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# THE LEAVING CERTIFICATE AND FIRST YEAR UNIVERSITY PERFORMANCE

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## 1. INTRODUCTION

The manner in which students are admitted for third level education and in particular the points system have become matters of increasing public controversy in recent years. While the subject is understandably emotive, a sad feature of many of the arguments presented to date has been the very limited factual support. Our purpose in this paper is threefold: firstly to introduce some research which has and is being carried out at University College Cork on the effectiveness of performance in the Leaving Certificate examination and in such alternatives as scholastic aptitude and personality tests, as measures of subsequent university performance; secondly, to suggest some statistical methodology for the analysis of data in this area; and thirdly to offer some personal comments on aspects of the overall problem in an effort to establish a fair and hopefully constructive viewpoint and to redress some misconceptions.

Our measure of university performance in this paper is the result of the First University Examination which is held in the summer following entry. Although performances in subsequent years and in degree examinations are also of interest and are under analysis it is obvious that the First Year Examination is of particular significance. A student who passes this examination has certainly been fully accepted by the university in accordance with its own criteria for assessment and any subsequent failure to graduate is indicative of faults in this assessment rather than any pre-university assessments. The restriction to first year has also the important advantage of allowing the analysis of very recent university and school examinations to be presented. Such analyses cannot, of course, provide definitive answers to many important questions concerning entry to third level, as many of these are essentially political in character. Statistical investigations can hopefully inform such political decisions and may encourage the various groups concerned to construct and agree on systems which are as just, reasonable and effective as can be, for selecting students for education and education for students.

## 2. SOME RELATED WORK

2.1 The literature on the predictive value of school leaving, scholastic aptitude and related tests for subsequent university performance is immense. Virtually all of this work has been undertaken outside Ireland and the only detailed research published in the Irish context has been Nevin (1974). Our review of such work will be confined to what we consider most relevant and useful in the Irish context. It is hoped that it may help to put our own study in some perspective.

2.2 Nevin's study concerned the relationship between performance in the Leaving Certificate, First University and Degree examinations and was based on 1,053 students who entered the Faculty of Science of University College Dublin over the period 1963–1967. She showed[1] that academic achievement improved with better leaving Certificate performance and that a pass at the First Science examination was a good predictor of a student's prospects of successfully completing a degree course. An earlier study by McHale (1971) gave details of pass rates according to number of C grades or better in the Leaving Certificate for various faculties with similar conclusions. A good balanced review of the Irish University selection procedures as operated in 1976 is provided by Raftery (1977). A more polemical account is provided by Beausang (1976, 1977). More recently a seminar[2] organised by the Irish Federation of University Teachers was devoted to "University Entrance Requirements and their effect on Second-Level curriculum".

2.3 In the UK numerous studies have been made of the relationship between performance at school and university levels. The problem of applying selection procedures is not as acute compared to Ireland as the ratio of university applicants to places is lower. The situation is also different to Ireland in that students in England are selected on the basis of a small number of subjects in which students have specialised for the GCE A level examination. In Scotland, however the curriculum is much wider than that pursued in England. University entrance requirements are based on performance in the Scottish Certificate of Education (SCE) examination. Powell (1973) reports on an investigation aimed at finding better predictive measures of academic performance in Scottish universities as a basis for improved selection procedures. A major objective was to discover whether, for purposes of university admission, scholastic aptitude tests would be a useful substitute or addition to the SCE examination. The study covered the 2,791 students who sat the SCE examination in 1962 and subsequently entered the five universities, Aberdeen, Dundee, Edinburgh,Glasgow and St. Andrews. Results of a Scholastic Aptitude Test[3] and school teachers' forecasts of success were also obtained for each student prior to entry. Two criteria of university performance were adopted; percentages passing at degree level and a points score which varied from 10 for first class honours degree obtained in the minimum time to 0 for students who dropped out after failing to pass in more than two subjects in their first university examination. The statistical methodology used was multiple regression of each of these criteria on various measures of SCE results and other predictive variables. Powell concluded that performance in the scholastic aptitude test was a very poor predictor of performance in the university and that its introduction, even as a supplementary measure to SCE results was unjustified. As far as SCE was concerned, the best predictive measures were the average of the four highest grades and a points score which took account of the number and quality of the grades obtained.

1 The $X^2$ and Kolmogorov tests are applied incorrectly in Tables 5 and 6 of Nevin which cross-tabulate degree class with points score.

2 The proceedings of this seminar, which was held in August 1978, were published in 1979 by the IFUT in a monograph entitled "University Entrance Requirements and their Effects on Second Level Curricula," editor J. Coolahan.

3 The College Entrance Examination Board Scholastic Apititude Test, Form HSAI (Education Testing Service, Princeton, New Jersey, USA).

2.4 An excellent and very perceptive review of three earlier studies of the relationship between academic scores at the university entrance stage and performance in the university itself is provided by Dale (1952). One of the three is a very extensive investigation by Saunders (1948) into the relation between performance at school and at university in Australia. Although this work was completed over thirty years ago, it is remarkable and still valuable for the sound choice of statistical method and the insight shown in the interpretation of analyses. Some of the features of the Australian education system then, still remain, and have parallels in Ireland. Among these are: a broad based school leaving examination; choice of honours or general degrees at university, adverse university staff/student ratios; and comparatively lower pass rates as compared with the UK. Saunders' general conclusion was that "In every Australian university there is evidence of a solid relationship between entrance examination results and the results in University First Year Examinations at least; but the extent of such demonstrable relationships is not such as to give grounds for any educational complacency".

## 3. THE DATA

3.1 The study reported in detail here is based on the 1,142 students who registered for first year courses in the six largest faculties of University College Cork in October 1976. Some results of a similar study for the corresponding 1972 entry will also be reported. For each student, entering in October 1976, details of age, sex, educational and other background were obtained. In particular full results for each student in the Leaving Certificate Examination and NUI Matriculation examination were recorded. Corresponding results in the subsequent first university examination held in Summer 1977 were also obtained. The data were transferred to computer files with, in the interests of confidentiality, students' names being replaced by code numbers. It was decided that the study should be confined to students who had entered UCC for the first time in 1976, thereby eliminating repeat students. Other students, as for example, foreign students who had not taken the Leaving Certificate Examination were also omitted as were the 2 per cent of students who registered in October but subsequently did not sit the examination the following Summer. The total number of students so excluded was 218 or 19 per cent of the original number registering.

3.2 The final number of students on which analyses were based was 924. Their distribution over the six major faculties was as follows:–

*TABLE 1:* **Distribution of students by faculty**

| | Faculty | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Arts | Commerce | Law | Medicine | Science | Engineering | |
| Number of students | 342 | 114 | 57 | 100* | 201 | 110 | 924 |

*This figure includes 24 pre-dental students who take an identical first year course to pre-medical students.

3.3 The age distribution of the students was much the same for the six faculties and is briefly summarised in Table 2.

*TABLE 2:* **Distribution of age by faculty**

| Age | Faculty | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Arts | Commerce | Law | Medicine | Science | Engineering | |
| 16–17 | 104(30%) | 30(26%) | 27(47%) | 37(37%) | 61(36%) | 42(33%) | 301(33%) |
| 18 | 175(51%) | 62(54%) | 26(46%) | 50(50%) | 104(52%) | 54(49%) | 471(51%) |
| 19 | 50(15%) | 16(14%) | 4( 7%) | 12(12%) | 31(15%) | 14(13%) | 127(14%) |
| 20 + | 13( 4%) | 6( 6%) | 0( 0%) | 1( 1%) | 5( 5%) | 0% | 25( 2%) |
| Total | 342 | 114 | 57 | 100 | 201 | 110 | 924 |

3.4 There were 372 females and 552 males and their distribution by faculty was as follows:--

*TABLE 3:* **Distribution of sex by faculty**

| | Faculty | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Arts | Commerce | Law | Medicine | Science | Engineering | |
| Number of females | 213 | 29 | 15 | 36 | 74 | 5 | 372 |
| Number of males | 129 | 85 | 42 | 64 | 127 | 105 | 552 |
| Percentage female | 62% | 25% | 36% | 36% | 37% | 5% | 40% |

As would be anticipated, there are substantial differences in the sex distribution between the faculties. While 40 per cent of all students are female, the percentage varies from 62 per cent in Arts to only 5 per cent in Engineering.

3.5 Performance in the Leaving Certificate Examination obviously varied considerably between the six faculties in view of the quotas in force for Medicine and Engineering, for example. The scoring scheme in operation in 1976 for obtaining a composite measure of performance in the Leaving Certificate and/or Matriculation Examinations is given in Table 4.

*TABLE 4:* **UCC Scoring scheme (1976) for Leaving Certificate and Matriculation examinations**

| Leaving Certificate Grades | | Matriculation Grades | Score |
|---|---|---|---|
| (Higher and Common Paper) | (Ordinary Paper) | | |
| A | – | I | 5 |
| B | – | II | 4 |
| C | – | III | 3 |
| D | A | IV | 2 |
| – | B | – | 1 |

A double score was awarded for grades A to D on the higher grade paper in Mathematics for the Leaving Certificate. A student who presented two or more Leaving Certificate Examinations was given the benefit of his best score in each individual subject, provided that results from at most two examinations, not necessarily consecutive, were combined.

3.6 The means and standard deviations of the points score calculated on the basis of Table 4 for the various faculties were as follows:–

*TABLE 5:* **Mean and Standard deviation of points score for each faculty**

| | Faculty | | | | | |
|---|---|---|---|---|---|---|
| | Arts | Commerce | Law | Medicine | Science | Engineering |
| Mean | 15.4 | 15.7 | 19.7 | 25.0 | 18.4 | 23.5 |
| Standard deviation | 3.5 | 3.6 | 2.9 | 3.0 | 4.8 | 3.7 |

3.7 In Table 6 are given details of the numbers of various Leaving Certificate grades contributing to the points scores for the six faculties where only the six best grades in the order A – D higher paper, A – D ordinary, E higher, E ordinary are counted for each student.

*TABLE 6:* **Distribution of six best Leaving Certificate grades for each Faculty**

| Faculty (Number of students) | Higher and common papers | | | | | Ordinary papers | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | A | B | C | D | E |
| Arts (342) | 16 | 246 | 948 | 477 | 3 | 8 | 81 | 186 | 81 | 3 |
| Commerce (114) | 3 | 50 | 340 | 171 | 3 | 4 | 37 | 52 | 24 | 0 |
| Law (57) | 7 | 71 | 159 | 84 | 2 | 0 | 13 | 5 | 1 | 0 |
| Medicine (100) | 35 | 256 | 265 | 40 | 0 | 1 | 2 | 1 | 0 | 0 |
| Science (201) | 29 | 178 | 544 | 316 | 2 | 8 | 43 | 63 | 22 | 0 |
| Engineering (110) | 50 | 195 | 295 | 100 | 0 | 2 | 5 | 11 | 2 | 0 |
| Totals (924) | | | | | | | | | | |

Table 6 reveals in a rather dramatic fashion the substantial differences in nominal ability at least between students entering different faculties.

3.8 In Table 7 is given the mean and standard deviations of points score according to the total number of distinct Leaving Certificate subjects taken in a maximum of two examinations.

*TABLE 7:* **Points score by total number of Leaving Certificate subjects taken in one or two examinations**

| Number of subjects | Number of Students | Mean score | Standard deviations |
|---|---|---|---|
| 5 | 3 | 17.0 | 8.5 |
| 6 | 154 | 17.7 | 5.5 |
| 7 | 587 | 18.5 | 5.0 |
| 8 | 147 | 18.6 | 5.0 |
| 9 | 30 | 18.0 | 4.6 |
| 10 | 3 | 19.3 | 4.1 |

There is a tendency for the mean score to increase as the number of subjects taken increases with a peak at 7 to 8 subjects. The points scores quoted are, of course, those actually used in 1976 and therefore contain a contribution from the matriculation examination which accounts for the anomalous result in the first row of the table. Our attention in this paper will be confined to the Leaving Certificate Examination but it is worth mentioning that analysis of the contribution of matriculation grades shows that their role is very subsidiary to grades in the Leaving Certificate.

