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TRANSPARENCY AND DISCRIMINATORY POWER OF THE LEAVING CERTIFICATE EXAMINATION

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Two major issues arise when the final marks for an examination are simply the aggregate of the marks awarded for individual subjects, which happens in the Leaving Certificate Examination (LCE). The first relates to transparency, that is, the assumption that all subjects contribute equally to the aggregate mark. The second relates to the discriminatory power of the examination, that is, its capacity to distinguish between different levels of achievement. Two sets of data were analysed to address these issues: the grades awarded to all candidates in the 2001 LCE in the examinations they took, and the frequency with which the different grades were awarded in LC examinations in the surrounding decade (1998 to 2007). Results indicate that (i) in the 2001 LCE, the weights achieved by subjects deviated considerably, and to different degrees, from expected weights and (ii) for the period 1998 to 2007, there were large and consistent differences between subjects in their discriminatory power, which declined over time. Of the two, the latter is more fundamental insofar as it concerns the validity of the examination, and the unfairness that arises when the same mark is awarded to candidates of different levels of achievement. Both problems stem almost entirely from differences between LCE subjects in the percentages of candidates who take the Higher level examination and in the average marks awarded candidates.

Research has shown that specifying the proportions of marks available for the components of an examination does not ensure that the proportions will be maintained when marks are aggregated to provide a total mark for the examination. This is an important consideration when the order of the aggregate marks is used to make selection decisions for candidates, since it is not the proportion of the marks that is allocated to a subject that determines the value of a component but the dispersion or variance of the marks awarded within it, that is, the extent to which the marks record differences between candidates (Cresswell, 1987). Thus, in a hypothetical case, if all candidates were awarded the same mark in a particular component of an examination, this would merely add a constant to their aggregate scores, leaving their order unchanged. Although this is not a realistic case, it is certain to be approximated to some extent when the dispersion of marks within a

component is limited. The matter is of particular importance when multi-component examinations are used for selection purposes, as is the case with the Leaving Certificate Examination (LCE). In this examination, there are large and consistent differences between subjects in the dispersion of grades and in points based on grades (Kellaghan & Millar, 2003; Mac Aogáin, 2005).

In practice, the unequal dispersion of marks within LCE subjects does not attract much attention. One reason may be that the LCE is not a single examination, but rather a family of several thousand examinations, each defined by a unique combination of six subjects that provides candidates with their highest six-subject total. Since it is only within these combinations that the effects of unequal variances show their effects, the issue may appear too complex to warrant further discussion.

The situation in which several subjects contribute to the aggregate marks (and grades) awarded in an examination mirrors that in which the achieved weights of internal components of individual subjects, such as the written and practical papers provided in some subjects, or the written, oral, and listening components of second and foreign languages, does not match the intended weights. The situation, however, is somewhat different since in the case of individual subjects, exact figures can be given for the departure of the intended weights of components (the maximum marks available for the component) from the achieved weights (the portion of the variance of the total mark that they control), given that components of this sort are usually obligatory for all candidates taking a subject. It has been shown, for example, for selected LCE subjects that there is a large loss of variance in non-written components when compared to written components (Millar, Kellaghan, & Mac Aogáin, 2006). It would seem that markers are reluctant to award the highest and lowest marks that are available for non-written examinations (leading to clustering around the mean) or, alternatively, that they award a lot of marks close to the maximum (leading to clustering at the top, or a ceiling effect). There can be little doubt that similar effects take place in the six-subject combinations of the LCE which, for most practical purposes, are irretrievably lost in the multiplicity of six-subject combinations.

A further reason for the neglect of the dispersion problem may be that it is overshadowed by another feature of the marks awarded in LCE subjects, their average. It is well established that LCE subjects differ considerably both in their average marks and in their workloads (Kellaghan & Millar, 2003). Given this situation, and provided the average is high, candidates and

teachers may not be unduly concerned that there is a low dispersion of marks in a particular subject.

