PREDICTING STUDENT SUCCESS

ABSTRACT

This present study investigates the legitimacy of using the Cambridge General Certificate of Education (GCE) alternative ordinary mathematics (AOM) results to predict student success at the GCE advanced level mathematics (ALM). AOM students begin at age 16 and finish at 18, while ALM students start at age 18 and finish at 20. A random sample of 177 high school students of the 17- 19+ age cohort was selected from a seven-year, state-run, co-educational high school with a broad-based curriculum and a wide catchment area of student intake in The Republic of Trinidad and Tobago, West Indies. Survey instruments used for the study included semi-structured interviews and student academic records from the school. Numerical scales were used to quantify student grades. Findings suggest that AOM serves as a good predictor of success for ALM at the Cambridge GCE examination. Implications of the findings and related issues are discussed.

Keywords: GCE, alternative ordinary level mathematics (AOM), advanced level mathematics (ALM).

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INTRODUCTION

Several correlational studies have been found in the literature examining the relationship between subjects done at the ordinary and advanced levels. Although correlational studies do not establish cause and effect, they serve the useful purpose of indicating relationships that could inform authorities. Many correlational studies have been done in a variety of fields, for example in medicine (Wolf, 1997); in ecological political systems (Homer-Dixon, 1995). Correlation studies show students who have had several years of foreign language do better on SATs, particularly the verbal part (Redmond, 2002). Murphy (1981) found that ordinary level examination grades were closely related to teachers' estimates as predictors of the advanced level results of UUCA applicants. Wilson (1971) predicted levels of first year university performance from advanced level examinations. Whilst these studies have focused on single student groups for examination for a given year, no studies were found using a single group covering a number of years. This present study seeks to fill that gap in the literature.

The decision to pursue mathematics at advanced level is often difficult. Irrelevant and futuristic criteria are used, for example parents' aspirations, students' wishful thinking, joy of being identified with the 'brilliant and gifted' and the pride of

attempting a perceived ‘difficult’ subject. This present study seeks to provide empirical evidence for predicting ALM performance from AOM. It also attempts to investigate the commonly held belief that alternative ordinary mathematics (AOM), oftentimes called additional mathematics adequately prepares the student for advanced level mathematics (ALM).

The Cambridge General Certificate of Education (GCE) examination is a well-recognised international examination done by several British Commonwealth countries. The results of this examination are used to assess and evaluate student achievement in different subjects and at different levels in high schools in the Republic of Trinidad and Tobago, West Indies. A carefully selected number of students from the equivalent of the American Grade 11 level take AOM in preparation for ALM. High school students enter university with minimum matriculation requirements of two advanced level subjects and an equivalent English proficiency pass. For the student, the prospective field of study in higher education is partly determined by the subjects passed at advanced level.

AOM is a two year program commencing at the equivalent of Grade 10 level of American high school (approximately 14 –15+ age cohort). ALM is also a two year program usually taken after completion of AOM. It commences at the beginning of the equivalent of American Grade 13 (approximately 18 – 20 age cohort). For ALM, paper 1 focuses on all pure mathematics questions whilst paper 2 focuses on one section with two options viz. applied mathematics and statistics. The format for the AOM paper is similar.

METHOD

Participants

Participants for the study were 117 high school students (16 - 19+ age cohort). The participants were selected on the basis of availability of their academic records for both the AOM and ALM examination results. The examination boards do not store information about individual examination candidates in a manner to allow for retrieval of information about the same candidates in different years at different levels.

The high school sited in The Republic of Trinidad and Tobago, West Indies was selected from among available high schools because it offered both AOM and ALM under a seven-year curriculum. In addition, the school was state-run, coeducational and had a broad-based curriculum with a mixed ability student intake from a wide catchment area in the country, representative of the typical high school student.

Instruments

Semi-structured interviews were used to gather background information about the high school and the participants for the study. Student academic records obtained from the school provided data about student grades at both AOM and ALM examinations.