3.9 In Table 8 is given the corresponding breakdown of mean points scores according to total number of Leaving Certificate subjects taken at higher or common level.

*TABLE 8:* **Points score by total number of Leaving Certificate subjects taken at higher or common level in one or two examinations**

| Number of subjects | Number of Students | Mean score | Standard deviations |
|---|---|---|---|
| 3 | 23 | 10.8 | 4.0 |
| 4 | 129 | 13.4 | 3.0 |
| 5 | 234 | 16.3 | 3.4 |
| 6 | 350 | 19.5 | 4.0 |
| 7 | 159 | 23.2 | 4.8 |
| 8 | 24 | 23.1 | 4.2 |
| 9 | 5 | 24.0 | 3.3 |

The tendency for the means points score to increase with increasing numbers of subjects is more marked than in Table 7, with diminishing marginal returns setting in again at about 7 or 8 subjects. Even though the points scheme then as now takes account of only the six highest grades, it would seem that students taking 7 to 8 subjects at higher or common level obtained the highest points scores on average. It does not follow, of course, that those who did take six would have been better to have taken an additional subject or two, but nine or more look excessive for the purposes of optimising one's points score.

## 4. THE RELATIONSHIP BETWEEN PASS RATE AND POINTS SCORE

4.1 Two obvious criteria of performance in the first university examination held in summer are pass/did not pass and the average mark attained. While the two are obviously related they do contain independent information on a student's performance. For example, a student who passed all subjects but one could have a higher average mark than a student who narrowly passed all subjects. A pass is awarded on the basis of a certain minimum standard in each subject of the examination and is the criterion of university performance considered in this section. As a measure of performance in the Leaving Certificate examination we have adopted the points scheme described in Table 4 but with single scoring for Mathematics and neglect of the Matriculation contribution. Points scores quoted subsequently in this section will therefore have been calculated solely on the basis of performance in a maximum of two Leaving Certificate examinations.

*TABLE 9:* **Means and Standard deviations of points score for each faculty**

| | Faculty | | | | | |
|---|---|---|---|---|---|---|
| | Arts | Commerce | Law | Medicine | Science | Engineering |
| Mean | 14.5 | 14.2 | 17.1 | 20.8 | 15.8 | 19.3 |
| Standard deviations | 3.3 | 3.4 | 3.0 | 2.6 | 3.9 | 3.6 |

4.2 In Table 9 we present means and standard deviations of the points scores as defined in 4 1 for different faculties.

Further tabulations on the lines of Section 3.5 lead to similar conclusions.

4.3 In Table 10, we present a summary of the percentages passing in each faculty for 12 levels of points score. Table 11 gives the corresponding frequencies. It should be remembered that these results refer to the summer 1977 examination only. A supplementary examination is held in autumn for those who did not pass in summer and the overall pass rate is much higher.

One might expect that there would be some variation in pass rates between faculties even for students with similar points scores and this is confirmed by standard chi-squared tests for some of the columns of Table 11. Despite such variation however, it is clear that in every faculty the pass rate increases with points score and that there are clear-cut differences between the pass rates of students with high and low points scores respectively. A formal statistical test for the existence of the relationship is superfluous and what is needed is a suitable model.

4.4 Considering for the moment just a single faculty, let $p_i$ be the probability that a student with points score $x_i$ passes the summer examination in that faculty. In the light of Table 10 the probability $p_i$ may reasonably be taken to be a monotonically increasing function of $x_i$. One possible choice is the so-called linear probability function, $p_i = \alpha + \beta x_i$, with $\beta > 0$. Estimation of this relationship, if problems such as appropriate weighting are overlooked, may be carried out quite easily by simple regression of a binary variable taking the values 0 and 1 on the points score x. A serious objection to such a model is that it leads to estimates of $p_i$ outside the range 0 to 1. It is clearly unsuitable in this instance with high scoring students virtually certain to pass.

4.5 The simplest alternative, perhaps, is to assume a relationship of the form

$$p_i = \frac{e^{\alpha + \beta x_i}}{1 + e^{\alpha + \beta x_i}} \quad , \quad \beta > 0 \qquad (1)$$

or equivalently

$$\log_e \left(\frac{p_i}{1 - p_i}\right) = \alpha + \beta x_i$$

implying that the logarithm of the odds of passing is taken as a linear function of the points score. An extended account of the use of this model for the analysis of binary data is provided by Cox (1970).

*TABLE 10:* **Pass rate (%) by points score for each Faculty**

| Faculty | Points score | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ⩽ 8 | 9–10 | 11–12 | 13–14 | 15–16 | 17–18 | 19–20 | 21–22 | 23–24 | 25–26 | 27–28 | ⩾ 29 |
| Arts | 86 | 42 | 51 | 54 | 68 | 82 | 75 | 100 | 100 | – | – | – |
| Commerce | 75 | 50 | 60 | 74 | 96 | 77 | 100 | 100 | – | – | – | – |
| Law | – | – | 100 | 83 | 95 | 85 | 100 | 100 | 100 | – | – | – |
| Medicine | – | – | – | 100 | 80 | 86 | 90 | 88 | 100 | 100 | 100 | – |
| Science | 0 | 14 | 15 | 46 | 42 | 61 | 90 | 94 | 75 | 100 | 100 | 100 |
| Engineering | – | – | 33 | 33 | 50 | 60 | 62 | 94 | 89 | 88 | 100 | 100 |



*TABLE 11:* **Pass rate (fractions) by Points Score for each Faculty***

| Faculty | Points score | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ⩽ 8 | 9–10 | 11–12 | 13–14 | 15–16 | 17–18 | 19–20 | 21–22 | 23–24 | 25–26 | 27–28 | ⩾ 29 |
| Arts | 6/7 | 13/31 | 29/57 | 48/88 | 54/79 | 37/45 | 15/20 | 12/12 | 4/4 | – | – | – |
| Commerce | 3/4 | 5/10 | 12/20 | 23/31 | 24/25 | 10/13 | 10/10 | 1/1 | – | – | – | – |
| Law | – | – | 2/2 | 5/6 | 19/20 | 11/13 | 7/7 | 6/6 | 3/3 | – | – | – |
| Medicine | – | – | – | 2/2 | 4/5 | 6/7 | 34/38 | 21/24 | 15/15 | 8/8 | 1/1 | – |
| Science | 0/6 | 1/7 | 3/20 | 25/54 | 17/40 | 19/31 | 17/19 | 15/16 | 3/4 | 2/2 | 1/1 | 1/1 |
| Engineering | – | – | 1/3 | 1/3 | 10/20 | 18/30 | 10/16 | 17/18 | 8/9 | 7/8 | 2/2 | 1/1 |

*The numerator of each fraction is the number passing while the denominator is the number sitting the examination.

If $n_i$ denotes the number of students with points score $x_i$ for the faculty in question then $r_i$, the number who pass, will be taken to have a binomial distribution with parameters $n_i$ and $p_i$. Equations for $\alpha$ and $\beta$ in (1) may be obtained by the method of maximum likelihood. The equations, which resemble those for weighted linear regression, must be solved iteratively and provide in addition to estimates $\hat{\alpha}$ and $\hat{\beta}$ also estimates of their large-sample standard errors (s.e.). Substitution of $\hat{\alpha}$ and $\hat{\beta}$ in (1) provides $\hat{p}_i$ and hence expected frequencies from which a standard goodness of fit statistic with k-s d.f. may be constructed, where k is the number of distinct points scores and s is the number of parameters fitted.

**4.6** In the case of the Science Faculty, for example, the estimates ± s.e. of $\alpha$ and $\beta$ obtained from the original data are $-5.09 \pm 0.88$ and $0.33 \pm 0.06$ respectively. A plot of the observed and fitted pass rates for the various points scores is given in Figure 1. The value of the chi-squared statistic (log-likelihood ratio) for goodness of fit is 20.4 with 22 d.f. As a further check on the fitted model the standardised residuals

$$\frac{r_i - n\hat{p}_i}{\sqrt{n_i\hat{p}_i(1-\hat{p}_i)}}$$

may be calculated. Their distribution should resemble a standardised normal distribution and their plot on normal probability paper should approximate a straight line. Such a plot is presented in Figure 2 which again suggests that the assumed model is adequate.

FIGURE 1.
Observed and fitted pass rates for Science

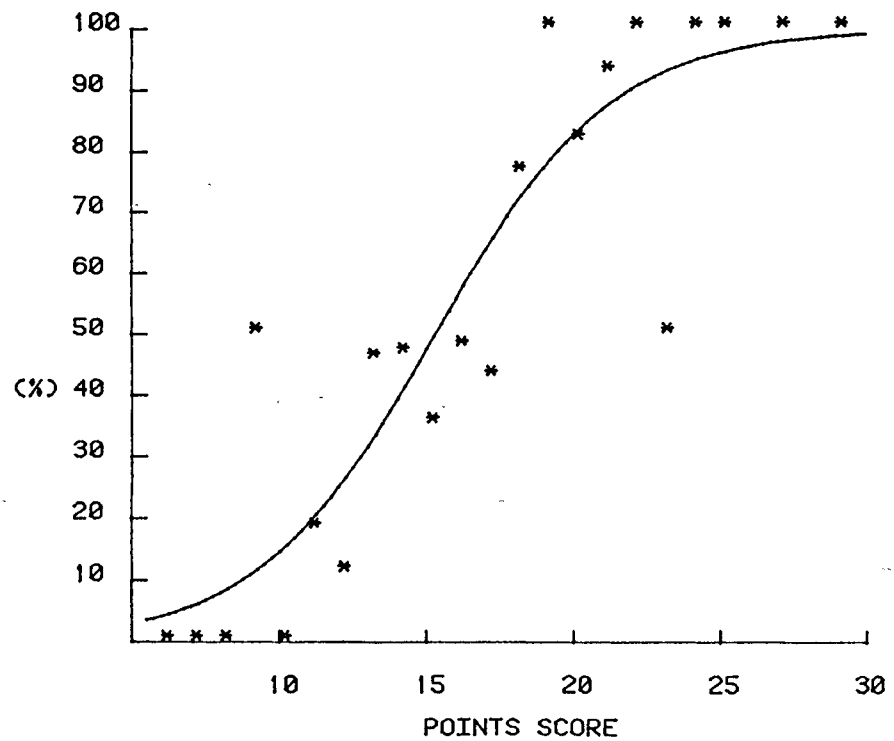
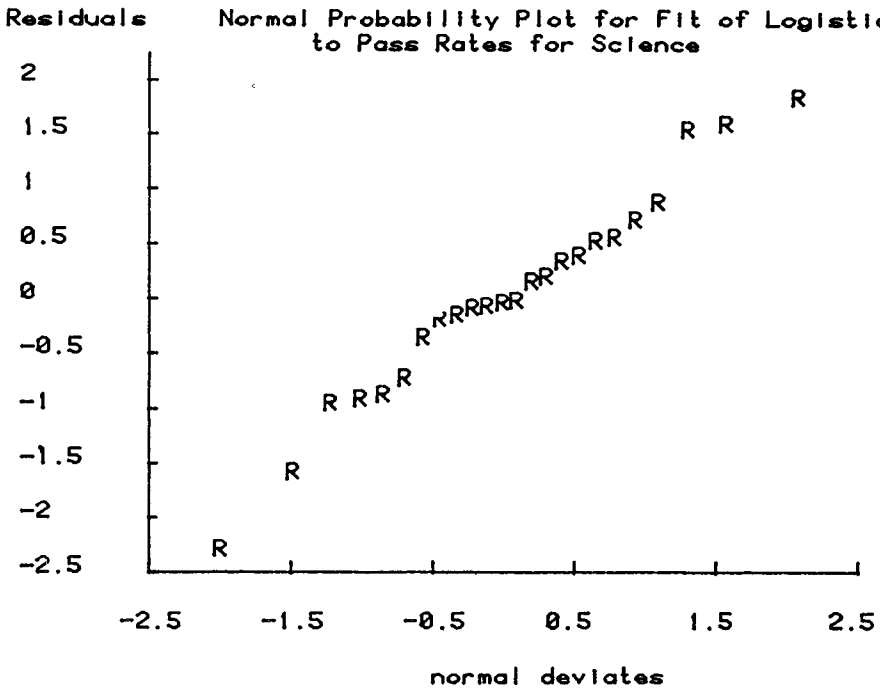