Yet it may be argued that unnecessary loss of dispersion, inaccessible though it may appear in summary reports of LCE results, is a central issue concerning the validity of the LCE as an assessment of educational achievement, since it is the degree of dispersion in marks for subjects that determines its discriminatory power, that is, its capacity to record differences of achievement among candidates. This point is recognized by the State Examinations Commission (2003) when it states that

> Discrimination is the extent to which an individual question, or the examination as a whole, effectively distinguishes between candidates of different underlying levels of achievement. (p. 29)

In this paper, we look first at the great number of six-subject combinations that made up the 2001 LCE and give an overview, as far as possible, of the effects of unequal dispersion of marks within them. Following that, to provide a broader picture of the effects of reduced dispersion of LCE marks over time, the award of grades per subject is analysed for the years 1998 to 2007.

METHOD

Data

1. Grades were obtained from the Department of Education and Science for the 52,717 candidates who took the Leaving Certificate Examination in 2001. Grades (on Higher and Ordinary papers) were converted to CAO points values (from 100 to 0). The study was restricted to the 20 most commonly-taken examinations and had to be further restricted to candidates who took at least six of these. This reduced the number of candidates to 39,759. The data revealed 3,834 different combinations of six best subjects. Some 1,500 candidates had combinations unique to themselves, and more than half had combinations that they shared with less than 20 candidates, analyses of which would have yielded unstable results. Only six-subject combinations represented by 50 candidates or more, of which there were 155, involving 19,580 candidates, were considered for analyses.

2. Data on grades awarded on the LCE for the years 1998 to 2007 were obtained from the *Statistical Reports* of the Department of Education and Skills (1997-98 to 2006-07). Again, analyses were restricted to the 20 most commonly taken examinations.

Analyses

1. *Contribution of Individual Subjects to Total Examination Points.* The following statistics were calculated for the four most common combinations of six best examination subjects.

Intended Weight: the proportion of total points available for individual subjects. Since 100 points are available for each subject, and the total for all six subjects is 600, the proportion is .167.

Achieved Weight: the contribution of a subject to the total number of points a student is awarded on the LCE based on a component-with-aggregate covariance definition. The formula to calculate the Achieved Weight was

$$W_i = \frac{S_i r_{it}}{S_t}$$

where S_i = the standard deviation of points on the *i*th subject
r_{it} = the correlation between points on the *i*th subject and total points
S_t = the standard deviation of total points (Adams & Murphy, 1982).

Percent Deviation: Achieved Weight (AW) expressed as a percentage deviation from the Intended Weight (IW) (.167):

$$\left(\frac{AW}{IW} - 1\right) \times 100$$

2. *Discriminatory Power of the LCE.* The purpose of analysis was to provide an account of the inequality of dispersion in the LCE, covering the 10-year period from 1998 to 2007, based on data from the yearly reports for these years. To obtain a measure of dispersion that could be pooled across subjects, a non-parametric measure of dispersion was used, based on a count of upward gradings (*UGs*) per subject, or the total points awarded, and the subset of these that may be called discriminating gradings (*DGs*) in the sense that they are gradings away from the median. The percentage of *UGs* that are *DGs* may then be taken as an index of the Discriminatory Power (*DP*) of the examination in that subject. The count of *UGs* can be read from reported grades: it stands at 0 for grades E/F/NG; 1 for grade D3; 2 for grade D2; and so on up to 20 for grade A1. Discriminating gradings are counted on the same scale, except that they are centred on the median grade, and the count is outwards from the centre.

To quantify change in *DP* for each of the 20 subjects under study in the period 1998-2007, the linear model

$$DP = b_0 + b_1 Y$$

was fitted to each row of the *DP* figures in Table 4. The dependent variable is *DP* and the independent variable is *Y* (year), and b_0 is the additive constant.

The regression coefficient b_1 is interpretable as the slope of the regression line, where the predominantly negative values give the yearly loss of *DP* per subject, or when multiplied by 10, the figure for the period.

RESULTS

1. *Contribution of Individual Subjects to Total Examination Points.*

Table 1 presents results for the four most common combinations of six best subjects, involving 2,835 candidates. The average points awarded to candidates is in Column 1 and the standard deviation (SD), measuring the dispersion of points scores (i.e., their average distance from the mean), is in Column 2. It is obvious that there is an inverse relationship between these two measures: the higher the points awarded, the lower the dispersion. The correlations between the average points awarded and their dispersions for the four subject combinations in Table 1 are, from top to bottom, -.93, -.71, -.92, and -.74. There is a sharp linear decline in dispersion as the average is moved closer to the maximum.