DATA ANALYSIS

The Statistical Package for the Social Sciences (SPSS) (Norusis, 2000) was used for data analysis. Overall student grades for AOM are issued by the Cambridge

examination board, in descending order of achievement as grades A, B, C, D, E, F, and U. To obtain numerical equivalents for these grades, the following alphanumeric transformation was used: A=1, B=2, C=3, D=4, E=5, F=6, U=7. For AOM, Grades A to E were considered as passes, F as a failure to reach an acceptable standard and U the state of being ungraded.

Similarly, for ALM, overall grades, in descending order of achievement are given as grades A, B, C, D, E, O, F and U. These grades were transformed into numerical scores as follows: A=1, B =2 C=3, D=4, E=5, O=6, F=7 and U=8. For ALM, Grades A to E were considered as passes, O as a pass below the advanced level standard, F as a failure to reach an acceptable standard and U represented the state of being ungraded. Missing values were approximated using the teachers' estimated predicted scores for the students. Since grades for two papers for ALM are reported it was important to have a single numerical grade for ALM. This was done using the following grid specifications in Table 1.

Table 1
Indices used in statistical analysis for ALM

		PAPER 2 GRADES							
		A	B	C	D	F	O	F	U
PAPER 1 GRADE	CODED GRADE	1	2	3	4	5	6	7	8
A	1	1	2	3	4	5	6	7	8
B	2	9	10	11	12	13	14	15	16
C	3	17	18	19	20	21	22	23	24
D	4	25	26	27	28	29	30	31	32
E	5	33	34	35	36	37	38	39	40
O	6	41	42	43	44	45	46	47	48
F	7	49	50	51	52	53	54	55	56
U	8	57	58	59	60	61	62	63	64

A student with grade C in ALM paper 2 and a grade B in ALM paper 2 was assigned the index 18. Similarly, a student with grade U in ALM paper 1 and a grade F in ALM paper 2 was assigned the index 63. These numerical composite grades for ALM were compared to the numerical grades for AOM for the overall correlation analysis.
From available information, no data was found to indicate that there were changes in the grade scale that could have affected the relationship between the two examinations over the period studied.

RESULTS

Chi-square, Somer' s D (symmetric and asymmetric), Gamma and Tau C are statistical measures that measure the relationship between variables with different emphases. Performance in AOM was significantly related to performance in and ALM (chi-square (42) = 96.16, $p < 0.01$ sig.). Kendall' s Tau C (.36, .00 sig.) indicated a stringent measure of association giving both pairs tied to AOM but not ALM and pairs tied on ALM but not on AOM. Results show that there is a 36 % uncertainty that a student obtaining a specific grade at AOM would receive the same grade at ALM. A fairly monotonic association was shown between AOM and ALM as indicated by Gamma (0.48). Both one way and two predictions were found: Somer' s D (asymmetric) (0.38) with AOM dependent and asymmetric (.40) with ALM dependent whilst Somer' s D (symmetric) (.39). This meant that there was a 38% uncertainty that a candidate who passed ALM would pass AOM. Also, it was found that there was a 39% uncertainty that a candidate who passed AOM would pass ALM (Somer' s D (symmetric) (.39)).

Using the composite grades for ALM obtained form Table 1, it was found that AOM had a .48 correlation with ALM for the overall paper (Table 2). AOM and ALM paper 1

also had a correlation 0f .48 whilst AOM and ALM paper 2 had a correlation of .47 (Table 2). It is significant to note that for ALM paper 1 contained all pure mathematics questions whilst paper 2 contained one section with pure mathematics and another section with applied mathematics and statistics as two options. The correlations indicate that relationships between AOM and ALM may be reasonably established in terms of inferring predictive validity.

Table 2
Spearman's Correlation Matrix of AOM and ALM by paper

Subject	Advanced Level Mathematics (AOM)		
	Overall A Level	ALM Paper 1	ALM Paper 2
AOM	.48	.48	.47
ALM		.90	.91
ALM Paper 1			.76

Note. Significance levels less than 0.01.

A similar analysis was done by sex (Table 3). It was found that amongst males correlations were higher than for females on the overall ALM paper and also on the separate ALM papers (males: .54 overall; .60: paper 1; .54: paper2; females: .35 overall; .21 paper 1; .33 paper 2).