FIGURE 2




4.7 In view of the variation between faculties in pass rates for students with similar points scores it is clear that a separate relationship of the form

$$p_{ij} = \frac{e^{a_j + \beta_j x_i}}{1 + e^{a_j + \beta_j x_i}}$$

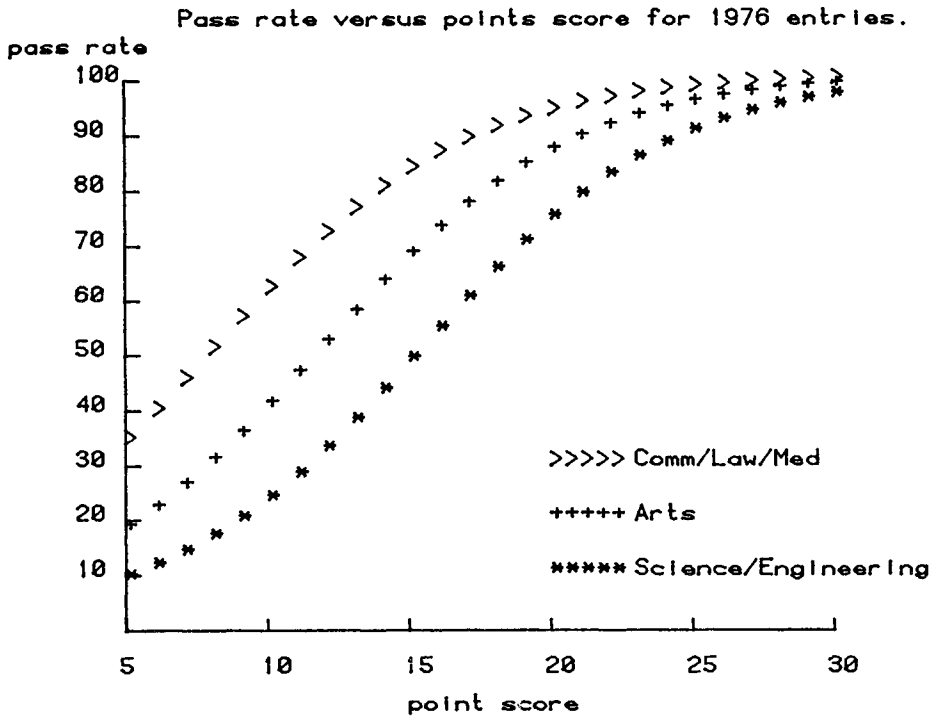
where $p_{ij}$ is the probability of passing for points score $x_i$ in the $j^{th}$ faculty might be required for each faculty. A likelihood ratio test of whether $\beta_1 = \beta_2 \ldots = \beta_6$ gives a $\chi^2$ statistic of 6.55 with 5df, P = 0.26, indicating that the data are consistent with a common value of $\beta$ for all faculties. In other words, the rate of increase of log-odds with points score is the same for all faculties. Subsequent tests for differences between $a_1, a_2, \ldots a_6$ indicate that three separate coefficients are required for Arts; Law, Commerce, Medicine; Science and Engineering. Estimates of the coefficients and their standard errors are given in Table 12.

*TABLE 12:* **Coefficients for the dependence of pass rate on points score for students entering UCC in 1976**

| Faculty | Coefficients | |
|---|---|---|
| | $a_j \pm$ s.e. | $\beta \pm$ s.e. |
| Arts | $-2.648 \pm 0.50$ | |
| Commerce, Law, Medicine | $-1.793 \pm 0.40$ | $0.226 \pm 0.024$ |
| Science, Engineering | $-3.451 \pm 0.54$ | |

A plot of the three relationships is given in Figure 3. For a given points score, the pass rates from high to low are Commerce, Law, Medicine; Arts; Science and Engineering. The presence of Medicine in the first group is surprising given the substantial overlap between the Pre-Medical and Pre-Dental first year course and that of First Science. While it is true that the courses taken by medical and dental students are certainly less difficult than those prescribed for first Engineering and optionally taken by many Science students, we feel that motivation is also an important factor and that further breakdown of the Science results according to subject and level would be informative.

FIGURE 3.

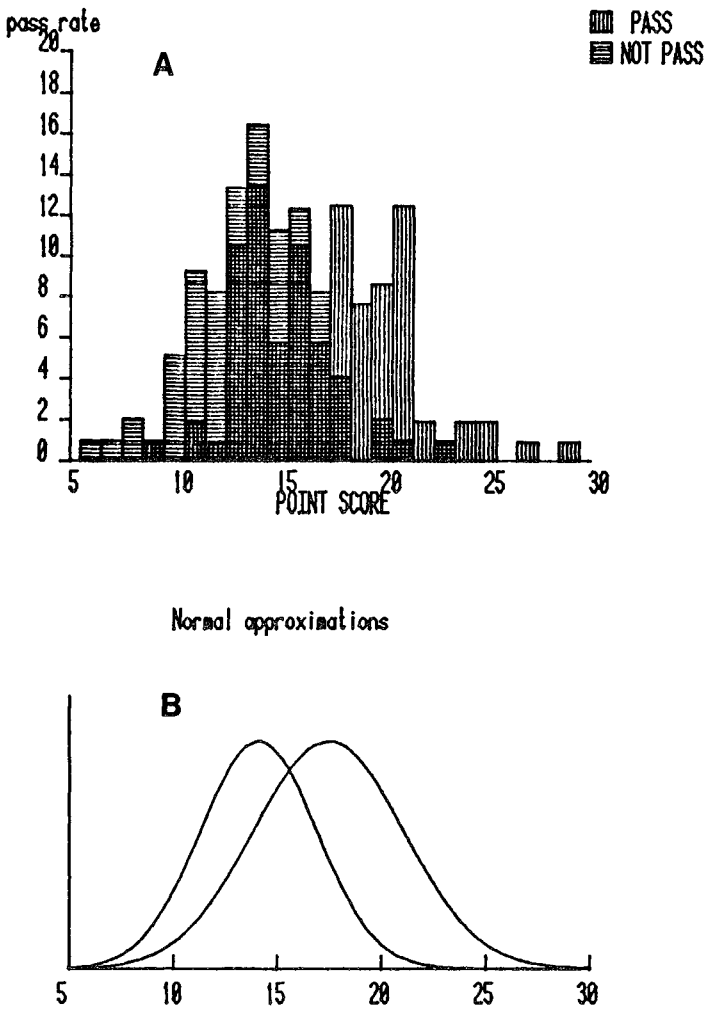



4.8 In view of the pronounced relationship between performance in the LCE and subsequent performance in first year university, one might be inclined to suggest that an increase in the pass rate for many faculties could be achieved by raising the points score required for entry. (There is no implication here that university teachers are not very concerned to increase the pass rate through their own efforts or that they feel no responsibility in the matter). An alternative presentation of the results for Science in terms of the distributions of points scores for students who pass and those who do not pass shows the flaw in the above suggestion and reveals the limited predictive ability of the points system. There is a *substantial overlap* in the distributions of points score for the two groups as shown by the corresponding histograms in Figure 4(a). Normal curves have been fitted to the two distributions to further illustrate the amount of overlap and these are presented in Figure 4(b). It is worth noting that it is the difference in

mean points score for the two groups expressed in units of within group standard deviation that essentially determines the amount of overlap and not the value of the conventional t-statistic for testing the difference in means. While the latter is often quoted and will indicate the evidence for a difference, it is the magnitude of the difference that will determine its usefulness, if any, for purposes of selection. In the case of Science, it is obviously impossible to deny entry to many who will not pass without substantially raising the minimum entry standard and, therefore, dramatically reducing the number of students permitted to enter.

FIGURE 4

Pass/Did Not Pass Distribution Of Point Score In Science




4.9 A similar analysis of the dependence of pass rate on points score was undertaken for a comparable cohort of 715 students who entered UCC in autumn 1972 and whose results were previously studied by Buckley (1977). The sequence of tests described in 4.7 indicates that a summary in terms of the faculty groups Arts;

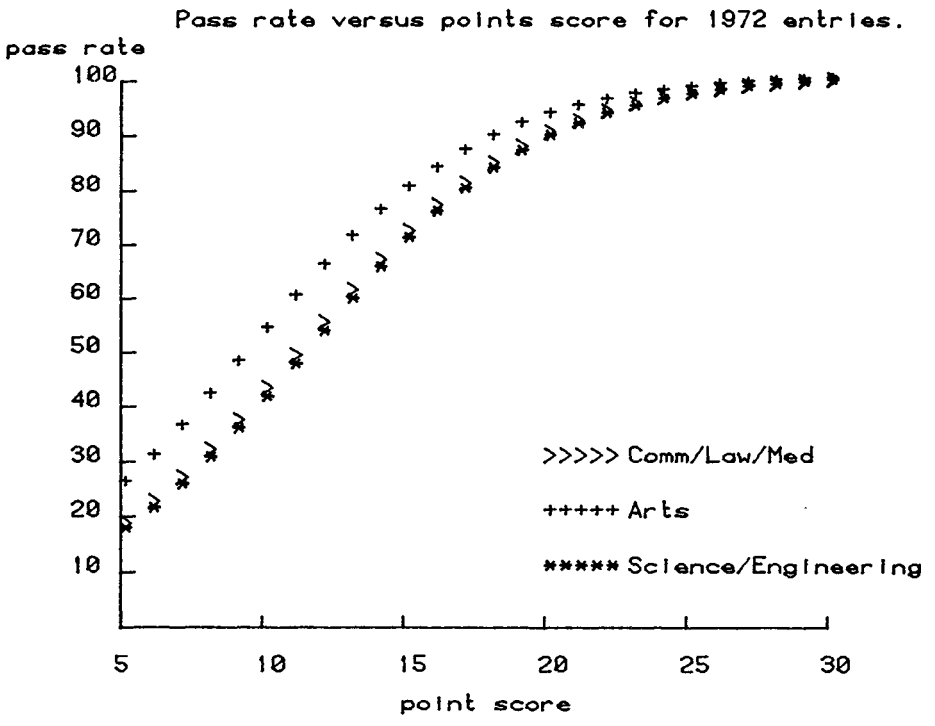
Commerce, Law, Medicine; Science and Engineering is again possible. Estimated coefficients for the three relationships are presented in Table 13 and corresponding plots are given in Figure 5.

