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INSTITUT TEKNOLOGI MARA SARAWAK

THE ACADEMIC PERFORMANCE OF PRE-SCIENCE STUDENTS IN RELATION TO THEIR SPM RESULTS

By

Iris Syawe Seh Ling
Ong Mooi Lian
Yap Yin

ABSTRACT

The problem of too many applicants for the limited places in tertiary institutions is a rule rather than exception at present. The Pre-Science course offered by ITM which prepares students for courses in science and engineering also faces the same problem. Traditionally, the criterion of student selection is based on a student's SPM results in mathematics and sciences plus a minimum of credits in English and Bahasa Malaysia. These are the core subjects relevant to the courses in science and engineering. For students having similar results in the core subjects, the selection becomes difficult for there is no quantitative measure to evaluate the relative importance of these subjects as well as the subsidiary subjects such as Geography, Art, History or Religious Studies.

In this paper, an attempt is made to quantify the relative importance of the core as well as the subsidiary subjects using the Multiple Regression technique. The objective of the model is to help identify and thus admit into the Pre-Science course students with better potential to succeed in science and technical courses. It is hoped that such a model when incorporated into the admission system, would provide an empirical basis for the computerised screening and selection procedure for students intake and thereby reduce the student drop-out rate for a more efficient production of science and technical human resource to meet the Country's Vision 2020.

1.0 INTRODUCTION

In the past, the Faculties of Applied Science, Mathematics and Computer Science and Engineering were plagued by a lack of qualified applicants for the various courses offered in these three faculties. Hence, to help those students who fail to meet the entrance requirements to these courses, the Pre-Science course was introduced. The objectives of this course are to increase the intake into the three faculties mentioned, to match the student enrolment with the planned target, and to provide an avenue for Bumiputera students to further their studies.

Since the introduction of the Pre-Science course, the scenario has changed dramatically. The number of students qualifying for various diploma courses after successfully completing the Pre-Science course is encouraging. The success of these students has prompted an increasing number of applications into the Pre-Science course and this overwhelming number of applications poses a new problem to ITM as there are not enough places to be offered to all the applicants. Generally, the criteria for the selection of Pre-Science students are two passes in any two science subjects and a pass in either Modern Mathematics or Additional Mathematics. In addition, ITM Sarawak imposes an additional overall requirement of at least a credit in any three subjects.

This paper covers the study of the Pre-Science students in Sarawak. The students selection model so built is only valid for groups having similar selection criterion as in the Sarawak campus. For different courses having different selection criteria, new models can be arrived at by re-entering past students' profile and their actual CGPA attainment and re-running the whole process.

2.0 THE STUDENTS' PROFILE

Since the inception of Pre-Science course in ITM Sarawak in July 1992, 74 students (32 in the Physics group and 42 in the Biology group) have gone through the system. All of them took Bahasa Malaysia, English, Modern Mathematics and Physics at SPM level. Geography is the only Arts subject that was taken by the majority. Table 1 below shows the mean grades and standard deviations of all the SPM subjects taken by these students.

TABLE 1: MEAN GRADES OF SPM SUBJECTS FOR ALL STUDENTS

SPM SUBJECT	MEAN GRADE	STANDARD DEVIATION	NUMBER OF STUDENTS
BAHASA MALAYSIA	5.0	1.84	74
ENGLISH	5.4	2.38	74
MODERN MATHEMATICS	4.3	1.56	74
PHYSICS	7.0	1.11	74
CHEMISTRY	7.7	1.15	73
BIOLOGY	6.5	1.46	70
ADDITIONAL MATHEMATICS	8.4	0.94	67
GEOGRAPHY	6.3	1.80	50
ISLAMIC STUDIES	4.4	1.99	30
ARTS	3.7	1.33	29
HISTORY	4.7	2.34	6
GEOMETRIC DRAWING	7.5	1.00	4
BUILDING TECHNOLOGY	7.5	1.29	4

Table 1 also shows that Modern Mathematics has the best mean grade of 4.3 which is a good credit. However, Additional Mathematics has the worst mean grade of 8.4 which is between pass and fail. This is not surprising as 67.2% of these students either did not take Additional Mathematics or failed it altogether and none passed with a good credit.

