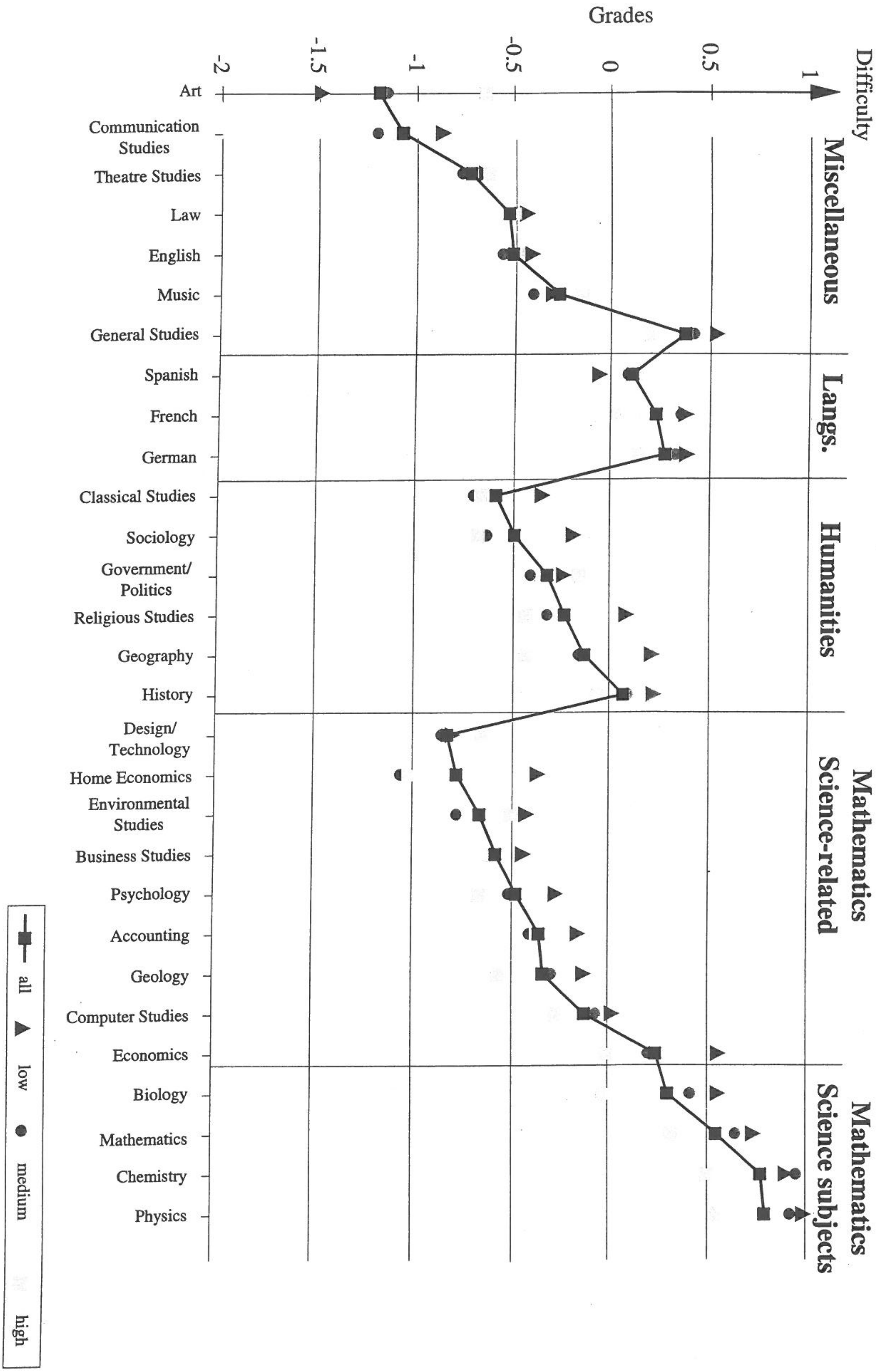
Percentages of total entries at A level, 1993



* These titles cover a range of subjects.
** N.B. Provisional National results for 1993.

National data (n = 682,135, SCAA)
ALIS (n = 82,094)

Correction factors for 1993



Source: ALIS, candidates who took at least 2 A levels. (30,263)

The sample was split into 3 groups by prior achievement (AVGCSE) and the correction factors for each plotted. AVGCSE = average of student's GCSE grades.

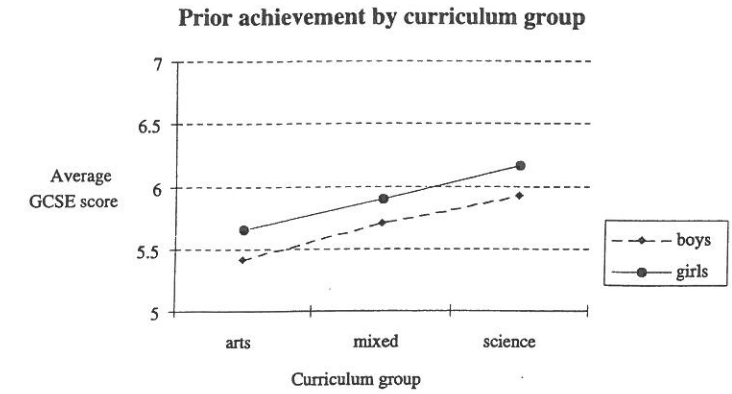


Figure 4(i)

Among both boys and girls, those who had attained a higher average GCSE score tended to opt for science subjects*. Girls had higher levels of prior achievement (GCSE scores) but were less likely than boys of the same academic ability to opt for sciences.