*TABLE 13:* **Coefficients for dependence of pass rate on points score for students entering UCC in 1972**

| Faculty group | Coefficients | |
|---|---|---|
| | $\alpha_j \pm$ s.e. | $\beta \pm$ s.e. |
| Arts | $-2.32 \pm 0.39$ | |
| Commerce, Law, Medicine | $-2.77 \pm 0.41$ | $0{:}246 \pm 0.027$ |
| Science, Engineering | $-2.83 \pm 0.39$ | |

A comparison with the corresponding results in Table 12 and Figure 3 respectively for students entering UCC in 1976 has some unexpected features. It indicates that in terms of pass rate at the first university examination in Arts, Science and Engineering, 1976 points scores are worth less than their nominal equivalents in 1972, but that the opposite is true for Commerce, Law and Medicine. The latter result conflicts with the assertion sometimes made that there has been a general decline in the level of performance required to achieve specific grades in the Leaving Certificate over the years when this level is assessed in terms of subsequent university results. There have also been some changes in the mean points score between 1972 and 1976 but these are fairly modest with, for example, increases of approximately two points in the case of Medicine and Engineering

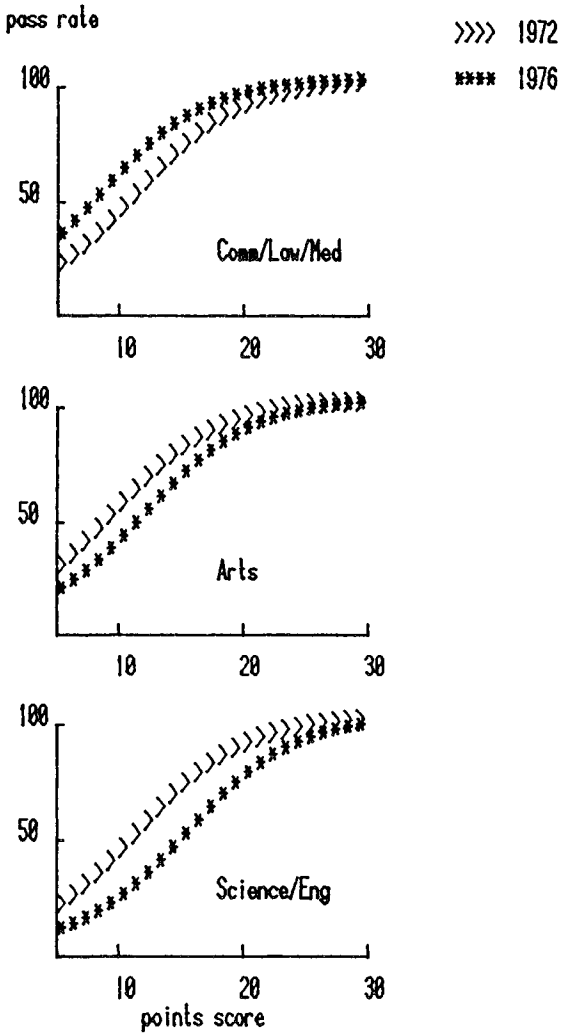
FIGURE 5.



and decreases of one point in Arts and Science. The estimates of $\beta$ for the two years are very similar and a combined estimate $0.235 \pm 0.018$ can be obtained. Plots which compare the dependence of pass rate on points score for the two years calculated on this basis for each of the Faculty groupings are presented in Figure 6. They show that the change in pass rates can be substantial for students with intermediate points scores and, whatever about variations in Leaving Certificate standards, they certainly reveal variations in university standards.

FIGURE 6.

Pass rate versus point score compared for 1972 and 1976 entries



## 5. ANALYSIS OF SCORING SCHEMES

5.1 One of the objectives of this study was to examine the optimality and sensitivity of the scoring scheme currently adopted for Leaving Certificate grades. Attention was confined to schemes, like the current system, which are simply linear combinations of the numbers of various grades. Thus, for example, three higher level B grades will contribute three times as many points as a single B grade and points from different grades are simply added to obtain an overall points score. As in Section 4.1 all subjects are treated equally and the question of the special position given to higher level grades in Mathematics will be considered later.

5.2 The measure of performance in the first year university examination adopted here is the average mark in all subjects taken at general level. Pass/did not pass was also investigated but one would hope that average mark would contain some additional information particularly in situations such as Medicine where virtually all students pass. The restriction to performance in subjects taken at general level is not as restrictive as it might seem. In many instances, a common paper is set and in others, students doing honours take the general paper in addition to the honours paper. In the minority of cases where mutually exclusive level papers were set, there was no obvious means of converting an honours mark to an equivalent general mark and the measure of performance was taken as the average mark in the remaining subjects.

5.3 NUI matriculation requirements on the basis of the Leaving Certificate require among other things that a student have at least six grades of D or more on higher or lower papers. Points scores were estimated in our analysis on the basis of the best six scoring subjects where grades in the range A–D on both level papers were admitted as possible contributors. The choice of the six best subjects poses a problem in the sense that while A may reasonably take precedence of B on higher level papers and likewise on ordinary level papers, it is not obvious that A at ordinary level should be regarded as equivalent to D on a higher level paper as is the case at present. For the moment we shall assume that the four higher level grades, A–D, take precedence over the corresponding ordinary level grades. On that basis each student's Leaving Certificate result for the purpose of scoring consists of the values of eight variables $x_1, x_2, \ldots, x_8$ as defined in Table 14.

*TABLE 14.* **The eight variables used to define Leaving Certificate performance for the purpose of scoring**

| Variable | Interpretation | |
|---|---|---|
| $x_1$ | No. of A grades | higher level |
| $x_2$ | No. of B grades | |
| $x_3$ | No. of C grades | |
| $x_4$ | No. of D grades | |
| $x_5$ | No. of A grades | ordinary level |
| $x_6$ | No. of B grades | |
| $x_7$ | No. of C grades | |
| $x_8$ | No. of D grades | |

In view of the matriculation requirement mentioned above each student has at least six subjects and hence $x_1 + x_2 + \ldots + x_8 = 6$ for all[4] students.

**5.4** If y denotes average first year mark as defined in Section 5.2, the usual model for regression of y on the variables $x_1, x_2 \ldots, x_8$ assumes

$$E(y) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_8 x_8 \qquad (2)$$

It will be seen that $\beta_1, \beta_2, \ldots, \beta_8$ are immediately interpretable as the appropriate points for the corresponding Leaving Certificate grades which will provide a points score having *maximum* correlation with average first year mark. The restriction

$$x_1 + x_2 + \ldots + x_8 = 6 \qquad (3)$$

however, implies that the $\{\beta_i\}$ cannot be uniquely estimated. The singularity can be removed by eliminating one of the $\{x_i\}$ from (2). If $x_8$, the number of ordinary grade D's is omitted, the model becomes

$$E(y) = (\beta_0 + 6\beta_8) + (\beta_1 - \beta_8)x_1 + (\beta_2 - \beta_8)x_2 + \ldots + (\beta_7 - \beta_8)x_7$$
$$= \beta_0' + \beta_1' x_1 + \beta_2' x_2 + \ldots + \beta_7' x_7$$

which is now of full rank allowing each $\beta_i'$ to be uniquely estimated. The coefficients so estimated represent the differences in points for each grade and the points for ordinary grade D. In some faculties no student will have an ordinary grade D and the model (2) with restriction (3) will apply for a smaller number of grades. In all cases, therefore, the optimum points to assign to Leaving Certificate grades may be obtained by straightforward multiple regression. If pass/did not pass is used as the criterion of university performance, a version of the model discussed in Section 4.5 may be used instead.

**5.5** The multiple regression described in the previous section was carried out for each faculty and the coefficients of squared multiple correlation $R^2$ given in Table 15 were obtained.

*TABLE 15:* **Values of $R^2$ for regression of average first year mark on all Leaving Certificate grades**

| Faculty | Arts | Commerce | Law | Medicine | Science | Engineering |
|---|---|---|---|---|---|---|
| $R^2$ | 0.15 | 0.32 | 0.33 | 0.28 | 0.49 | 0.51 |

Those values set an *upper* limit, therefore, on the $R^2$ attainable by points scores based on the six best grades selected in the order stated in 5.3. For each faculty the same regressions were performed for alternative orderings of the higher grades C, D and the lower grades A, B, C and D. The effect on the value of $R^2$ or on the values of the individual regression coefficients was very slight.

**5.6** It will be recognised that even when ordinary grade D and indeed further grades are omitted from the model, the total of the remaining grades will continue to add to six for many students. This results in a very high degree of inter-correlation

4 There were, as indicated in Table 7, three exceptions who had only five Leaving Certificate subjects which they had to supplement with Matriculation Examination results.

*TABLE 16:* **Optimum points for each grade as determined by multiple regression**

| Faculty | Grade | Number of grades | Points (s.e.) |
|---|---|---|---|
| *Arts* | Higher A | 16 | 6.5 (1.9) |
| | Higher B | 246 | 3.2 (0.6) |
| $R^2 = 0.13$ | Higher C | 948 | 2.5 (0.5) |
| | Higher D | 477 | 1.3 (0.6) |
| (342)* | Ordinary A | 8 | 3.4 (3.0) |
| | Ordinary B | 81 | 2.0 (1.0) |
| *Commerce* | Higher A | 3 | 2.6 (1.4) |
| | Higher B | 50 | 4.5 (4.2) |
| $R^2 = 0.24$ | Higher C | 340 | 3.0 (0.9) |
| | Higher D | 171 | 1.0 (0.9) |
| (114) | Ordinary A | 4 | 7.0 (3.7) |
| | Ordinary B | 37 | 0.2 (1.4) |
| *Law* | Higher A | 7 | 6.5 (3.1) |
| | Higher B | 71 | 1.2 (2.4) |
| $R^2 = 0.31$ | Higher C | 159 | 0.8 (2.6) |
| | Higher D | 84 | -1.3 (2.4) |
| (57) | Ordinary A | – | – – |
| | Ordinary B | 13 | -0.3 (3.2) |
| *Medicine* | Higher A | 35 | 5.1 (10.7) |
| | Higher B | 256 | 1.0 (10.6) |
| $R^2 = 0.28$ | Higher C | 265 | -1.8 (10.7) |
| | Higher D | 40 | -1.0 (10.8) |
| (100) | Ordinary A | 1 | -1.8 (14.9) |
| | Ordinary B | 2 | -1.6 (13.0) |
| *Science* | Higher A | 29 | 14.9 (1.8) |
| | Higher B | 178 | 8.8 (1.2) |
| $R^2 = 0.48$ | Higher C | 544 | 5.4 (1.2) |
| | Higher D | 316 | 2.6 (1.2) |
| (201) | Ordinary A | 8 | -4.9 (4.4) |
| | Ordinary B | 43 | -2.7 (2.2) |
| *Engineering* | Higher A | 50 | 7.7 (2.4) |
| | Higher B | 195 | 3.7 (2.4) |
| $R^2 = 0.51$ | Higher C | 295 | 0.8 (2.3) |
| | Higher D | 100 | -0.9 (2.6) |
| (110) | Ordinary A | 2 | 3.0 (6.8) |
| | Ordinary B | 5 | -1.0 (4.6) |

*Number of students.

between the remaining $\{x_i\}$ making estimates of individual $\beta_i$ very unreliable. In view of this, lower grades C and D were also omitted from the regression and average first year mark was regressed on numbers of higher grades A, B, C, D and lower grades A and B. The values of $R^2$ together with the points ± s.e. awarded to each grade are given in Table 16.

It must be remembered that the scoring scheme for any individual faculty may be altered by multiplication by an arbitary constant without altering the value of $R^2$ for that faculty. As may be seen from Table 16 points to be assigned to the

various Leaving Certificate grades have large standard errors in many cases. In some instances, for example Medicine, this is due to multi-collinearity as mentioned above but in general it shows that a wide range of scoring schemes will give comparable results to the optimal scheme. It can be seen from Table 16, however, that with the exception of Commerce, the grades on the higher papers are in the appropriate order[5] and that A receives relatively more than B than is the case at present. By inspection some simpler scoring schemes were devised which approximated to the optimum system where it is assumed that a single scheme is to be used for all faculties. The values of $R^2$ for the alternative schemes for each faculty are tabulated in Table 17.