The Stepwise Regression Analysis was used to identify the relevance of these SPM subjects to the students' grade point average (GPA) score at the end of the first semester of their Pre-Science course. The results of the analysis indicate that Islamic Studies, Art, History, Geometric Drawing and Building Technology are statistically insignificant in the overall contribution to the GPA performance of the students. Hence, this paper concentrates on the remaining eight subjects: Modern Mathematics, Physics, Chemistry, Biology, Additional Mathematics, English, Bahasa Malaysia and Geography. Table 2 gives the students' SPM performance in the eight subjects mentioned above.

TABLE 2: PRE-SCIENCE STUDENTS' PERFORMANCE IN SPM

SUBJECT	GRADE										
	DISTINCTION (1-2)		GOOD CREDIT (3-4)		CREDIT (5-6)		PASS (7-8)		FAIL (9)		TOTAL NUMBER OF STUDENTS
	NO.	%	NO.	%	NO.	%	NO.	%	NO.	%	
BAHASA MALAYSIA	7	9.5	20	27.0	26	35.1	21	28.4	0	0	74
ENGLISH	6	8.1	24	32.4	18	24.3	14	18.9	12	16.2	74
MODERN MATHEMATICS	6	8.1	36	48.6	26	35.1	6	8.1	0	0	74
PHYSICS	0	0	3	4.1	15	20.3	56	75.7	0	0	74
CHEMISTRY	0	0	0	0	11	15.1	39	53.4	23	31.5	73
BIOLOGY	0	0	9	12.9	23	32.9	34	48.6	4	5.7	70
ADDITIONAL MATHEMATICS	0	0	0	0	5	7.5	17	25.4	45	67.2	67
GEOGRAPHY	0	0	10	20.0	17	34.0	17	34.0	6	12.0	50

The students on entering ITM were given the chance to decide whether they would like to be in the Physics or Biology group. Some of the students based their choice on the Diploma courses that they could take after completing Pre-Science while others based their choice on their ability in either Additional Mathematics or Biology. There were others who could not even make a choice and needed advice. This paper would not be complete without the comparison of these two groups of students.

CHART 1: MEAN GRADES OF SPM SUBJECTS

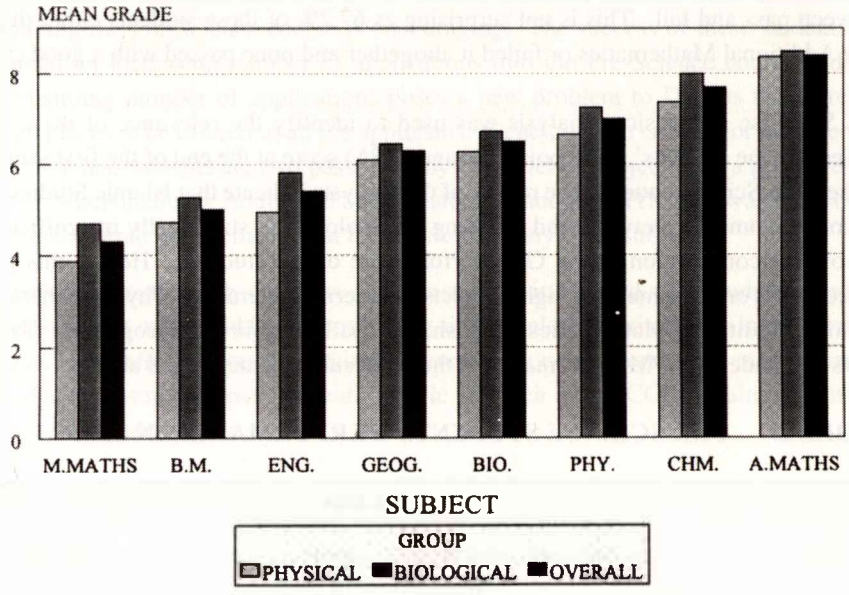


Chart 1 shows that the mean grades of the Physics group in all the core SPM subjects are higher than the Biology group. Further analysis show that the standard deviations of most of these subjects are also higher in the Physics group. This implies that not only the better students chose to be in the Physics group. Some weaker students also chose the Physics group probably because they do not like Biology or they want to meet the prerequisite to their Diploma courses. The mean score of Modern Mathematics for the Physics group is 3.9 which is a good credit with a standard deviation of 1.31 whereas for the Biology group, the mean score for the same subject is 4.7 which is a lower credit and the standard deviation is higher at 1.66. This result confirms the general opinion that the Biology group is weaker in Mathematics.

