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Can We Predict Student Success (and Reduce Student Failure)?

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The final year performance of the first intake to the master of pharmacy programme at the Manchester School of Pharmacy and Pharmaceutical Sciences has been correlated with data available from UCAS forms, diagnostic tests and course examinations and attendance records. We have found evidence of factors that predispose students toward success or failure. For example, final degree classification was much more sensitive to the grade in biology A-level than to the total A-level points-score in this cohort of students. Final examination scores were essentially independent of the affluence of the students' backgrounds (as measured by the Index of Multiple Deprivation (IMD)). Perhaps the most important finding was the strong correlation of final examination marks with marks in the diagnostic test in English. These and other data have been used to inform admissions policy, but their most important use is in refining the curriculum and in student support and guidance.

Keywords: A-levels; Diagnostic tests; English; Pharmacy; Student performance

INTRODUCTION

The role of an admissions tutor in a school of pharmacy, as in other university departments, is to offer places to those students most likely to complete the course and to perform well. There is increasing concern (The Comptroller and Auditor General, 2002) that some potentially good students are not offered places at university because of unconventional or disadvantaged educational backgrounds; admissions tutors are under pressure to identify such students (Higher Education Funding Council, 2001). At the same time, especially in a subject like pharmacy where student retention rates are good, experiments with admissions, which may result in reduced retention rates, can be costly both financially and in terms of human resource. Clearly, it would be useful to identify the factors influencing student success, especially those which are already evident prior to admission. Even predictions of student success after the course has been started are useful; students with known risk factors can be alerted and given additional help.

These were some of the considerations that persuaded us to begin a major prospective study of the University of Manchester 1997 student intake, the first cohort to complete the newly-introduced Masters of Pharmacy programme. We also planned to monitor the baseline knowledge of each intake beginning in 1997 because of the expected changes in A-level syllabi. Thus, the 1997 intake was the first to sit baseline skill tests in chemistry, physics, biology, mathematics and English during their first week as undergraduates. They also sat an IQ test, intended as a control.

The 1997 intake has now graduated. This paper reports the analysis of the data obtained before, and at entry to, the programme, and how these data correlate with the final degree classification.

METHODS

One hundred and twenty-three pharmacy students who started the programme in 1997 participated in this study. The data recorded about each student are known before the start of the programme included age, gender, home or overseas status, ethnic origin,

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A-level grades, work experience prior to the course and whether or not they attended a school of pharmacy open day. The pre-curriculum 2000 points system (i.e. ten points for a grade A, eight points for a grade B, six points for a grade C) was applied in 1997 and is used here to calculate the total A-level points-score. Data recorded during the course included performance in skill tests taken in Freshers' Week (in chemistry, physics, biology, mathematics and English), an IQ test also taken in Freshers' Week, work and attendance data throughout the four years of the programme and end-of-semester examination results.

The skill tests were designed to assess aspects of subjects particularly relevant to pharmacy programmes on a year-to-year basis. Each test consisted of 40 or 50 multiple choice or text-match questions and was computer-based, using Questionmark software. The four science tests were written in-house and designed to incorporate material from Key Stage Three up to A-level. The English exam was the University of Manchester's Chaplen English test (Chaplen, 1970), normally used to assess the English of overseas students. The IQ exam used was the AH4 test, a simple, off-the-shelf test administered under the supervision of the Department of Psychology.

Each of the categories of data listed above was treated as a potential factor influencing students' performance. The factors were divided into three groups: interval variables (measured on a continuous numerical scale, such as exam marks), ordinal variables (those in ordered categories, such as A-level grades) and nominal variables (categories with no order, such as gender).

Using SPSS (Version 10.1, 2000) the final year exam marks were compared between different groups. Significant differences in achievement were tested using either the Student's *t*-test (for comparison of two group means, such as examination marks of males and females) or ANOVA (analysis of variance, for comparison among more than two groups, such as examination marks of students with different grades of A-level math).

Using correlation analysis, the degrees of association between exam marks and interval variables (for example, the results of the skill tests) were measured. To quantify the relationship between final exam marks and other variables, regression analysis was used. Interval variables were used directly in the regression analysis, whereas all ordinal and nominal variables had to be converted to interval measures prior to being included. Initially, each variable was studied separately (simple regression analysis) to indicate factors of possible importance; then, to avoid misleading conclusions, the effects of potentially important variables were further investigated using multiple regression analysis. The possibility of the effect of one variable depending on that of another (interaction) was also investigated. However, the inclusion of interaction terms did not improve the modelled relationships between variables and was not pursued.