*TABLE 17.* **Value of $R^2$ for relationship of average first year mark to points score for some alternative scoring schemes**

| Faculty | Scoring scheme | | | | |
|---|---|---|---|---|---|
| | 543221 | 742110 | 853210 | 842110 | 632110 |
| Arts | 0.11 | 0.10 | 0.11 | 0.10 | 0.11 |
| Commerce | 0.20 | 0.20 | 0.21 | 0.19 | 0.20 |
| Law | 0.21 | 0.24 | 0.26 | 0.25 | 0.26 |
| Medicine | 0.23 | 0.26 | 0.24 | 0.26 | 0.25 |
| Science | 0.43 | 0.46 | 0.46 | 0.46 | 0.47 |
| Engineering | 0.45 | 0.50 | 0.50 | 0.50 | 0.49 |

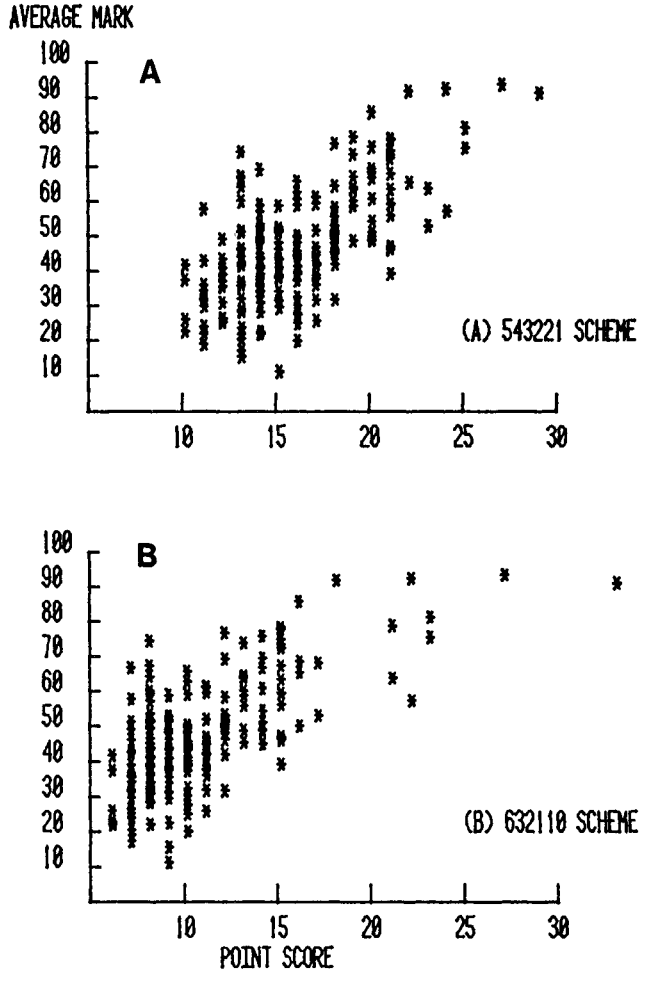
In general the largest values of $R^2$ are given by the sequence A–6, B–3, C–2, D–1 for higher and common grades and A–1 for ordinary grades, but as already noted, a wide variety of scoring schemes give comparable results. In any event, the values of $R^2$ cannot exceed the maxima given in Table 15. A similar study by Buckley (1977) on the 1972 entry for the same faculties also indicated that the higher grades A and B are undervalued in the points system as operated at present. The numbers of ordinary grades is relatively limited and determination of their appropriate weighting is really not possible.

Scatter diagrams of average pass mark versus points score as calculated using the existing 543221 scheme and the suggested alternative 632110 scheme are given in Figures 7(a) and 7(b) respectively. The plots serve to highlight the considerable variability in average marks of student with a given points score. They also show that the relationship between average mark and score, such as it is, is linear. Values of R as high as 0.7 such as those obtained in this study for Science and Engineering are often quoted in defence of the points system. The scatter plot and more particularly Figure 4 show just how *small* a correlation of 0.7 is if one wants to use it for prediction. While the values of $R^2$ may reasonably be used to compare alternative points systems within the one faculty, inter-faculty comparisons on the basis of $R^2$ are not possible in view of the widely different marginal distributions of points score in the six faculties.

**5.7** The analysis of Section 5.5 adopted the average mark for the summer examination in each faculty as the criterion of university performance. As absolute marks in

5 The natural order of the grades may be incorporated as constraints in a quadratic programming model. This was done with similar conclusions as from the multiple regression.

FIGURE 7.
SCATTER DIAGRAMS FOR SCIENCE




individual subjects are not directly comparable, even within a faculty, in view of variation in marking patterns between individual subjects and examiners, some alternatives to the simple average of the raw marks were considered. One of these was the average of the standardised marks where the raw mark y in a particular subject is replaced by $z = (y - \bar{y})/s$, where $\bar{y}$ and s are the mean and standard deviation for that subject. It was hoped that this standardisation would have most to offer in the case of Arts where students have a wide variety of first year courses and the average of raw marks could be misleading in regard to the ranking of students above and below the pass line. As it turned out, the value of $R^2$ for Arts was 0.18 when the average of the standardised marks was taken as the dependent variable as compared with 0.13 when the average of the raw marks is used. The order of magnitude however, is much the same as is the points given to the various Leaving Certificate grades.

In contrast to Arts, all Engineering students take the same four subjects in

first year and a more refined index of university performance as related to the Leaving Certificate may be obtained using a canonical correlation analysis. The two sets of variables in the analysis are: $x_1, x_2, \ldots, x_6$ the numbers of Leaving Certificate grades as defined in Table 14, and $y_1, y_2, y_3, y_4$, the marks in the four subjects in the first Engineering examination. A standard canonical analysis was applied to obtain the canonical variates as successive linear combinations $\sum_{i=1}^{6} \beta_i x_i$ and $\sum_{j=1}^{4} a_j y_j$. The first two linear combinations are those which have maximum correlation $R_1$, the first canonical correlation; then from all linear combinations uncorrelated with these, a second pair of linear combinations is obtained having maximum correlation $R_2$ and so on. The results of the canonical analysis are set out in Table 18.

The statistical significance of the overall association between the x and y variables as assessed by an approximate $\chi^2$ test, Bartlett (1951), is obvious. The contribution of the three smaller roots has a significance level of only 13 per cent and we conclude that the overall association is primarily associated with the first pair of canonical variates. Although the best linear index of university performance

*TABLE 18:* **Canonical correlation analysis for Faculty of Engineering**

| Canonical correlations (squared) | | Test for association | |
|---|---|---|---|
| $R_1^2 = 0.51$ | | $\chi^2$ | df |
| $R_2^2 = 0.10$ | Total | 93.6 | 24 |
| | $R_1^2$ | 72.5 | 9 |
| $R_3^2 = 0.09$ | Remaining roots | 21.1 | 15 (P = 0.13) |
| $R_4^2 = 0.01$ | | | |

| Leaving Certificate grades | Mean | s.d. | Coefficients of first canonical variate |
|---|---|---|---|
| $x_1$ No. of Higher A grades | 0.45 | 0.97 | 0.70 |
| $x_2$ No. of Higher B grades | 1.74 | 1.35 | 0.35 |
| $x_3$ No. of Higher C grades | 2.69 | 1.52 | −0.27 |
| $x_4$ No. of Higher D grades | 0.91 | 1.10 | −0.28 |
| $x_5$ No. of Ordinary A grades | 0.02 | 0.13 | 0.01 |
| $x_6$ No. of Ordinary B grades | 0.06 | 0.23 | −0.00 |

| First University Results<br>Subject | Mean | s.d. | Coefficients of first canonical variate |
|---|---|---|---|
| $y_1$ | 53.4 | 18.4 | 10.5 |
| $y_2$ | 59.2 | 22.2 | 1.8 |
| $y_3$ | 55.4 | 17.5 | 5.8 |
| $y_4$ | 54.3 | 13.3 | 2.0 |

in terms of the correlations with the Leaving Certificate grades gives different weights to the four Engineering subjects we note that the improvement in $R^2$ over the single average of the four raw marks is marginal and that the weights given to the different Leaving Certificate grades are very similar to those obtained previously.

5.8 Our treatment so far has been directed towards optimisation of a linear points system based on the six best subjects where all subjects are treated equally. We now look briefly at what information might be extracted from a Leaving Certificate performance over and above that contained in the points score. For this purpose subjects for the Leaving Certificate were divided into two groups, Science and non-

*TABLE 19:* **Correlation coefficients between the average mark in the First Year University Examination and certain measures of performance in the Leaving Certificate Examination**

Variables
y = Average mark in First Year University Examination
$x_1$ = Points score
$x_2$ = Average grade in science subjects
$x_3$ = Average grade in non-science subjects
$x_4$ = Average grade in all subjects
} all calculated on 543221 basis.

Arts (n=342)

| | y | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|---|---|---|---|---|---|
| y | 1.00 | 0.33 | 0.28 | 0.20 | 0.34 |
| $x_1$ | – | 1.00 | 0.47 | 0.68 | 0.86 |
| $x_2$ | *0.15* | – | 1.00 | 0.08 | 0.42 |
| $x_3$ | *-0.03* | – | – | 1.00 | 0.85 |
| $x_4$ | *0.12* | – | – | – | 1.00 |

Commerce (n=114)

| | y | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|---|---|---|---|---|---|
| y | 1.00 | 0.45 | 0.48 | 0.22 | 0.51 |
| $x_1$ | – | 1.00 | 0.53 | 0.61 | 0.87 |
| $x_2$ | *0.32* | – | 1.00 | –0.02 | 0.58 |
| $x_3$ | *-0.08* | – | – | 1.00 | 0.74 |
| $x_4$ | *0.27* | – | – | – | 1.00 |

Law (n=57)

| | y | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|---|---|---|---|---|---|
| y | 1.00 | 0.46 | 0.13 | 0.34 | 0.40 |
| $x_1$ | – | 1.00 | 0.28 | 0.73 | 0.86 |
| $x_2$ | *0.00* | – | 1.00 | –0.05 | 0.44 |
| $x_3$ | *0.01* | – | – | 1.00 | 0.81 |
| $x_4$ | *0.01* | – | – | – | 1.00 |

Medicine (n=100)

| | y | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|---|---|---|---|---|---|
| y | 1.00 | 0.48 | 0.47 | 0.26 | 0.52 |
| $x_1$ | – | 1.00 | 0.53 | 0.62 | 0.85 |
| $x_2$ | *0.30* | – | 1.00 | –0.02 | 0.60 |
| $x_3$ | *–0.05* | – | – | 1.00 | 0.77 |
| $x_4$ | *0.25* | – | – | – | 1.00 |

Science (n=201)

| | y | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|---|---|---|---|---|---|
| y | 1.00 | 0.64 | 0.70 | 0.32 | 0.67 |
| $x_1$ | – | 1.00 | 0.75 | 0.69 | 0.91 |
| $x_2$ | *0.42* | – | 1.00 | 0.24 | 0.79 |
| $x_3$ | *-0.24* | – | – | 1.00 | 0.76 |
| $x_4$ | *0.22* | – | – | – | 1.00 |

Engineering (n=110)

| | y | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|---|---|---|---|---|---|
| y | 1.00 | 0.67 | 0.66 | 0.31 | 0.61 |
| $x_1$ | – | 1.00 | 0.66 | 0.72 | 0.90 |
| $x_2$ | *0.39* | – | 1.00 | 0.20 | 0.68 |
| $x_3$ | *–0.33* | – | – | 1.00 | 0.83 |
| $x_4$ | *0.01* | – | – | – | 1.00 |

*Note* The figures in italics are the partial correlations coefficients of y with $x_2$, $x_3$, and $x_4$, conditional on $x_1$.