Charts 2, 3, 4 and 5 show the comparison between groups of students' performance in Modern Mathematics, Physics, Chemistry and Biology. In general, the students are better in Physics than in Chemistry as the Physics grades range between good credit and pass but the Chemistry grades range between credit and fail. Although all the students have passed Modern Mathematics, the majority of the students in the Physics group have either distinction or a good credit in Modern Mathematics whereas the majority of the students in the Biology group have credit. Where Additional Mathematics is concerned, the majority of the students have either failed the subject or did not take the subject.

CHART 2: PERFORMANCE IN MODERN MATHS
(PERCENTAGE OF STUDENTS)

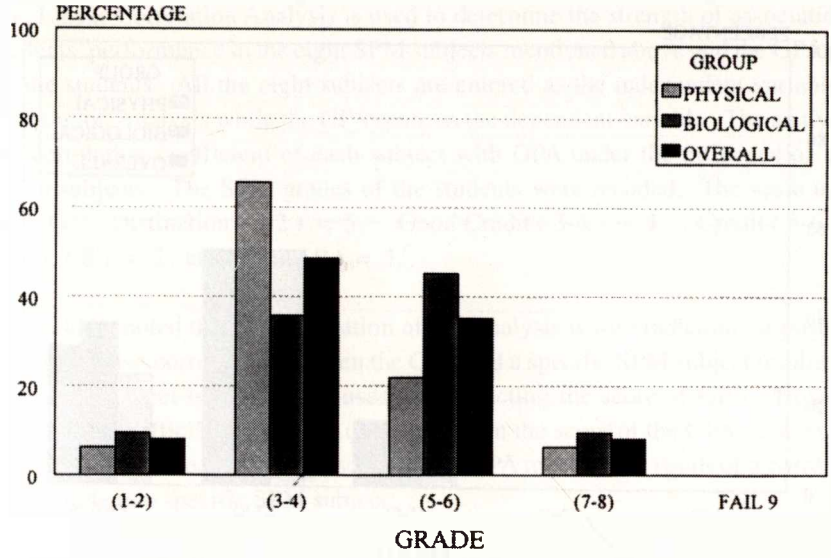


CHART 3: PERFORMANCE IN PHYSICS
(PERCENTAGE OF STUDENTS)

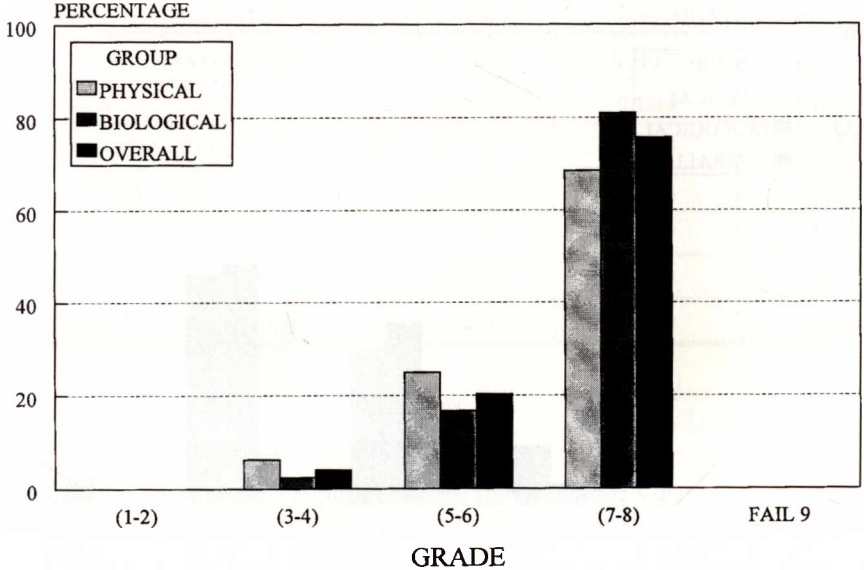


CHART 4: PERFORMANCE IN CHEMISTRY
(PERCENTAGE OF STUDENTS)