To determine the likelihood of a particular result (dropping out of the programme, for example), log-linear analysis was used. Initially, students were divided into two groups. Group one consisted of students who graduated after four years; group two consisted of students who did not, usually due to withdrawal from the programme or exam failure. Next, graduates of group one were studied (using chi square tests) to detect any significant associations between students achieving different degree classes.

RESULTS

When a student arrives at the beginning of the programme, we know his or her gender, ethnic origin, home or overseas status, normal residence, date of birth, work experience, whether they have visited the Manchester School of Pharmacy and their A-level subjects and scores. Within a week we also know the results of the six skill tests. Over the next four years, the results of semester-end examinations and any work and attendance problems are recorded.

One hundred and twenty-three students began the programme in 1997. Of these, 96 graduated with honors M.Pharm. degrees in 2001, two graduated with honors B.Sc. (Pharmaceutical Sciences) degrees in 2000 and two with pass B.Sc. degrees in 2001. Eleven graduated with honors M.Pharm. degrees in 2002 (eight with class 2i, two with class 2ii, one with class 3), and 12 withdrew. The results are summarised in Table I.

Possible correlations between factors known in 1997 and the final outcomes in 2001 were considered in two different ways. First, the students were divided into two groups, those who graduated with M.Pharm. honors in 2001 and those who did not. This enabled us to identify risk factors associated with failure to complete the programme. Second, variables were compared with the final mark obtained in fourth year examinations. This allowed

TABLE I 2001–2002 outcomes for the University of Manchester 1997 M.Pharm. intake

Outcome in 2001/2002	Number of students
First class honors	18
Upper second class honors	59
Lower second class honors	18
Third class honours	1
B.Sc. Pharmaceutical Sciences (graduated in 2000 or 2001)	4
Honours degrees in 2002	11
Withdrawn from course	12

some estimation of the relative importance of different factors.

A-Level Subjects and Grades

Admissions policy in the Manchester School of Pharmacy, as in most traditional university departments, is dominated by A-level grades and scores. A student entering the programme will normally hold the equivalent of three A-level passes, including chemistry, all at grade B or above. The other two subjects are normally drawn from biology, mathematics and physics, but for the first time the 1997 entry contained a number of students offering only two science subjects, the third being an arts subject (e.g. music, geography or French).

Admissions policy works from the premise that students with good A-levels are more likely to complete the programme and more likely to do well than students with poor A-levels. But in fact, there was no significant difference in average total A-level points between those who completed the programme in 2001 and those who did not. Among students who completed the programme on time, the A-level score was only a weak predictor of outcome. On average, two A-level points equated to a one percent increase in the final year examination mark results (Pearson correlation coefficient = 0.32, significance level = 0.002, $n = 92$). At first sight these results are surprising. However, the range of A-level scores in the Pharmacy intake is very narrow (mean 24.6, standard deviation 2.7), masking any correlation.

Students with non-standard A-level subjects were neither advantaged nor disadvantaged relative to other students at the final-year level (see Table II). The first semester of the Pharmacy programme includes foundation modules in mathematics, biology and physics; each student takes one of these. A student with science A-levels will take the subject in which he or she does not have an A-level. For students missing two science A-levels, mathematics and biology foundation courses take precedence over physics, which is believed to be less directly relevant to the M.Pharm. programme. Every student with an arts A-level also had an A-level in chemistry and either mathematics or biology.

The effect of the A-level subject only becomes significant when students with different grades are compared. Interestingly, for those students ($n = 96$) with an A-level in biology, final degree outcome is strongly correlated with A-level grades. Students with a grade A scored (on average) five percent above those with grade B, who, in turn, scored five percent above those with grade C. This effect is almost independent of gender, ability in English, chemistry A-level and total A-level score, reducing only to 4.5% (difference between grades A and B) and 4.2% (difference between grades B and C) when these factors are adjusted for.

The correlation of mathematics A-level with final mark is only significant when considered independently of gender. On average, men in the programme had better A-level mathematics grades than women, but went on to perform less well in their final examinations. Although men achieving lower second-class honors had the same average mathematics A-level grade as women with first class honors, there was a strong correlation between mathematics A-level and final degree mark when the two sexes were considered independently (see Fig. 1). On average, students with a grade A scored 4.2% more in finals than those of their own sex with a grade B. There were no significant differences between performances of students of the same sex with grades B and C.