One important effect of reduced dispersion in a component is shown in Column 3, namely a reduction in its correlation with the aggregate score. Since they carry less information on differences between candidates, components with low dispersion control less of the variance of the aggregate total out of 600, that is, they carry less weight in determining its value. The Achieved Weights, expressed as portions of 1.00, are reported in Column 4. Had the components been of equal weight, their Achieved Weights would each have been .167. Achieved Weights are shown as Percent Deviations from the Intended Weight of .167 in the last column of Table 1. Components with low averages and high dispersions control up to 20% more of the variance of the aggregate score than they ought to, while those with high averages and low dispersions control up to 20% less. Symmetry at either side of the Intended Weight is due to the fact that Achieved Weights must sum to 1, and to zero when expressed as deviations from the mean.

Similar analyses were performed on the remainder of the 155 combinations of six best subjects with more than 50 candidates, and the combined results are shown in Table 2. The median values for Percent Deviation in Column 1 are broadly in line with those observed in Table 1, while the large range of these values, indicated by their minimum and maximum values in Columns 2 and 3, shows how the Percent Deviation of the Achieved Weight of a component from

its Intended Weight (.167) can vary dramatically depending on the subjects with which it is combined.

Table 1
Achieved Weights and Percent Deviation from Intended Weights (.167) for the Four Most Common Combinations of Six Best Subjects in the 2001 LCE

Subject	Average Points	SD	Corr. with Total	Achieved Weight	Percent Deviation
French	48.15	22.53	0.904	0.198	+19
Biology	53.09	22.52	0.893	0.196	+17
Irish	51.02	20.90	0.853	0.173	+4
English	60.15	19.24	0.827	0.155	-7
Home Econ	63.54	17.96	0.844	0.148	-11
Geography	64.42	16.38	0.817	0.130	-22
Total	340.37	102.75		1.000	0
Candidates: n = 807					
French	40.04	21.75	0.866	0.205	+23
Irish	42.56	20.56	0.789	0.177	+6
English	54.66	19.76	0.797	0.171	+2
Maths	32.39	19.46	0.784	0.166	-1
Business	56.11	17.32	0.819	0.154	-8
Geography	59.62	15.50	0.750	0.127	-24
Total	285.37	91.89		1.000	0
Candidates: n = 725					
Biology	47.66	23.85	0.901	0.187	+12
French	45.04	23.35	0.917	0.186	+11
Irish	47.12	22.14	0.859	0.166	-1
Home Econ	61.85	20.32	0.879	0.155	-7
English	55.62	20.91	0.848	0.154	-8
Business	60.11	19.75	0.880	0.151	-10
Total	317.40	114.91		1.000	0
Candidates: n = 672					
French	38.74	22.09	0.890	0.184	+10
Home Econ	53.70	20.72	0.879	0.171	+2
English	52.40	20.90	0.854	0.167	0
Irish	41.28	20.50	0.855	0.164	-2
Business	55.01	19.63	0.885	0.163	-2
Geography	56.68	18.68	0.855	0.150	-10
Total	297.81	106.62		1.000	0
Candidates: n = 631					

Total candidates n=2,835

Table 2
Median, Minimum, and Maximum Values for Percent Deviation from Intended Weights (.167) in 20 Subjects in Combinations (n = 155) of Six Best Subjects in the 2001 LCE with 50 or more candidates. (Subjects are in ascending order of the median value of deviation from Intended Weighting.)

	Median	Minimum	Maximum	Combinations	Candidates
French	+15	-38	+36	100	12,384
Biology	+12	-20	+32	68	893
German	+10	-7	+23	19	1,003
Chemistry	+10	-4	+17	11	2,753
Irish	+9	-29	+44	133	17,712
Engineering	+9	-31	+27	5	1,772
Physics	+8	-14	+18	14	2,232
Accounting	+6	-16	+21	21	390
Maths	+5	-17	+36	107	1,882
Tech Draw	+5	-7	+33	10	9,890
Agriculture	+1	-11	+11	3	192
Economics	-1	-9	+18	11	1,546
English	-4	-35	+36	152	19,382
History	-9	-28	+8	29	847
Home Econ	-9	-25	+15	51	9,358
Business	-9	-25	+13	65	11,898
Construction	-13	-55	+9	14	768
Art	-21	-33	+12	22	8,143
Geography	-22	-39	+20	85	13,772
Music	-38	-48	-3	10	663
N combinations				155	
N candidates					19,580