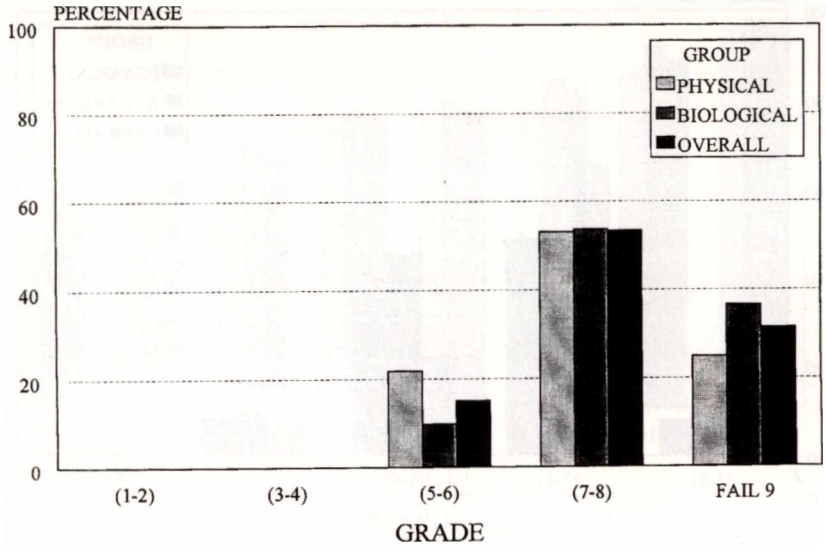
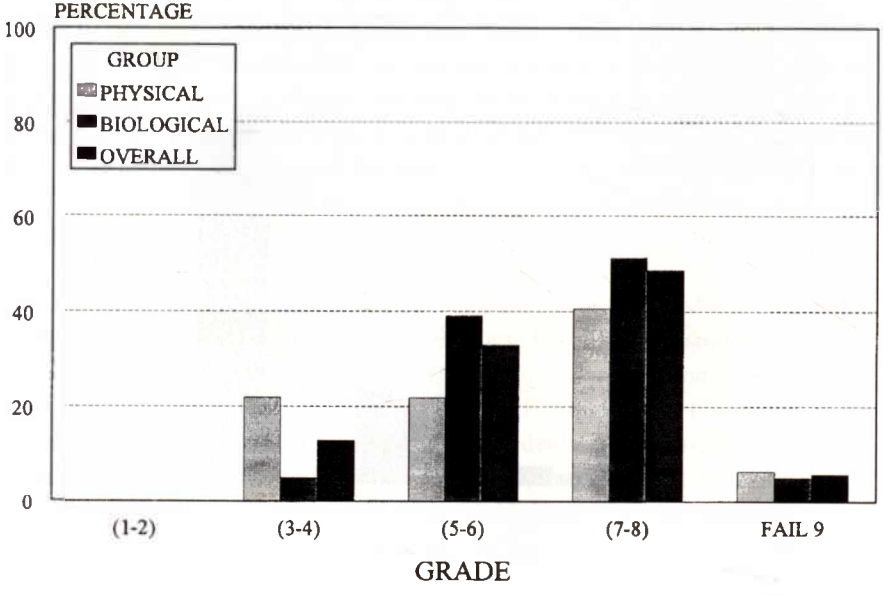


CHART 5: PERFORMANCE IN BIOLOGY
(PERCENTAGE OF STUDENTS)



3.0 CORRELATION OF SPM SUBJECTS WITH GPA

The Linear Correlation Analysis is used to determine the strength of association of the students' performance in the eight SPM subjects mentioned above and the GPA obtained by the students. All the eight subjects are entered as the independent variables in the Correlation Analysis while the GPA score as the dependent variable. The analysis gives the correlation coefficient of each subject with GPA under the influence of the other seven subjects. The SPM grades of the students were recoded. The scale used is as follows: Distinction (1-2) = 5, Good Credit (3-4) = 4, Credit (5-6) = 3, Pass (7-8) = 2 and Fail (9) = 1.