Gender and Race

Because of the legal and ethical requirement that admissions decisions be made independent of them, gender and race are here considered together. Yet in a school in which most of the academic staff (16 out of 23) and, during the period 1997–2001, all the professional staff were white males, there is a danger that white males might yet be advantaged through shared culture and background with their teachers. In fact, the results obtained are much more complex.

Of the initial cohort of 123 students, 66% were female and 57% were male. The predominant ethnic groups were white (67) and Asian (37). The small number of students of Afro-Caribbean (4) and Far Eastern (4) ethnic origin performed well, but their numbers were too small to be statistically significant.

Of the 12 students who dropped out of the programme completely, six were female and six were male, very close to the expected ratio. The performance of students who completed the programme was, however, strongly correlated with gender, women achieving about four percent higher scores (on average) than men. Over the four years,

TABLE II Mean result, standard deviation and number of cases for students with standard A-levels compared with others

Type of A-level achieved	Mean result obtained	Standard deviation	Number of cases
3 Science A-levels	63.3	6.5	76
2 Science and 1 other A-level	64.1	5.3	17
Non-standard qualifications	69.7	5.7	3

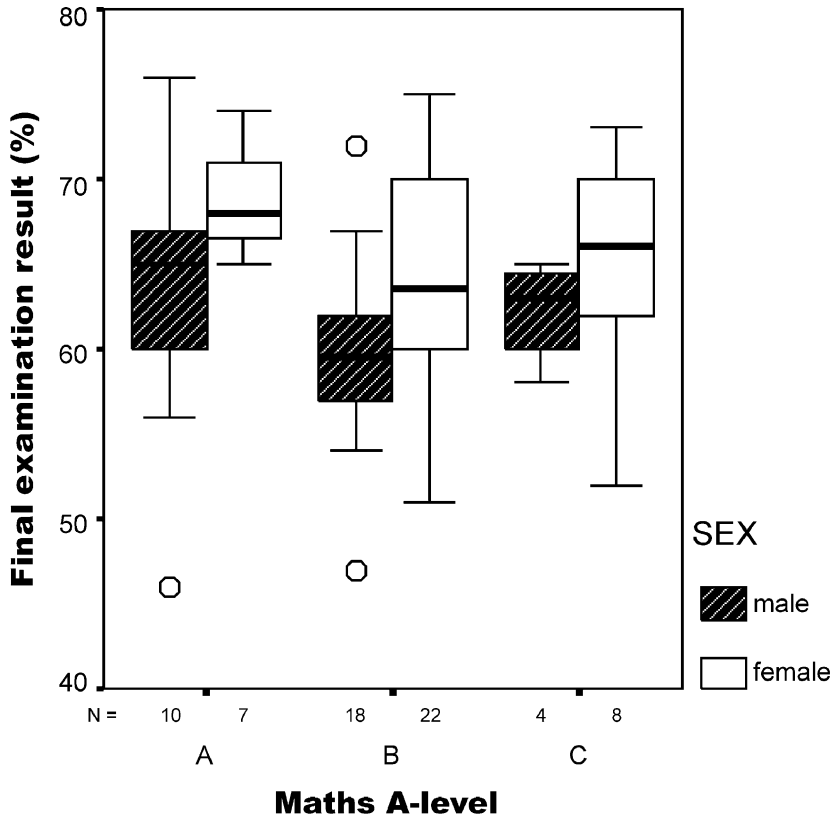

FIGURE 1 Box plot of students' performances by gender and maths A-level. Vertical bars on each plot represent the range of marks for each particular grade. The solid black lines represent the middle value (median). The top and bottom borders of the boxes correspond to the 75th and 25th percentiles (inter-quartile range), i.e. the boxes represent the middle 50% of the data. Three circles on the graphs represent outliers. As can be seen, students with grade A in mathematics A-level perform better on average than those *of their own sex* with grade B or C in mathematics.

nearly a quarter of the male students ($n = 13$, 23.6%) were identified as falling short of the required 80% attendance in all courses, as compared to only three women (4.8%). However, even when only students with acceptable attendance were compared, women scored an average 3.4% better than men.