Science, where the Science group consisted of Mathematics, Applied Mathematics, Mechanics, Physics, Chemistry, Physics and Chemistry, Agricultural Science, Biology, and all other subjects were regarded as non-Science. An alternative classification would have been Numerate and non-Numerate where the former could include, for example, Economics, Accountancy and Geography. We doubt if the classification for such marginal cases is critical to our discussion. Denoting average mark in the first year examination by y and points score by $x_1$, the other variables considered were; $x_2$, the average grade in Science subjects; $x_3$, the average grade in non-Science subjects; and for interest $x_4$ the average grade in all subjects; where each subject was scored according to the conventional 543221 system. The simple correlation of the four predictive variables $x_1$, $x_2$, $x_3$ and $x_4$ with each other and with y are presented in Table 19 for each faculty. The partial correlations of $x_2$, $x_3$ and $x_4$ with y conditional on points score $x_1$ are given in the same table.

In view of selection effects inter-faculty comparisons are somewhat inhibited and the correlations should be regarded as convenient surrogates for the corresponding regression coefficients. On that basis, correlations as small as 0.2 are statistically significant for samples of 100 or more. It can be seen, that with the exception of Law, the average mark in Science subjects is a better single predictor of first year performance than average mark in non-Science subjects and that it, points score and average grade in all subjects, are comparable. The partial correlations show that for most faculties the average performance in Science subjects has the greatest additional contribution to make to points score. Although this additional contribution is potentially greater than that which can be obtained by alterations in the credits for various grades and indeed often comparable in magnitude to the contribution of points score itself, it should be recognised that such additions are very modest in absolute terms, Our results relate, of course, only to UCC in a single year and the problem deserves further study.

5.9 One subject that does receive special attention in the existing points system is Mathematics. For entry to UCC up to and including 1978 double scores were awarded to Mathematics for grades A to D on the higher level paper; for entry in and after 1979 an intermediate system A(7); B(5); C(4); D(2) will be adopted. The basis for these particular scores is obscure but among the reasons sometimes advanced for extra credit for Mathematics are that it reflects additional teaching time at school and that the subject might be neglected otherwise. Our analysis is directed towards the separate question of whether Mathematics deserves extra weighting by virtue of its predictive role for subsequent academic performance. By way of comparison we look at the corresponding role of English.

Accordingly, the mean grades for Mathematics and English and their correlations with average first year mark are presented in Table 20 for each of the faculties. The standard deviations for the two subjects are fairly comparable and of the order one point in most cases. A small minority of students in Arts and Law did not take Mathematics in their Leaving Certificate and these were assigned a score of zero. The contrast in the results for the two subjects is striking, with Mathematics being the much better predictor in all faculties apart from Law, which remains the one exception. Mathematics on its own rivals points score and has a relatively substantial additional contribution to add to points score as

shown by the partial correlations. English is a poor predictor on its own and an additional contribution to points score is not established in any faculty apart from Science and Engineering. In their case the implication is that a points score which gave more emphasis to Mathematics and less to English would be a more effective predictor of first year university performance than the existing points score. The additional contribution of Mathematics can be quantified in terms of a weighting on the lines of double scoring. If the estimated regression of average first year mark (y) on points score (P) and Mathematics (M)

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 P + \hat{\beta}_2 M$$

is rewritten as

$$\hat{y} = \hat{\beta}_0 + \hat{\beta}_1 \left[P + \frac{\hat{\beta}_2}{\hat{\beta}_1} M\right]$$

we see that this corresponds to use of points score in which the points for Mathematics are weighted by the factor $1 + (\hat{\beta}_2/\hat{\beta}_1)$. An approximate standard error for this weight is easily obtained using first order Taylor series expansion of the ratio $\hat{\beta}_2/\hat{\beta}_1$. The weights calculated on this basis for Mathematics and also English, with their standard errors are presented in Table 20. They indicate strongly that, if selection of students who will do well in first year is of primary concern, then special weighting for Mathematics is indeed justified and that the recent NUI modification to double scoring for Mathematics has been in the wrong direction in this regard at least. Similar analyses were also made of the contributions of Physics and Irish to points score. The role of Irish was similar to English and additional weighting for Physics was indicated only in the case of Science. It would appear then that Mathematics is deserving of special consideration.

**5.10** Finally, we should like to mention briefly one further approach to scoring Leaving Certificate grades which was investigated. This involved allocating scores to the grades in different subjects which reflected the proportion of such grades awarded. Thus, for example, a higher A grade in a subject for which such grades were rare would receive a higher score than for a subject for which higher A grades were fairly common. The converse would be true for grades at the opposite end of scale. The basis for this scoring system will not be described here, but its purpose was to overcome varying standards in different subjects and hopefully thereby to construct a more reliable points score. Accordingly scores for the various grades in each subject of the Leaving Certificate were calculated using the full national results for 1977. (Although the results for 1976 would have been much more relevant they were not available in a convenient form and a scoring system of this type will be of little use if there is not some stability in standards.) As it turned out, the levels of predictability were virtually the same as those reported in Table 17 for the existing 543221 points system.

## 6. ALTERNATIVES TO THE POINTS SYSTEM

**6.1** Critics of the points system may feel vindicated by the limited although real effectiveness of the points system in selecting students likely to perform well academically at university. Unfortunately, recent work at Cork in this area and

*TABLE 20.* **Performance in Mathematics and English as related to first year university performance and points score.**

| Faculty | Means | | | Correlations with average first year mark | | | | | Weighting ± s.c. | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Simple | | | Partial | | | |
| | P | M | E | P | M | E | M | E | M | E |
| Arts | 14.5 | 0.6 | 2.4 | 0.33 | 0.28 | 0.17 | *0.18* | *0.17* | 3.4 ± 1.0 | 1.3 ± 0.5 |
| Commerce | 14.2 | 1.1 | 2.2 | 0.45 | 0.49 | 0.02 | *0.46* | *−0.07* | 3.1 ± 1.4 | 0.6 ± 0.5 |
| Law | 17.1 | 1.4 | 2.8 | 0.46 | 0.00 | 0.19 | *−0.07* | *−0.02* | 0.7 ± 0.6 | 0.8 ± 1.0 |
| Medicine | 20.8 | 3.4 | 2.8 | 0.48 | 0.42 | 0.12 | *0.36* | *−0.06* | 3.1 ± 0.5 | 0.7 ± 0.4 |
| Science | 15.8 | 1.9 | 2.0 | 0.65 | 0.65 | 0.09 | *0.43* | *−0.19* | 3.4 ± 0.6 | 0.3 ± 0.2 |
| Engineering | 19.3 | 3.6 | 2.3 | 0.67 | 0.63 | 0.09 | *0.39* | *0.09* | 3.3 ± 1.0 | 0.1 ± 0.3 |

comparable research elsewhere indicate that alternatives such as scholastic aptitude and personality tests are even *worse* predictors of subsequent academic performance.

6.2 The study in this area at UCC was carried out by our colleague Mr A. Humphreys and was designed to complement our larger study of the Leaving Certificate. It involved a random sample of 282 students drawn from those who had been accepted for entry to the College in autumn 1976. The sample was divided approximately equally between the five faculties, Arts, Commerce, Medicine, Engineering and Science. The selected students were contacted in September 1976 and invited to co-operate in the project and to begin by providing some biographical data such as size of family, birth order, parents' education, reasons for attending university, type and size of school attended, exposure to careers guidance etc. The final response rate was 91 per cent which is very good for a study of this nature. In the weeks immediately before and after registration a series of scholastic aptitude and personality tests were taken by these students. The tests included: the AH5 test of general intelligence designed for use with potential entrants to university and the professions which consists of three parts, verbal, numerical, and diagrammatic, Heim (1968); the Edwards Personal Preference Schedule (EPPS), Edwards (1959); the Sixteen Personality Factor Questionnaire (16 PF), Cattell (1950), Buros (1972); the Personality Orientation Inventory (POI), Shostrom, (1966). Each test involved a complicated and inter-related set of responses and it is impossible to do justice to the study in this paper; full details will be found in Humphreys (1977). On two issues however clear answers emerged. Firstly, apart from the Faculty of Arts, the single best predictor of subsequent performance in the first university examination was the points score in the LCE, the superiority being very marked in some faculties. Secondly, the test score on the AH5 aptitude test was very poorly related, when at all, to subsequent performance in the first university examination in summer 1977.

6.3 This latter result may seem surprising but agrees entirely with the much larger study of Powell (1973) already cited in Section 2.3 which involved all 2,781 entrants to five Scottish universities who first sat for the Scottish Certificate of Education examination in 1962. The aptitude test, which was administered to all entrants in their final school year, was the College Entrance Examination Board Scholastic Aptitude Test, Form ASAI, (Education Testing Service, Princeton, New Jersey, USA). Powell concludes that "there is no reason to believe that any changes in the educational situation in Scotland or any change in the way SAT is administered or employed would lead to its predictive value rising appreciably above the very low levels found in this investigation". He cities studies in other English speaking countries which again do not give any cause for optimism and concludes that the weight of existing evidence is that, when the target population is one which is at the upper end of the ability spectrum, scholastic aptitude tests are unlikely to discriminate usefully. Scholastic aptitude tests are, of course, widely used in North America, but it should be remembered that the situation there is very different from Ireland involving a wide variety of educational institutions and the absence of any national examination like the Leaving Certificate.

**6.4** It would appear then that individually or collectively scholastic aptitude and personality measures are inferior predictors of subsequent performance at university than performance in the LCE. One might still ask whether such variables can add to the information provided by the LCE. The results are in general disappointing. In the case of Science, for example, the only personality factor for which an additional contribution was established was nurturance. This factor concerns a person's capacity for generosity and forgiveness and their willingness to help friends and the less fortunate. It was in fact *negatively* associated with success in first university examination albeit marginally. Biographical variables such as a student's sex and age also played a small role in predicting academic success. This raises some ethical problems for those who advocate the use of such tests, for example, Beausang (1976). What if, as in the case of Science, an effective selection process should favour those with selfish or other socially undesirable instincts or discriminated between the sexes? The stability of the personalities of persons emerging from adolescence must also put some limitations on the use of such tests. It may be argued that our study in this area is based on only 258 students and that a larger study would establish more statistically significant relationships. We accept this but statistical significance relates only to the existence of a relationship and not to its worth and we are doubtful if larger studies will establish relationships of practical significance. In any case the Leaving Certificate result is not purely a measure related to scholastic ability but also implicitly measures factors such as application and motivation and it is not surprising that it is difficult to improve on its predictive capacity limited though this may be.