Table 3
Spearman's Correlation Matrix of AOM and ALM by sex

	Equal number of cases		Unequal number of cases	
	Coeff	Sig	Coeff	Sig
Males	.67	.001	.54	.001
Females	.50	.002	.34	.004

The canonical analysis was used as a means of investigating the possibility that success at ALM involved more than one component that related to AOM. It examined the

relationships between several criterion variables (A level papers) and the predictor variable AOM. The process extracted pairs of linear combinations (canonical variates) from each set of variables so as to maximise the correlation between the combinations. The first canonical variate was extracted to account for maximum variance. Greater contribution arose from AOM than ALM paper 1. The canonical correlation of .61 between predictor and criterion variables indicates that approximately 37% of their variance was held in common. No further variates were extracted to account for as much as possible of the remaining variance since there was no remaining residual linear association between the two sets of variables. Table 4 shows that the canonical coefficients obtained indicating the significant contribution of AOM to ALM.

Table 4
Canonical correlations

Set	Variable	Canonical coefficient
1	AOM	.92
2	ALM overall	.25
2	ALM paper 1	.81
2	ALM paper 2	-.05

Linear stepwise regression by the method of forward selection chooses the first variable with the highest correlation followed by the next variable in terms of magnitude of correlation and continues onwards. The results indicated the equation: ALM = 2.70 + 4.93 AOM. This means that a unit change in AOM would increase in ALM from 2.7 to 7.63.

A small sample of six students of given A Level year not used in the analysis was the only available sample for use in the cross validation analysis and to control for the effect of time. It was found that ALM= 2.26 + .58 AOM. A unit change in AOM would

increase ALM from 2.26 to 2.84. Generally, predicted grades here tended to be lower than the actual ALM grades obtained but there was consistency throughout. High AOM grades predicted high ALM grades.

The expectancy or probability table (Table 5) indicates probabilities of obtaining single grades that are useful in anticipating class assignments for ALM.

Table 5

Expectancy table showing probabilities in percentages for ALM given AOM by sex

		ALM Grades						
AOM Grades	Sex	A	B	C	D	E	F	O
A	M	46.2	30.8	7.7	7.7	7.7	0.0	0.0
	F	28.6	42.9	0.0	0.0	28.6	0.0	0.0
	A	40.0	35.9	5.0	5.0	15.0	0.0	0.0
B	M	14.8	18.5	18.5	11.1	18.5	7.4	11.1
	F	0.0	0.0	27.3	26.4	18.2	18.2	0.0
	A	10.5	13.2	21.1	18.4	18.4	10.5	7.9
C	M	2.9	14.7	5.9	5.9	41.2	20.6	8.8
	F	3.8	7.7	3.8	26.9	26.9	23.1	7.7
	A	3.3	11.7	5.0	15.0	35.0	21.7	8.3
D	M	0.0	0.0	0.0	9.1	54.5	18.2	18.2
	F	0.0	0.0	25.0	25.0	50.0	0.0	0.0
	A	0.0	0.0	6.7	13.3	53.3	13.3	13.3
E	M	0.0	0.0	20.0	0.0	50.0	0.0	50.0
	F	0.0	0.0	0.0	0.0	100.0	0.0	0.0
	A	0.0	28.6	14.3	0.0	57.1	0.0	33.3
F	M	0.0	0.0	20.0	0.0	80.0	0.0	0.0
	F	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	A	0.0	0.0	0.0	10.0	10.0	50.0	0.0

U	M	0.0	0.0	0.0	16.7	16.7	50.0	16.7
	F	0.0	0.0	0.0	0.0	0.0	0.0	50.0
	A	0.0	0.0	0.0	0.0	100.0	0.0	30.0

Table 5 indicates that generally students who had grades 1 (A) in AOM had higher probabilities of obtaining grades A (40%) in ALM than of obtaining grades D (0%). Similarly, generally students who had grades 3 (C) in AOM had lower probabilities of obtaining grades A (3%) in ALM than of obtaining grades E (35%). By the same principle generally students who had lower grades in AOM tended to have corresponding low grades in ALM. Grade C appeared to be problematic but there are several possible explanations for this phenomenon which are outside the scope of this preset paper.