In a crude analysis, students of Asian origin scored an average 4.4% less than whites. This result is not quite independent of gender or A-level grades; yet after adjustment for these factors, an Asian student score of 3.3% below white students is the residual effect. The correlation between race and final examination results is not independent of the skill tests results (see below), although the correlation between gender and examination results is independent of all the factors considered.

The 18 students with first class honors provide a snapshot of these issues. Only three students with first class honors were men and all of these were white. The 15 women included only two of Asian origin, two from minority racial groups and 11 white students.

Residence

Among the students who completed the programme, there was no significant difference between the results of home and overseas students. Four overseas students were among the 12 who withdrew from the programme; three of these were identified as having poor English.

The majority of students lived in rented accommodation, either owned by the University or the private sector, and 17 lived in the family home. There was no significant difference in performance between these two groups.

The effect of the family home environment on students' success was investigated using the Index of Multiple Deprivation (IMD) (Department of the Environment, Transport and the Regions, 2000). The IMD is a score containing information on six separate domains, each reflecting a different aspect of deprivation: income, education, health, employment, housing and geographic access to services.

The first striking point is that this group of pharmacy students comes from the complete spectrum of backgrounds, with IMDs ranging from 3.32 to 78.28. Nationally, the most deprived ward has an IMD of 83.77 and the least deprived 1.16. These results are represented graphically in Fig. 2.

Students were divided into two groups based on their performances in the Pharmacy programme; they were separated between those obtaining a first

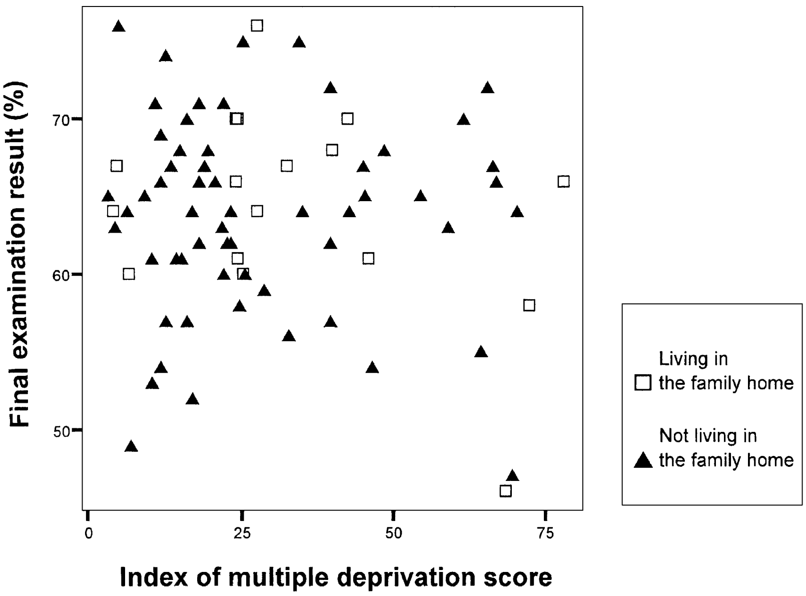

FIGURE 2 Scatter plot of percentage mark obtained in the final year against IMD. It can be seen that average mark is independent of the IMD both for students living in the family home during term-time and for students living away from home.

or upper-second class (2i) honors degree in 2001 and the rest. Each of the individual indices of deprivation and the cumulative IMD were then compared for the two groups. Table III shows the results of the analysis for the two indices for which significant differences were seen. The IMD itself showed no significant correlation with examination scores.

As Table III shows, there is a significant difference ($t = -2.15, p = 0.03$) in housing deprivation between the two groups. Students with first and upper second-class honors degrees were more likely to have come from areas of good housing than the rest of the students. When students with the same term time and family addresses are excluded from the analysis, the difference in housing deprivation index between the two groups narrows considerably and ceases to be statistically significant.

The only other index of deprivation to feature significantly was access ($t = 2.25$, significance level $= 0.03$). In this case, the trend was reversed; those coming from areas of poor access to basic facilities (such as primary schools and GPs) performed better than those coming from areas of good access. The access domain also ceases to be a statistically significant factor after excluding students who live in the family home during the term. No significant differences in IMD and other individual domains between the two groups were observed.

Date of Birth

Most of the students started the course at the age of 18 (straight from school) or 19 (following a gap year). A few began the course at the age of 20, and just three were mature students. There was neither a significant difference in performance between students who took a gap year and those who did not nor between mature students and others.