2. *Estimation of Discriminatory Power of the LCE*

The Leaving Certificate Examination results for Mathematics in 1998 are used to illustrate how Discriminatory Grades were calculated (Table 3). Numbers of candidates, Higher and Ordinary, who were awarded the various grades (expressed in Points values) are shown in Columns 1 to 4. The *UG* scale is in Column 5, and when multiplied by the number of candidates for

Table 3
Percentage Discrimination for LCE Mathematics, 1998

1	2	3	4	5	6(=3x5)	7	8(3x7)	9(=8/6) x 100
N Higher	N Ordinary	Total N	Points	UGs	All UGs	DGs	All DGs	
1051	0	1051	100	20	21020	13	13663	
965	0	965	90	18	17370	12	11580	
1147	0	1147	85	17	19499	11	12617	
1319	0	1319	80	16	21104	10	13190	
1319	0	1319	75	15	19785	9	11871	
1244	0	1244	70	14	17416	8	9952	
1115	0	1115	65	13	14495	7	7805	
815	3073	3888	60	12	46656	6	23328	
590	0	590	55	11	6490	5	2950	
440	3299	3739	50	10	37390	4	14956	
386	3706	4092	45	9	36828	3	12276	
0	3751	3751	40	8	30008	2	7502	
0	3706	3706	35	7	25942	1	3706	
0	3751	3751	30	6	22506	0	0	
0	3751	3751	25	5	18755	1	3751	
0	3570	3570	20	4	14280	2	7140	
0	3389	3389	15	3	10167	3	10167	
0	3028	3028	10	2	6056	4	12112	
0	3706	3706	5	1	3706	5	18530	
322	6417	6739	0	0	0	6	40434	
10713	45147	55860			389473		237530	61%

each scale value, and then summed, gives the total number of *UGs* (389,473) (Column 6). The recentred scale for discriminatory gradings (*DGs*) is in Column 7, with its zero-point on the median grade, and the count of *DGs* comes to 237,530 (Column 8). The latter is then given as a percentage of the former (61%), which is the discriminatory power of the combined Ordinary and Higher level examinations in Mathematics in the 1998 LCE, in other words, the percentage of *UGs* that are *DGs,* or the extent to which the Mathematics examination records differences between candidates.

Table 4 shows values of *DP* for the 20 most commonly taken subjects from 1998 to 2007, where the subjects are in descending order of their *DP* values. The figures show two clear effects: (i) large and consistent differences between subjects in values of *DP,* which range from 66% to 17%, and (ii) a gradual reduction over time in values of *DP* in most subjects, and hence in the overall LCE, which declined from 52% in 1998 to 43% in 2007.

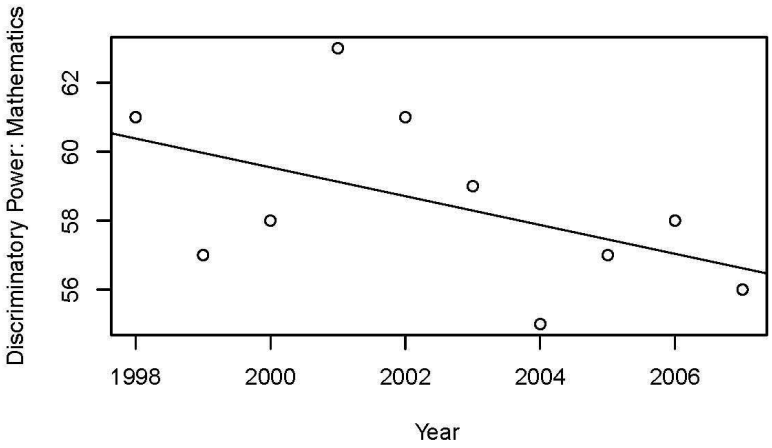
Table 4
Percentage of Gradings Discriminating between Candidates in 20 LCE Subjects from 1998 to 2007, and Beta Coefficient (b_1) Showing Yearly Change