**6.5** Among the other methods suggested for selecting students for university are school reports, interviews and lotteries. As one of a series of practical projects in Statistics for his degree, an undergraduate student at UCC recently investigated, in the case of one faculty, the usefulness of the school principals' reports sought by the College on each applicant for entry in 1976. No reports were received in the case of 25 per cent of the students. Those that were received added nothing to what was already known from the students' points score as to their subsequent performance in first university examination. School principals were obviously reluctant to give any pupil a bad report and no student was considered unsuitable for university. The poor predictive value of the reports was, therefore, not surprising as one is dealing with different pupils, teachers and schools, and the ratings of pupils within a school may not have much significance outside that school. One would at the very least also need ratings for schools and their principals. We have not formally investigated the effectiveness of interviews in selecting entrants for university and our remarks must be based on the literature and on the experience of one of us (M. A. Moran) of interviewing prospective entrants at a British university and service on many interview boards for positions in the public service and academic appointments. Interviews can be very effective when one has a clear concept of what is required in an applicant but like all measuring devices in this area they are prone to error and moreover bias. As argued earlier, it is difficult to construct a well defined and quantifiable prescription of what is sought in a potential university entrant and perhaps the most reasonable definition of suitability in this context is an applicant's capacity to do well in his chosen

degree course according to the criteria of the university. While an interview may eliminate a minority of candidates as clearly unsuitable on any reasonable criteria, we foresee considerable difficulties in using interviews to rank with confidence a large number of candidates of comparable suitability. Moreover, the problem of properly interviewing the large numbers of applicants involved casts doubts on the feasibility of the whole procedure. The literature on the subject of interviews is very divided. The comprehensive report entitled "The Selection of Students for Medical Education" produced by the European Office of the World Health Organisation cites very conflicting references on the issue. The major difficulty is that assessors differ in their opinions and the report expresses considerable doubts on the usefulness of interviews, at least in the conventional form in which selection committees or selectors see each individual applicant separately. Finally, there is the lottery system in which all suitable candidates are given an equal chance of obtaining a place. If one interprets suitability as suggested above, it follows that some applicants are more suitable than others and a weighted lottery is sometimes suggested. If performance in the Leaving Certificate is taken as an indicator of suitability, it is intuitively clear that the weights required to optimise the overall suitability of entrants selected are those used in the points system as operated at present.

## 7. CONCLUSIONS AND DISCUSSION

**7.1** Our conclusions may be summarised as follows:–

(i) The pass rate in the first year university examination increases monitonically with performance in the Leaving Certificate with very clear cut differences between students with low and high points scores respectively.

(ii) While the relationship between points score and subsequent academic performance is real, there is a substantial overlap between the distributions of points scores for students who pass and students who do not pass respectively. For students with intermediate points scores the predictive ability of the Leaving Certificate is limited.

(iii) A wide range of points system in terms of the points awarded to the various grades will have comparable predictive value. Grade A on higher and common level papers appears undervalued relative to other grades.

(iv) Science based subjects have in general greater predictive value than non-Science subjects and Mathematics, in particular, merits special weighting for this purpose.

(v) Pass standards in different faculties can differ substantially for students with identical points scores.

(vi) The value of points scores in terms of ability to pass first year university examinations has changed in the period 1972 to 1976, but not in a consistent fashion. There has been depreciation in some faculties and appreciation on others.

(vii) Despite the limited predictive value of the Leaving Certificate, alternatives such as scholastic apritude test seem substantially worse and the prospects for other selection systems which can equal or improve on the Leaving Certificate seem poor.

7.2 The reasons for limited predictive value of the Leaving Certificate are many. A high degree of unreliability in the marking of all subjects in the Leaving Certificate is reported by MacNamara and Madaus (1969) and we have no reason to believe that university marking is necessarily any better. There are, of course, a myriad of non-academic factors which militate against good prediction. Students are subject to emotional, financial and family stresses. They may be diverted from their studies by social, sporting or other extracurricular activities. They may lack motivation or be bored by the academic routine. When all possible factors are taken into consideration, the level of predictive ability achieved by the Leaving Certificate is perhaps as good as one can expect and any appreciable improvement may well be impossible.

7.3 Although our primary purpose was to investigate the effectiveness and optimality of the Leaving Certificate and its associated points scheme as predictive measures of subsequent academic performance, we are acutely aware that any examination or degree result can be criticised on the grounds that it is not a reliable guide to an individual's success in their later professional or personal life and bears no relation to their human worth. Any experience of living would convince one of this and we doubt if the money required for a research project to provide formal confirmation would be well spent.

7.4 It is sometimes suggested that one should start by defining a profile of the desired end product, for example, a good doctor, and work back to the corresponding qualities required for entry into Medical School. The suggestion, attractive though it may seem at first sight, involves very serious problems of definition and measurement. What constitutes a good doctor will vary depending on whether the doctor is to work in general practice or specialise in surgery, pathology, or perhaps psychiatry. The qualities of a doctor are multi-dimensional and cannot readily be ranked on a one-dimensional scale. The suggestion also assumes that the qualities which are so arrived at as apparently necessary for entrants to Medicine will in fact be related to the desired qualities in later life assuming that these can be satisfactorily defined. Any test of this would encounter the problem of measuring or quantifying the worth of a doctor. Within some disciplines and institutions progress might be made but on a global basis reliable measurement will be so difficult as to rule out the establishment of any worthwhile relationships. It cannot be denied, however, that there are numerous students who would make excellent doctors according to any reasonable definition and yet are refused a place in Medicine on the basis of their points score. Nonetheless, is there any reason to believe that such students would be better on average than their counterparts with higher points who were admitted? Indeed, given the scientific content of modern medicine, the high ability of existing entrants in non-Science subjects and the apparently weak correlation between scholastic ability and personality, is it not reasonable to suppose that those admitted will be, at least, marginally

better on average than those refused entry? There will be individual exceptions but these will exist under any system of selection. The nub of the problem is that applications at present for places in Medicine from very suitable applicants far exceeds the limited number of places available and any selection system will have a certain arbitrariness in so far as a place for one student can only be provided by denying a place to another! This simple fact is often overlooked in discussion of selection procedures.

7.5 The most telling criticism of the points system is, in our opinion, the manner in which it magnifies the influence of the universities and indeed the third level sector in general on the schools. Some influence is inevitable and indeed can be benign, as for example, by increasing the opportunities for girls to study mathematics, but the influence ought to be controlled. The present points system introduces a level of competition at second level which is excessive and casts an unnecessary blight on many children's lives. By forcing children towards subjects which score high points, the system can interfere unduly with the curriculum of the majority who will not enter third level education. It will be clear from the earlier part of this paper that we regard performance in the Leaving Certificate examination as presently the best of a bad lot of predictors of subsequent academic performance. While the Leaving Certificate remains in the present form, we favour its continued use in some form for matriculation purposes, but, as far as possible, *not* as a criterion for entry into individual faculties. There is a substantial common core to the first year courses for Engineering, Science and Medicine, for example, and it should be possible to decide entry to an individual faculty on the basis of a student's performance during part or all of the first year at university. This proposal would mean that a student at school need only reach a reasonable standard to enter university and would transfer most of the competition from the school to the university where it reasonably belongs. Secondly, it should result in a more effective selection procedure for subsequent academic performance, and, moreover, would confront the various university faculties more squarely with the problems and implications of selection. Thirdly, it would provide all prospective entrants to a profession with an opportunity to study subjects at least indirectly related to that profession, for example, biology in the case of Medicine, and this supplemented with contact with other students and staff would facilitate a more informed choice of career. The student would also be somewhat more mature when this choice was made. The proposal would require some re-structuring of first and perhaps second year courses on the part of the universities, and would have to be implemented in a similar way at each. It ultimately would, we believe, be in the best interests of all. The proposal would substantially moderate the effects of the present points system on schools. If the demand for places in higher education continued to outstrip the supply, the effective standard for matriculation would inevitably rise, but one hopes that it would not reach the herioc levels associated with some faculties at present. In relation to this it is often overlooked that fashions for certain disciplines have corresponding consequences for others who must then cope with a disproportionate number of less able students. Indeed, a case could be made that it is too easy to enter some faculties at present and that the standard for matriculation should be raised, for example, in the case of Science.

7.6 What should constitute matriculation is much too large a question to deal with here, but we should like to comment briefly on three aspects of the question. The first relates to the subjects which ought to be recognised for matriculation purposes and the points awarded to the grades in each. We have shown that the effectiveness of the present points system is fairly insensitive to a wide range of scoring system. We would suggest, therefore, that the universities can afford to be and ought to be tolerant in respect of the subjects accepted for matriculation purposes and as to how they are scored, so long as an applicant shows competence in a basic core. The second aspect is the three languages requirement in the case of the National University of Ireland. In a paper already cited, Raftery (1977) states that because only 33 per cent of vocational students can take a third language that thereby 67 per cent of vocational students are made ineligible to enter the NUI. This is an abuse of statistics, for it assumes that all vocational school students are applicants for university entry. We accept that there is a problem here, but one would not quantify it on this basis but rather on the number denied entry expressed as a percentage of those seeking entry and eligible were it not for the language requirement. An essential issue here, we suspect, is whether Irish should be required for matriculation by the National University of Ireland and whether the discrimination is on the part of some vocational schools or the university. The authors would differ on this but agree that two languages should suffice. Raftery also claims that this language restriction is one of the greatest single obstacles to working class children going to university. On the contrary we consider it a small obstacle when compared with the obstacles imposed by finance and earlier educational deprivation. It is not without social significance that the present controversy over selection for university focuses on Leaving Certificate points rather than financial points. Our judgement is that it is to the former that the less well off must look for advancement and that they should look carefully at any proposal to move from selection on the basis of a public examination. In this regard, it is ironic how comparatively little controversy surrounds the multitude of private and unknown selection procedures that operate for entry into second level. Finally, it is very possible that a Leaving Certificate examination designed for the majority of school leavers, as it ought to be, is not suitable as a matriculation examination. The lack of suitability at the moment is not necessarily as might be expected. Many in the university technological sector are concerned at present at the lack of basic numeracy in many entrants and it would be ironic if Leaving Certificate Mathematics, for example, was considered unsuitable for matriculation purposes on grounds of lack of practicality!

7.7 This paper has of necessity been directed towards selection for university. This is only part of the larger and more important problem of matching a student's career to his inclinations and abilities which requires the cooperation of all educational institutions and has not been adequately tackled in this country to date. We should like to conclude by quoting Dale (1963) who writes:–

> "The problem (of a student's university career) cannot be limited to the social class of his home and the class of his degree; it is influenced by his teachers at primary and secondary school, moulded by his neighbourhood, moderated by his personality. His aspirations may be in conflict with his

powers, his amours with his work, his guidance imperil his degree. His fellow students may be so good they doom him to failure, or so poor as to present him with first class honours. There is a vast interweaving pattern of forces, the student at its centre, moving on to the culminating point of qualification or failure. The survivors are not always the ablest, nor is it always the students who fail".

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We should like to thank Dr M. D. McCarthy and Dr T. M. O Ciardha, the former and present Presidents of UCC for facilitating our access to the examination and admission records. Our thanks are also due to Mr M. F. O'Connell, Ms A. Gleeson and particularly Ms A. Skally of the Registrar's Office, UCC for their cooperation in assembling and checking the basic data, and to Ms N. Gallwey for typing of the manuscript. The statements and opinions expressed in the paper are obviously the authors' own and do not reflect the views of our colleagues or the College.

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## DISCUSSION

*Mr P. O'Flynn:* In proposing the vote of thanks to Dr Moran and Mr Crowley for their paper I speak with more sincerity than may sometimes be the case on such occasions. They are to be thanked not only for a paper which is interesting as an abstract statistical enquiry, but, perhaps, more deeply for having made a very significant inroad into the area of ignorance surrounding the whole question of university selection systems in Ireland.

In a policy statement published just last week the Irish Federation of University Teachers deplored the fact that so many decisions had been taken in this area on the basis of intuition rather than on statistically observed relationships and called for an extensive research programme into all aspects of our selection systems. With a perfect sense of timing Dr Moran has provided us with the first major study of the relationships between secondary school terminal examination and performance over a wide range of disciplines in the university. He has moreover given us substantial answers to a number of questions which have been raised in the 'points debate'. I am sure that he would not feel that he has answered all the questions that might be asked, but he has provided the framework for the further work which must be carried out. I hope that he will himself provide more of the answers in a continuing programme of research.

If I may make some brief comments on the details of the paper, I would agree with the authors' views that the only valid criterion to adopt in selecting students for entry is that those students should be selected who are most likely to perform well in university examinations. Even if the university decides, as I believe it should, to make specific provision for the admission of mature students in all faculties, the mature students selected should be those expected to perform best in the university. Any other criterion used, such as, for example, the selection of those who might conform to a model of the successful doctor or lawyer, will probably involve unacceptable value judgements on the part of academics who are subject to as much political and social fallibility as the rest of mankind.