It has been reported that people with birthdays toward the end of the academic school-year are disadvantaged in certain activities, even through adulthood. For example, the England football squad of December 2001 (England Football Online, 2001),

TABLE III Average scores for housing and access domains of the IMD, for all students and those with different term-time and family addresses; the higher the score, the more deprived a ward is

	Average score for each individual domain			
	For all students		For students with different term time and family address	
Domain investigated	Graduates with a first or upper second degree ($n = 62$)	Others ($n = 26$)	Graduates with a 1st or 2i degree ($n = 45$)	Others ($n = 15$)
Housing	0.25 (1.11)	0.82 (1.19)	0.32 (1.08)	0.70 (0.93)
Access	−0.32 (0.65)	−0.65 (0.53)	−0.27 (0.66)	−0.57 (0.58)

The values in brackets are the relevant standard deviations. The national maximum and minimum deprivation scores for housing are 3.36 and −3.28, respectively, and, for access, 2.95 and −2.78, respectively.

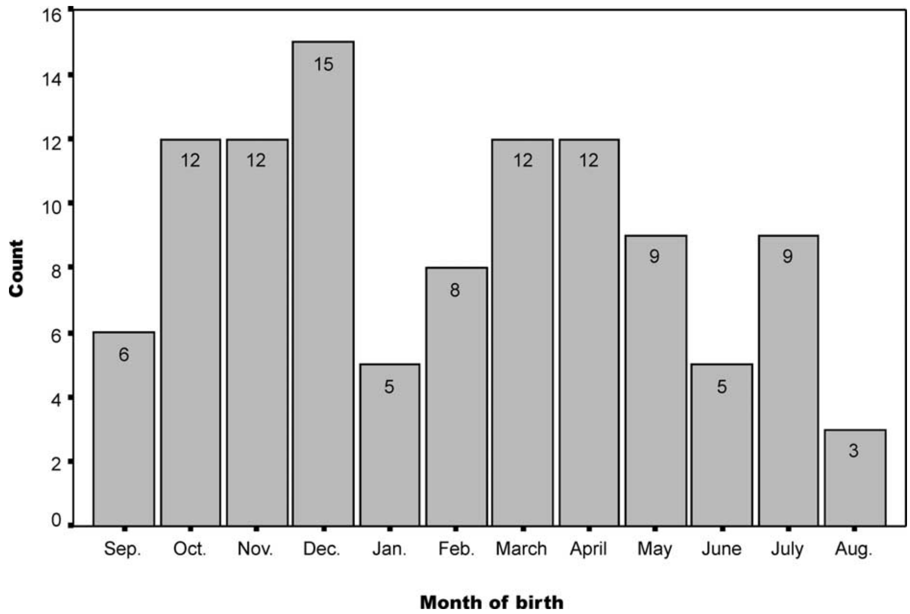

FIGURE 3 Bar chart showing months of birth of the 1997 Manchester M.Pharm. intake.

contained 17 players with birthdays in the first-half of the school year and only nine with birthdays in the second-half. We observed a preponderance of students with birthdays toward the beginning of the academic year among the 1997 pharmacy intake (Fig. 3). The same trend is reflected in the 1998, 1999 and 2000 entries (Table IV).

Data obtained from the Higher Education Statistical Authority suggest that the Manchester School of Pharmacy is following a national trend. University applicants with birthdays early in the academic year tend to have slightly better A-level grades (see Table V) than those with birthdays late in the year, a result significant at the $p = 0.05$ level.

The Russell Group of Universities recruits disproportionately from students with September to December birthdays, but these students still have slightly better A-levels than Russell Group students with January to August birthdays. By graduation, however, they are slightly less likely to achieve first class honors than students born later in the academic year (13.25% of Russell Group students with September to December birthdays achieved first class honors, against 13.5% of Russell Group students with May to August birthdays). These results suggest that students with birthdays later in the academic year may still be disadvantaged educationally at the beginning of their undergraduate courses, but on average, such students make slightly better progress than their peers.

TABLE IV Total number of students born in each month of the year for the 1997 to 2000 intakes combined

Month of birth	Number of students
September	36
October	42
November	47
December	38
January	33
February	35
March	29
April	37
May	43
June	22
July	35
August	32

As can be seen, 231 students were born from September to February, the early part of the academic year in England and Wales, whereas only 198 were born from March to August.