	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	b_1
Mathematics	61	57	58	63	61	59	55	57	58	56	-0.4
French	66	57	50	55	55	53	54	53	55	54	-0.7
Biology	58	59	55	58	53	55	52	47	46	50	-1.3
Irish	65	62	49	48	49	45	45	49	52	45	-1.6
Tech Drawing	60	52	49	50	47	48	48	47	46	47	-1.1
Agriculture	41	49	49	48	47	53	51	47	42	44	-0.1
Physics	52	50	46	49	46	47	42	44	42	42	-1.1
History	48	48	49	43	50	47	46	44	38	35	-1.2
Accounting	50	47	49	45	45	41	41	40	44	42	-0.9
Home Econ.	46	45	47	46	44	42	42	41	44	41	-0.6
English	51	52	49	44	40	39	39	39	38	39	-1.6
German	43	44	42	42	43	44	43	45	42	42	0.0
Business	51	40	41	41	39	40	39	44	44	44	-0.2
Engineering	49	41	38	39	43	40	39	36	39	40	-0.7
Chemistry	43	37	36	37	36	32	35	37	39	35	-0.4
Economics	38	38	36	39	37	36	36	36	35	35	-0.4
Art	41	38	38	35	37	35	34	29	33	34	-0.9
Construction	39	36	32	32	35	35	36	36	33	35	-0.2
Geography	36	32	35	34	36	35	35	36	35	33	-0.2
Music	26	17	17	18	17	16	18	17	17	17	-0.5
All subjects	52	49	46	46	45	43	43	43	43	43	-0.9

The data indicate that all subjects, with one exception (German), exhibited an overall decline in discriminatory power between 1998 and 2007. The decline varied between -0.2 (Business Studies, Construction Studies, Geography) and

-1.6 (Irish, English). In general, the decline is consistent, but for some subjects (e.g., Agriculture) it is not. The fitted regression time for the *DP* values in the first row of Table 4 (Mathematics) is shown in Figure 1.

Figure 1
Discriminatory Power of Mathematics, 1998-2007



The decline in discriminatory power of examinations, like the loss of dispersion for individual subjects in various six-subject combinations, stems from a ceiling effect, that is, the bunching of scores as their average approaches the maximum. Moreover, Table 4 shows that the problem is getting worse. The connection between high scores and reduced variance can be quantified by the correlation coefficients between the discrimination figure for LCE subjects in Table 4 and two other key LCE variables, (i) the average CAO points award for the subject, and (ii) the percentage of candidates for a given subject who took the Higher level examination. The average correlation of *DP* and Average Points is -.91 (ranging from -.87 to -.93), while the correlation with percentage of candidates taking the Higher level examination is -.58 (ranging from -.50 to -.66). Jointly, these two variables explain an average of 83% (ranging from 77% to 87%) of the variance of *DP* over subjects. Over 50% is controlled by differences between subjects in the percentage of their candidates taking the Higher level examination, and another (independent) 30% is controlled by differences between subjects in the size of their average awards.

CONCLUSION

The Leaving Certificate Examination is remarkable for the range of subjects it offers (about 35), based on its commitment to broad-spectrum education. In practice, a large majority of students in Ireland study a minimum of six subjects in a large number of combinations to the end of their second-level education. In theory, this would not pose a threat to the integrity of the examination if the dispersion of marks within subjects was approximately equal. But this is not the case.

A major factor contributing to differences in grade dispersion in LCE subjects is the large difference between subjects in the percentages of their candidates who take the Higher level examination. For example, in the 2001 LCE, the figure for Mathematics was 20%, compared to 35% in Irish, 47% in French, 61% in Biology, 71% in Art, 82% in Chemistry, and 89% in Music. Points averages per subject, in the same order, range from 35% to 72%, with an increasing loss of dispersion as averages approach the maximum. In addressing this issue, the CAO points system proposed a solution in the form of a 40-point difference between all Ordinary level examinations and their Higher equivalents. But this particular solution poses problems of its own, since the terms 'Ordinary' and 'Higher' do not have a fixed meaning across subjects, as is evident from the figures just given for the percentages of candidates taking the Higher papers in different subjects.

Good reasons can be suggested for the average high points scores recorded in some subjects, such as differences between candidates taking different examinations or differences in the academic demands of subjects (see Kellaghan & Millar, 2003). It is possible that such reasons could also be used to justify the unusually high proportion of candidates in Higher programmes. If so, the reasons should be articulated and put in the public domain. Otherwise, they belong with the many varieties of covert evaluation that public examinations were intended to eliminate, consisting of decisions that are not open to public scrutiny, but nevertheless have a major impact on the grades awarded to candidates. In most cases, however, there is no obvious explanation for discrepancies between LCE subjects in their average awards or in the sizes of their Higher programmes. The prevailing pattern appears to reflect nothing more than long-standing tradition, combined with the uneven effects of increasing competition between subjects in their efforts to ensure that their candidates are not at a disadvantage because of their choice of

subject and the cumulative effects of a yearly inflation of grades that has, however, been resisted in some subjects.