DISCUSSION

The use of participants' grades instead of raw scores (that would better reveal relationships peculiar to examination papers) and the effects of syllabus changes involving a transition from a traditional to a modern approach were obvious limitations of the present study. Grade transformations used assume that grades at the examinations approximately measured the same range of students' skills. There is a methodological problem with studies of this kind in which there is restriction in range on the predictor variable since only the better AOM candidates are normally selected for ALM. Correction for restriction in range of the correlation coefficients could not have been made because of unavailable data. Despite the limited sample size, the selected high school best represents the West Indian typical student profile so that guarded generalisations to wider populations may be made with due caution.

The Hawthorne effect that could have affected the results of the present study were minimised because the participants of the study were not aware of the conduct of the research study and so were not affected in their performance at both examinations by a knowledge that the relationship of their grades at AOM and ALM were being studied. Teachers and administrators' knowledge of the research study also had no effect on the results of the present study since the data used could not have been changed in any way.

Reliability and validity for AOM and ALM , like all other GCE examination subjects, have been established by the GCE examination board over the years through a series of quality control measures supplemented and monitored by action research (Jorge, 2002). The examination results are analysed and trends or patterns of student performance observed for variations from the expected statistical norms. Detailed statistical procedures are followed to ascertain that reliability and validity are established for all subject areas.

The present study empirically showed that a student' s performance in ALM is reasonably predicted by his/her performance in AOM. An analysis of available school records of the sample showed that the candidates who performed well at AOM also did equally well at ALM and conversely those who performed poorly at AOM also performed equally poorly at ALM. An examination of the overall grades of the candidates in other subject areas also confirmed the authenticity of the AOM/ALM relationship. Selection ratio or the number of vacancies to applicants and base rate or the proportion of applicants capable of qualifying for a pass at ALM interplay besides predictive validity. A delicate balance must be arrived at between selection of too many applicants who fail AOM (false positives) and rejecting too many who would have

passed (false negatives). High predictive validity is undermined if selection ratio for the test is too high. However, as the selection ratio decreases the predictive validity of the test plays a major role in decision making. From results obtained predictive validity at .01 significance was .48. Using the standard Taylor and Russell tables, the following percentage of test passes who are subsequently successful for different selection ratios when the base rate is 50% may be read off as:

Selection ratio	0.05	0.10	0.50	0.40	0.95	1.00
% test passes	88	84	67	54	52	50

This information may be useful to schools in deciding choices for ALM. Lewis (1974) insists that it is the incremental validity of the test or the extent to which it raises the multiple correlation between all predictors and ALM that is important. Thus, personality and interests tests, despite their low predictive validities may be useful in the selection process. A sequential rather than an irreversible approach is recommended.

This researcher conducted several semi-structured interviews with education officers, the school administration, teachers, students and parents. No significant background variables were found affecting the relationship between the two examinations. The collection of the raw data over a period of one month allowed for any possible errors in data retrieval and data recording to be corrected, thereby minimising experimental errors.

The sample did not arise from a single examination year because the researcher was interested in observing a pattern over a period of time, rather than on a single examination as was commonly done in other recorded research studies. This is a noted limitation of the present study and could have undermined the results since it could be

argued that if the AOM and ALM were more difficult in the certain years and they have been getting progressively easier (according to candidates' perceptions) one would expect a high correlation between the examination results. This would blur our vision about the relationship between AOM and ALM *per se*. This concern was addressed by observing the results of AOM and ALM candidates on a single year basis and noting similarities. The same pattern was found over the years confirming that AOM is a reliable predictor of ALM.

This present study recommends that AOM should be retained by school authorities as a reasonable prerequisite for ALM (r = 0.61, 0.05 sig.). Since validity and reliability of the external examinations have been established by the examination board (Jorge, 2002) one has a reasonable measure of confidence in the statements made about predictive validity. The present study also highlights the importance by examination boards of detailed planning and sequencing of mathematical concepts in a manageable, hierarchical manner at AOM in order to facilitate students' grasp of the material at ALM.

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