Visits to the School and Work Experience

Seventy-two percent of students attended the School of Pharmacy and Pharmaceutical Sciences visit day; only 59% of those who did not achieved first class or 2i degrees. Work experience prior to attending the University was more common among those who graduated a year late (82%) and those with upper second-class honors in 2001 (71%) than among those with first or lower second class honors degrees (61%). None of these results was statistically significant at the 0.05 confidence level.

Skill Tests Results

The most striking result from the skill tests data is that students who attended all the skill tests ($n = 112$) were about three times more likely to graduate on time compared with those who absented themselves from one or more tests ($n = 11$). Students who attended all the skill tests were about four times less likely to withdraw from the course in

TABLE V A-level points, standard deviations, months of birth and number of students for all students at all universities, for all students of the Russell Group of Universities and for students with first class degrees from Russell Group of Universities

	All universities			Russell Group of Universities			First class degrees from Russell Group of Universities			
Month of birth	Mean A-level points	Standard deviation	Number	Mean A-level points	Standard deviation	Number	Mean A-level points	Standard deviation	Number	% Intake
Jan.–April	19.18	7.5	43908	24.87	5.11	13851	27.47	4.14	1840	13.28
May–Aug.	19.07	7.5	44859	24.77	5.14	14050	27.46	4.12	1903	13.54
Sep.–Dec.	19.44	7.5	44482	25.05	5.04	14731	27.77	3.76	1952	13.25

comparison with others. Both these results are significant at the $p = 0.05$ level.

The results of two of the skill tests show statistically significant correlations with final examination marks. One is the chemistry test; a one percent increase in the chemistry mark is equivalent to a 0.31% increase in the final mark. This correlation is independent, or almost independent, of all other factors considered, including the chemistry A-level grade. The more surprising correlation is with the result in the English test, where there is an increase of 0.2% in the final examination mark for each one percent in the skill tests. For students with A-level biology, the effect of the English result is not significant at the 0.05 confidence level when the effect of the biology A-level grade is considered. However, after adjusting for English results, the effect remains, relative to grade B, significant on grade A biology, changing from 5.0 to 4.6% and also on grade C, changing from -4.9 to -4.2%. It appears that A-level biology (which not all students offer) may be a sensitive test of linguistic ability (Fig. 4).

Interestingly, the previously-mentioned correlation between race and the final year outcome is related to the apparent correlation observed between the English skill tests mark and the final examination mark, shown in Fig. 4a. As Figs. 4b and c show, the apparent correlation for the class as a whole is made up of both a white cohort, for whom there is no significant relationship between the English mark and overall performance, and students of Asian origin, for whom a significant correlation is seen (Pearson correlation coefficient $= 0.37$, significance level $= 0.04$, $n = 31$). While Asian students with good English perform as well as their white peers, many students of Asian origin perform poorly in the English test and correspondingly poorly in the final examinations.

Examination Results in Years One through Three

Obviously, these results become available only a considerable time after admission and cannot be used to inform admissions tutors. Nevertheless, they are presented here because they illustrate the importance of early intervention where problems are found. It can be seen from Fig. 5 that there is a strong correlation between first and fourth year examination results, an increase of one percent in first year corresponding to an increase of 0.41% in fourth year examinations. The mean first year examination mark for the students who graduated in 1997 was 66.1% (standard deviation $= 8$, $n = 95$), whereas the mean for those who did not graduate in 1997 (i.e. failed, withdrew or had to repeat a year) was 49.0% (standard deviation $= 9$, $n = 23$). Only one student who obtained first class honors in the fourth year scored less than 70% in the first year.