Unequal dispersion of marks in LCE subjects has reached a level that raises questions, not only about transparency but also about the capacity of many subject examinations to describe accurately the levels of candidates' achievement. Partly due to the arbitrariness of the points system, combined with the increase in points awards (Mac Aogáin, 2005), many LCE subjects now find themselves placing an ever larger proportion of their candidates into a small interval at the top of the 100-point scale, with large losses in the discriminatory power of their examinations. And given that the Ordinary and Higher levels of each subject are mapped to a common 100-point scale, this trend is accelerated by the steady transfer of candidates in recent years from Ordinary to Higher level courses.

A number of proposals have been made to deal with variation between subjects in the way grades are distributed in the Leaving Certificate Examination which, as our data show, has consequences for the weights achieved by subjects in the examination and the discriminatory power of the examination, though these issues are not recognized in the proposals. One proposal is to impose the same distribution on candidates' scores in all subjects (see, e.g., Walsh, 1999). While the proposal identifies two core issues, namely inequality of means and of dispersions, it incorrectly assumes that procedures used in the construction of norm-referenced standardized tests are relevant to the complex suite of examinations that make up the LCE.

In this context, a more bizarre proposal by Mac Craith (2012), described in a NCCA/HEA discussion paper, *Entry to Higher Education in Ireland in the 21st Century,* as 'valid' and 'logical' (Hyland, 2011), is that all the candidates taking an examination would be rank-ordered and allocated CAO points according to their percentile rank, the top 1% getting 100 points, the next 1% 99 points, and so on. As in the case of all proposals to impose a Normal distribution on LCE grades, this ignores measurement issues[1] and fails to address the non-equivalence of LCE grades across subjects, that for example, an A in one subject may not represent the same level of achievement as an A in another subject, or that candidates opting for different examinations differ in their characteristics (Kellaghan & Millar, 2003). The ranking, if adopted, would impose a limit on the proportion of candidates

[1] Mac Craith is mistaken in thinking that his proposal is in line with the measurement procedures of the American SATs.

awarded high and low grades, no matter how well they performed. Furthermore, if we were to translate points determined in this way into grades, a score of 39 or lower would merit an award of E, F, or NG for a candidate. This would lead to a hardly acceptable situation in which 39% of candidates would be assured of these grades in all future examinations, whereas in the LCE at present, the percentage awarded the grades is usually 10% or less, in some cases considerably less. It is clear that such proposals are not based on an analysis of the circumstances that give rise to the lack of conformity between subjects in how grades are allocated, that they ignore measurement issues, and fail to consider the consequences that would ensue if the proposals were implemented.

There is no simple, one-shot solution to the problems identified in this paper. There are, however a number of approaches that merit consideration (see Mac Aogáin, 2005). First, the ceiling on examinations could be raised by including more difficult questions, involving, for example, items that assess much vaunted 'higher-order' thinking skills. Secondly, efforts could be made to reduce variation between subjects in the proportion of their candidates taking the Higher level examination. Subjects in which only a minority of candidates take examinations at Higher level could expand to accommodate larger numbers at that level, moving towards parity with Ordinary level. This proposal, of course, has implications for curriculum provision in schools. Thirdly, the inclusion of common items in Higher and Ordinary level examinations would allow performance on the two levels to be placed on a single scale based on empirical data rather than on the intuitive and somewhat arbitrary judgments which underlie the present distinction in points allocation between Higher and Ordinary level examinations.

In considering these proposals, it should be borne in mind that they would not apply to all subjects since little or no adjustment would be required in some. Furthermore, change would have to be gradual, as implementation which involved a lowering of the current average mark, or a reduction in the proportion of high grades awarded in a subject, would be likely to encounter resistance. Finally, any proposal for change should recognize and respect the autonomy of subjects as an important element in the Leaving Certificate Examination's endorsement of broad-spectrum education.

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