I believe also with the authors that the use of the Leaving Certificate as a means of predicting performance in university examinations is, although inadequate, the best predictive measure that we can obtain. If I might add to their comments on its effectiveness I would draw attention to its apparent consistency as a predictor.

The authors quote a correlation coefficient, R, of about 0.72 as the maximum value obtainable between leaving certificate grades and performance in 1st university examination in engineering at UCC. In a similar study of the performance of 173 1st year engineering students in UCD in 1970 I found a maximum correlation coefficient of 0.721.(1)

Another feature which is, I think, of interest is that the Leaving Certificate appears to compare favourably with other types of 2nd level terminal examinations in its ability to predict performance in the university.

In his survey of research results for the UK, Heywood (2) quotes two studies of the relationship between A level results and first year university results in engineering schools. The correlation coefficients shown in Table 1 indicate that the predictive value of GCE A-levels and Leaving Certificate are comparable.

**TABLE 1: Correlation between 2nd level terminal examinations and first year university examinations**

| | | R | N (Number of Students) |
|---|---|---|---|
| U.C.C., Moran | | .714 | 110 |
| U.C.D., O'Flynn (1) | | .721 | 173 |
| Imperial College, Christopherson (3) | (a) | .81 | 35 |
| | (b) | .79 | 12 |
| | (c) | .60 | 19 |
| | (d) | .72 | 13 |
| UMIST, Bagg (4) | | .50 | – |

I would like also to refer to, perhaps the most substantial recommendation made by the authors, viz. that selection be deferred until the end of a first common university year thereby removing a great deal of the pressure from secondary school and putting it in the university where, it properly belongs. One notes that this proposal does not arise from the authors' data, but represents a political judgement as to the way things might develop. If I could reply in a similar way it first occurs to me that the subjects grouped together – Science, Engineering, and Medicine – represent only a relatively small group within the university. Is there not a fallacy therefore in assuming that a student who failed to be accepted for his first choice–medicine, for example–would have as a second choice another science-based subject? Is it not equally plausible that such a person would choose Social Science or some other 'caring' profession as a second choice?

A second difficulty in the proposal which would need thorough examination is the extent to which a common curriculum could be agreed. I know that in my own college where first year chemistry courses, for example, are given separately to students of Veterinary Medicine, Agriculture, and Medicine, there is pressure from the professional schools to have even more professionally-related topics in the basic courses. The introduction of a common first year would undoubtedly create pressure for the addition of an extra year to some professional courses. Nevertheless, the idea is undoubtedly worthy of detailed study.

If I might conclude by asking the authors for their views on two matters raised by the Irish Federation of University Teachers in their recent policy statement. Firstly, do they have any evidence to offer on the validity of accumulating points scores from multiple sittings of examinations? and secondly, do they have any thoughts on the best way for the selection of mature students with work experience?

Finally, may I again thank the authors for their most substantial contribution to the solution of one of the more significant social problems of our times.

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*Dr Paul Andrews, S.J.:* Seconded the vote of thanks to Professor Moran's and Mr Crowley's paper, and added some reflections from the viewpoint of one concerned with the backwash of university selection procedures on secondary schooling. This backwash is a different thing from the reliability of the selection: procedures which are reliably predictive of university success may still, by their backwash on second-level learning and

teaching, be overall quite detrimental to the education of our young people.

He pointed to two anomalies evident in the present picture: the first from the staff-room conversation of secondary schools, where one frequently hears the same teachers saying, in one mode, "Seamus should be working much harder"—when preparing end-of-term reports; and, in another mood, "It is deplorable that (on account of university entrance requirements) Seamus and his fellow-pupils should have to work so hard".

The second anomaly touches the accessibility of information which would make for more satisfactory selection. Teachers and fellow-pupils have rich and reliable information about the personality of Seamus and Mary, who are aspiring to university places. They know, from an experience of many years, whether they are reliable, honest, truthful, creative, sociable, gifted for leadership, persistent, hard-working, or marked by other qualities of vital importance to their future work. But this information is inaccessible to those who select for university, because we have found no reliable and objective means of conveying teachers' information to selection authorities. Interviews, school reports, and personality tests have all been tried and found wanting. Instead of employing important evidence, such as that mentioned above, we are forced, therefore, to fall back on evidence from Leaving Certificate performance, which may be a good predictor of performance in First University examinations, but is relatively unimportant for long-term forecasts.

Dr Andrews thanked the authors for their convincing demonstration of the predictive value of one or other 'points' system – at least as regards university examination performance. He warned against a reversion to the old system in which the first year at university was used as a selection, or thinning-out process. Schools will undoubtedly work cleverly and effectively to beat any selection system that is set up. But at present the backwash of the present points system is to make school learning, especially in the later secondary years, deplorably pragmatic and instrumental; it is very hard for pupils or teachers to raise their sights above the target of improving their grades in six or seven Leaving Certificate subjects. In this situation, our most promising approach to improving the system lay in improving the quality of the Leaving Certificate as an examination—compared with some public examinations in other countries it is very imperfect. An effort to improve the technical quality of the examinations, so that they incorporated higher-level skills and became increasingly difficult to cram for, could, over a period of some years, bear considerable fruits in the quality of our education.

*Dr R. C. Geary:* This paper is to be welcomed as one of the most sophisticated statistically that we ever had. Professor Moran has tempered the wind for the shorn lamb by the clarity of his presentation. It is a source of gratification to an old man who has ceased studying technical statistical papers that he is quite familiar with and has worked with, the methods exploited in tonight's typically modern research, maximum likelihood, canonical correlation and the logistic curve. The authors also mercifully provide elementary analyses. We must never forget that practically useful results from statistics can nearly always be provided by simple methods, percentages and the like, with the advantage of being understood by all concerned. Simplicity may mislead, hence recourse must be had to mathematics, also required for discernment of methods of maximum efficiency. A justification, sufficient in itself for mathematical methodology, may be that balm to the human spirit, elegance, reminding one of the famous Cambridge toast: "To mathematics, may they never be useful to anyone".

I have a few minor editorial notes. There are some small numerical errors in Table 6. In the title to Table 7 what is the meaning of "taken in any two years"? In the text there is reference to Figures 4 (a) and 4 (b) which are not provided, only Figure 4. This is a histogram, that simplest kind of statistical device: I do not understand the authors!

The authors make no large claims for their results, only that changing the weights of the points scores at LCE, devised by advanced statistical techniques, make little difference in discriminatory power at 1st university examinations. To what extent is this due to the notorious arbitrariness of examination marking, not only at LCE but at pass – not pass university appraisal? I recall controlled experiments in the marking of literary papers in which there was a wide difference in marks accorded on identical papers (i) by the same examiner at intervals of months and (ii) by different examiners. Only in mathematics and to a certain extent in science subjects can there be objective marking.

In his presentation Professor Moran stated that the terminology "not pass" instead of "fail" was deliberate. I imagine his point, and if so I agree, that the non-passers were not failures. In India BA (fail) was an honourable style. That students had attained university status was a success. In the Education Volume XII of the 1971 Census, there is properly no distinction pass/not pass, only attainment of level of education. Every effort should be made to remove the stigma. Non-passers are also people.

One undesirable effect of what the authors term the "immense" literature on the relationship between second and third level results is that secondary curricula may tend to be geared too closely to university requirements, too academic in fact. Now in 1976–77 the percentage of school leavers going to third level education was 39, so that the large majority, 61 per cent, sought jobs. I am unaware of any studies on the real educational needs of this large majority. Surely these are needed.

*Mrs Monica Nevin:* I should like to add my thanks to Professor Moran for a very fine paper. What is of particular interest to me is that the results confirm in a wider context my study of the relation between school performance and university achievement in the Faculty of Science in UCD. I hope Professor Moran and Mr Crowley will continue this work and follow the undergraduates through to graduation.

There are one or two points I should like to make. Professor Moran suggests transferring most of the competition from school to university. While I understand his thinking on this matter – the study which I did showed a high correlation between performance in the first-year university examination and performance at degree level, higher than the correlation between leaving certificate and degree result – nevertheless, in today's situation, to throw university entrance open to all who reach "only a reasonable standard in leaving certificate" is not practical. First, I do not think the universities could absorb all entrants with "only a reasonable standard". Secondly, would the public be willing to accept high failure rates? The public criticism in the 'sixties of the failure rate in first year was just as fierce as is the present criticism of the points system. And, as I have said elsewhere, if selection is postponed until the student is in the university, the consequences of failure will be more serious for him and for his future. A candidate rejected at entry may find another door to further education open to him without further loss of time or money.

I was interested in what Professor Moran had to say about mathematics as a predictor. When I was working on achievement in leaving certificate I did, in the beginning, isolate performance in mathematics but what I found was that those who did well in mathematics did very well all round, only one student out of 1,053 in my sample had honours in mathematics and indifferent results in his other subjects.

By and large, what has been found in studies in the UK is that the best correlation is between overall performance at A-level and performance at university. The correlation between performance in a specific subject at the school leaving examination and performance at university is considerably less good and in some cases very weak. I, personally, and I think many people would agree with me, am against specialisation in school and feel that all students entering university should have had a broad education. There are, of course, special faculty requirements. For example, the National University requires students wishing to enter any of the following faculties, Engineering, Science, Medicine, Veterinary Medicine or Agriculture to matriculate in physics or chemistry or biology and perhaps one science subject is enough. Certainly, in many schools those who attempt two science subjects may find a potential valuable subject such as history debarred to them because of time-table clashes and, no doubt, other examples could be found. There remains the vexed question of the three languages requirement for matriculation in the NUI. Much as one may regret it the National University may have to take a hard look at the compulsory Irish requirement.

A study such as the one done by Professor Moran, covering all faculties is particularly useful and I would ask him, once again, to continue the study through to degree level.

*Reply by Professor M. A. Moran:* I would like to thank all the speakers for their comments and try to answer some questions. Mr Flynn and Dr Nevin point to difficulties in any deferring of selection for individual faculties to the end of the first university year. Indeed, there are and undoubtedly more would emerge on closer investigation. Nonetheless, the lack of such investigation or conscious consideration on the part of the Universities to see what can be done in harmonising and indeed updating their interface with second level is distressing. In regard to Mr Flynn's specific queries, my impression is that data on accumulation of points scores from multiple sittings will be very inconclusive. I have not given specific consideration to the case of mature students but my general plea would be for greater flexibility and closer monitoring of subsequent performance.

I can only agree and sympathise with all of Dr Andrew's remarks although it has to be said that second and third level have their own responsibilities and some conflict of interest is inevitable. The initiative lies, I feel, with second level teachers who could and should be more visible as a profession and more assertive in identifying their role and devising curricula and methods of assessment accordingly.

It is a particular honour to have Dr Geary reply to the paper knowing, as I do, his accomplishments and international eminence in Statistics. The apparent anomalies he sees in Table 6 are due to three students listed in Table 7 who had only five Leaving Certificate subjects each. The meaning of "any two years" he will find in section 3.5 of the text and is clarified in the edited version. I apologise for omission of Figure 4(b) in the copy of the paper circulated prior to the meeting. It's purpose was to focus the distributions of points score for students who passed and did not pass and to highlight their overlap which is exhibited less clearly in the histograms. The extent to which unreliability of marking was responsible for arbitrariness in the scoring scheme has not been investigated as it is the observed grades on which prediction must be based. The question is nonetheless of intrinsic interest and should be looked at. It's reduction is very important but I feel arbitrariness in scoring schemes and limited predictability will still persist.