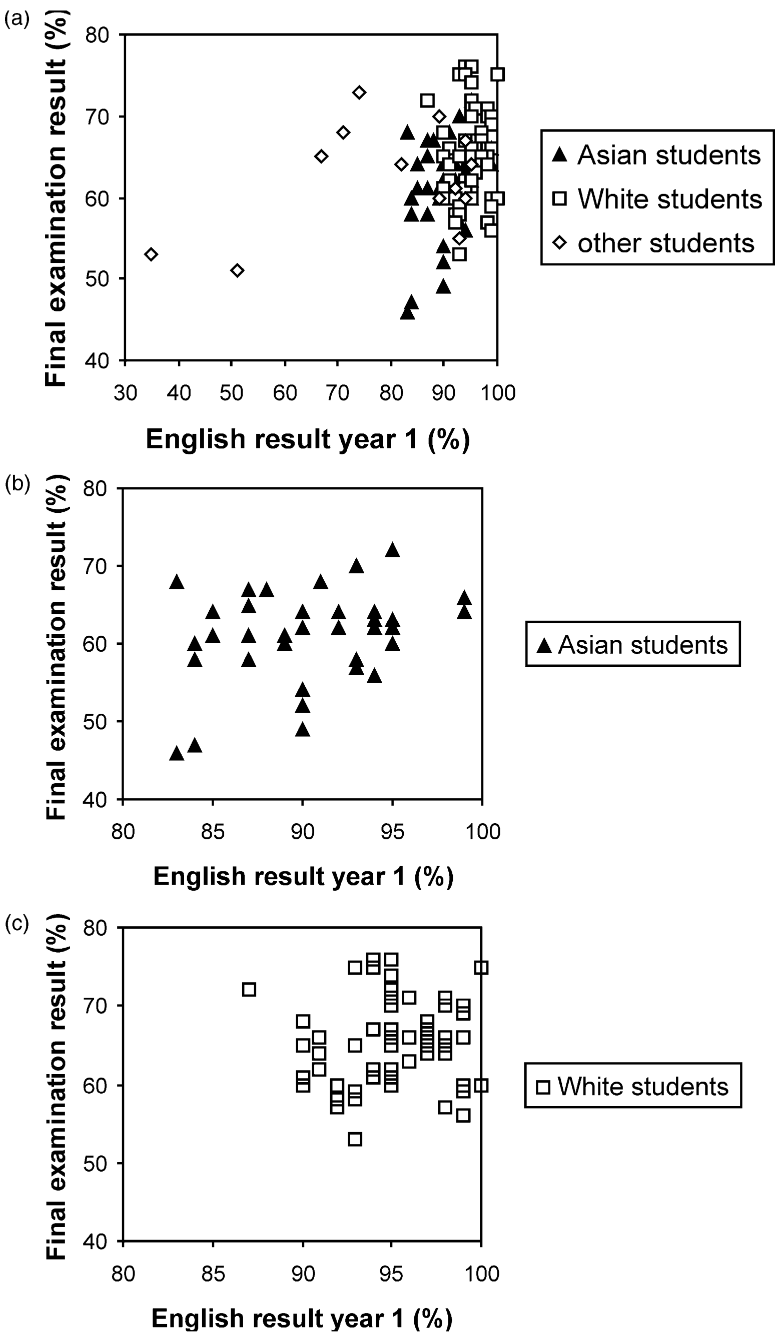

FIGURE 4 Scatter plots of (a) final marks (2001) for all students in the 1997 Manchester M.Pharm. intake against English results (1997), (b) Asian and (c) White cohorts.

By second year, an increase of one percent in end-of-year examinations corresponds to an increase of 0.52% in fourth year examinations. By third year 1% increase corresponds to 0.89% in the fourth year (there is a 20% carry forward mark from third year into fourth year, which strengthens this correlation).

DISCUSSION

The relatively weak correlation between general A-level scores and final degree outcome is not a great surprise; similar results have been found in previous studies (Peers and Johnston, 1994). Many other predictors of degree outcome correlate even less, a significant problem for admissions tutors. The finding that biology A-level grade is a relatively good predictor of final examination performance is therefore, interesting and potentially useful. Biology A-level, unlike mathematics, physics and chemistry A-levels, tests a student's ability to write scientific prose. Biology has a high information content compared with the physical sciences and mathematics, and success in biology is perceived as being

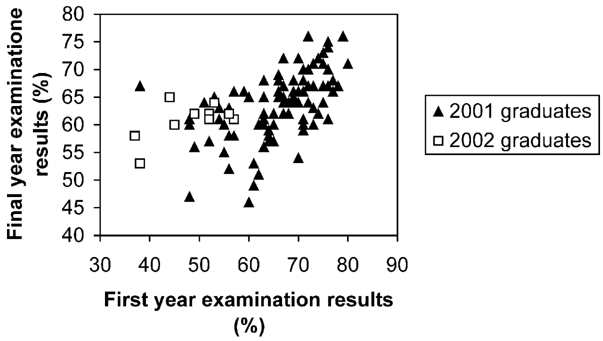

FIGURE 5 Scatter plot of the final year examination results for the 1997 Manchester M.Pharm. intake against year one examination results. These two parameters are closely correlated, especially at the upper end of the scale.

dependent upon hard work even for very able students. These factors may explain the relatively good correlation between A-level biology grade and final degree outcome.