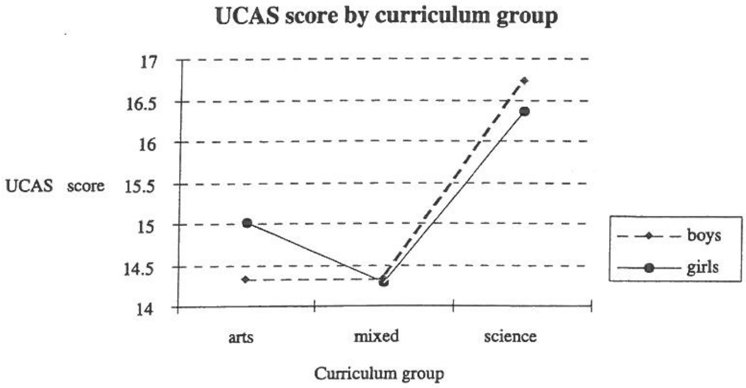


Figure 4(ii)

The University Central Admissions System (UCAS) uses a scale of 10 points for an "A" grade, 8 points for a "B" etc. The "UCAS" score is the total points based on grades in the subjects taken at A level. The graph is based on students who took exactly three A levels. The higher UCAS scores were obtained by students taking mathematics-science A levels. Were these as high as should be expected considering the higher ability of the intake? That question is answered by the Value Added graph (Figure 4(iii)) which records the relative progress made. Zero represents average progress for the whole sample.

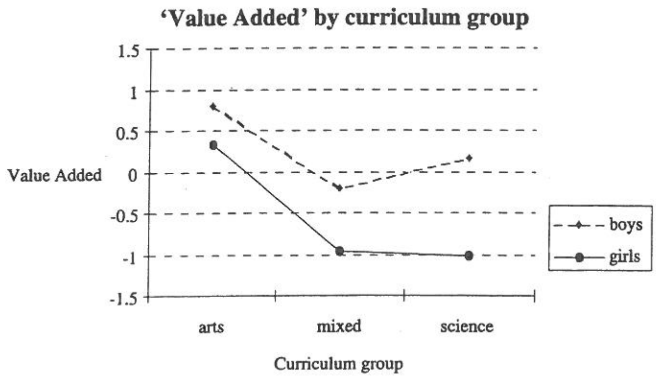
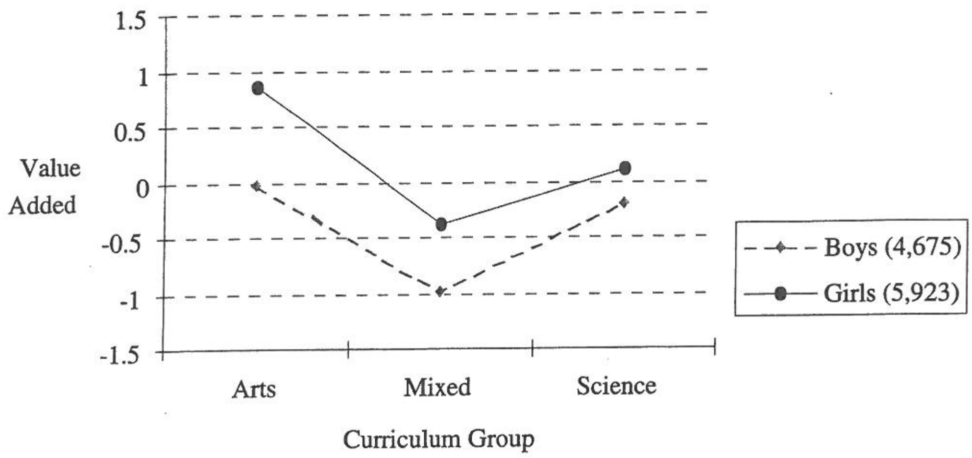


Figure 4(iii)

The Value Added scores show that

- Boys made greater progress than girls.
- Maximum Value Added scores were obtained in the arts subjects.

"Value added" by Curriculum Group using ITDA score



Source: ALIS, 10,598 Candidates who took ITDA test.
Residuals from linear regression equation.

Analysis of Variance, Residual by Gender and Curriculum Group

Source of Variation	Sum of Squares	DF	Mean Square	F	Sig of F
GENDER	1,146.245	1	1,146.245	73.475	.000
CURRICULUM GROUP	2,758.021	2	1,379.011	88.396	.000
GENDER CURRICULUM GROUP	111.242	2	55.621	3.565	.028
Residual	165,239.535	1,0592	15.600		
Total	169,957.439	1,0597	16.038		

RESIDUALS by GENDER and CURRICULUM GROUP

	CURRICULUM GROUP		
	Arts	Mixed	Science
Boys	-0.03 (1,687)	-0.99 (1,974)	-0.20 (1,014)
Girls	0.86 (3,351)	-0.39 (1,899)	0.10 (673)

Environmental Studies, Geology and Psychology were specified as counting as science A levels *if taken in conjunction with the target subjects* (Mathematics, Physics, Chemistry and Biology). These combinations defined the "Science" curriculum group. Other combinations that contained at least one of the target subjects were classified as "Mixed" and other combinations were labelled "Arts".

School Curriculum and Assessment Authority
Newcombe House, 45 Notting Hill Gate, London W11 3JB
Telephone: 0171-229 1234

Ref: P16/95/199
£4.00
ISBN 1 85838 060 X