It is easy to advance explanations for the good performances of women relative to men, but difficult to verify them. Since the women did not outperform the men in school, the explanation must lie in differences between doing A-levels at school and reading pharmacy at the university. Since women on the Manchester M. Pharm. programme outperform men in all subjects, including traditional male subjects such as chemistry and physics, we may be observing the consequences of women underperforming at school. Mixed school classes are known to favour boys, who dominate the classroom (Campbell and Storro, 1994; Howe, 1997). This is particularly marked in science, where girls are likely to be in the minority. But unlike most chemistry and physics university courses, the Manchester M. Pharm. programme has a close to 50:50 (actually 54:46 in the 1997 intake) sex ratio and a reasonable proportion (about a third) of women staff. It is possible that we are able to offer a true equal opportunity environment, in a way that mixed schools and sixth form colleges cannot. At present, this is conjecture, requiring further investigation.

The underperformance of students of Asian origin, relative to white students, correlates very strongly with English language ability. Although students of Asian origin come from a variety of backgrounds, they are nearly all second-generation immigrants who speak a language other than English with their parents. The results of the Chaplen English test suggest that many of these students, although they speak English fluently, do not have the breadth of vocabulary or command of grammar necessary to gain very high marks in a pharmacy degree programme. We became aware of this problem in 1998 when the 1997 intake sat first year examinations. From 1998 onwards, we have offered an "Effective Writing" module to first year students. We will be able to judge its effect on Finals performance when the analysis of the performance of the 1998 intake is completed, but in the 2001 (third year) examinations taken by the 1998 intake there was no significant correlation between ethnic origin and examination performance.

Admissions tutors are under pressure to recruit students from disadvantaged backgrounds under "widening participation" initiatives. Our results show that the Manchester School of Pharmacy recruits from the full range of backgrounds, as measured by the IMD, although recruitment is undoubtedly skewed in favour of less deprived backgrounds. The examination results do not appear to justify any positive discrimination in favour of students from more deprived backgrounds; overall, they have performed neither better nor worse than other students with comparable qualifications. This is not to say that more students from deprived backgrounds would not benefit from a university education; rather, that action by the universities would be more effective if accompanied by efforts to combat the ill effects of deprivation experienced at the pre-university level.

The national Higher Education Statistics Agency (HESA) data suggest that underachievement by students with May–August birthdays is still evident at age 18. Although the effect on any one student is small, the effect on the University population as a whole is significant. The Russell Group of Universities recruits disproportionately from students with autumn birthdays, despite slightly higher A-level targets for such students. To maximise the quality of degrees awarded, the Russell Group would need to increase the percentage of students with May–August birthdays by recruiting, for example, an extra 300 such students each year. This equates to just one student for a university department the size of the Manchester School of Pharmacy and Pharmaceutical Sciences.

The skill tests, sat during the first week of the semester, are very early guides to problems with individual students. Students who absent themselves tend to have motivation problems throughout the programme, and may fail to complete it. The correlation between English scores and final examination marks is discussed above. The correlation between chemistry scores and final examination mark is interesting, especially because it remains after adjusting for the effect of chemistry A-level grades. The skill tests are designed to test areas of chemistry most relevant to pharmacy; organic and physical chemistry are stressed while inorganic chemistry is not. A number of the questions involve simple calculations similar to those used by pharmacists.

Finally, the strong correlation between final examination performance and performance in all other end-of-year examinations shows that students need to adapt to the course at a very early stage if they are to do well. This probably reflects the intensity of M.Pharm. programmes (approximately 25 timetabled hours-per-week in all four years) and the way in which modules build on the material covered in earlier parts of the course.

CONCLUSION

A-level grades are imperfect predictors of student success. The only legal suggestion to admissions tutors we can derive from our data is that biology A-level grades should be given extra weight in assessing which students are likely to succeed. The most promising method of improving student success, as predicted from our results, is to provide language support for the many students whose English will otherwise prevent them from fulfilling their potential at the university.

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