It should be noted that the application of this analysis is for prediction purpose only. A strong positive correlation between the GPA and a specific SPM subject implies that the particular subject is good to be used for predicting the score of GPA. However, the correlation coefficient cannot be used to explain the score of the GPA. For example, it cannot be concluded that a high score of the GPA must be the result of a corresponding good grade in a specific SPM subject.

TABLE 3: CORRELATION COEFFICIENT OF SPM SUBJECTS WITH GPA

SPM SUBJECT	CORRELATION COEFFICIENT		
	PHYSICS	BIOLOGY	OVERALL
MODERN MATHEMATICS	0.4444	0.4995*	0.4832**
ADDITIONAL MATHEMATICS	-0.0202	0.5105*	0.3098
PHYSICS	0.4325	0.4285	0.4151*
BAHASA MALAYSIA	0.0020	0.1236	0.0797
CHEMISTRY	0.2334	0.4673	0.3741*
GEOGRAPHY	0.1154	0.2167	0.1737
BIOLOGY	0.0495	0.2040	0.1354
ENGLISH	0.2973	0.0358	0.0545

* *indicates one-tailed significance at $\alpha = 0.01$ confidence level.*
** *indicates one-tailed significance at $\alpha = 0.001$ confidence level.*

The Correlation Analysis is summarised in Table 3. It shows that at one extreme, there are very strong positive correlations of Modern Mathematics and Physics with GPA and at the other extreme there are almost negligible correlations of Bahasa Malaysia and

English with the GPA. Chemistry and Additional Mathematics, however, show moderately strong positive correlations with the GPA. Hence, Modern Mathematics, Physics and Chemistry should be taken as predictors of the GPA.

For the Physics group, none of the subjects seems to have any significant correlation with GPA. The two subjects closest to having a significant correlation with GPA are Modern Mathematics and Physics. This is consistent to general expectation because both are compulsory subjects in Pre-Science. The subject that seems to paint the most peculiar picture of all is Additional Mathematics. Generally, it is expected that Additional Mathematics should have some significance to these students. However, according to the table above, not only does it bear no significance, it is inversely proportional to the GPA. Although 59.4% of the students in this group fail the subject at SPM level, they are given the chance to study the subject right from the basics with fewer topics in the syllabus. Thus, many of them manage to grasp the concept and develop better understanding resulting in better performance. None of those students who passed their SPM Additional Mathematics failed Additional Mathematics at Pre-Science level.

For the Biology Group, Additional Mathematics is most highly correlated to GPA at 99% significance level followed by Modern Mathematics. Biology does not seem to be significantly correlated to the GPA.

4.0 MULTIPLE REGRESSION ANALYSIS OF GPA IN RELATION TO SPM RESULTS

The multiple regression analysis model used is of the form :

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + ... + \beta_p X_{pi} + e_i$$

where the notation X_{pi} indicates the value of the p^{th} independent variable for case i. The β_p terms are unknown parameters and the e_i terms are independent random variables that are normally distributed with mean 0 and constant variance, σ^2.

The model assumes that there is a normal distribution of the dependent variable for every combination of the values of the independent variables in the model. In this study, Y_i refers to the GPA of the i^{th} student while the X_{pi} refers to the precoded SPM result of the p^{th} SPM subject of the i^{th} student.

The notations of X_p used in this model are as follows:-

Geography	X_1
English	X_2
Chemistry	X_3
Bahasa Malaysia	X_4
Additional Mathematics	X_5
Physics	X_6
Modern Mathematics	X_7
Biology	X_8

The regression coefficients in Table 4 have to be normalised since the scaling system of the dependent variable Y (GPA) is not the same as the independent variables. Hence, the standardised or Beta coefficient would provide a common basis of comparison with regard to the significance of the independent variables (SPM subjects).

Table 4 shows that only the Beta regression coefficient of Modern Mathematics is significant at $\alpha = 0.012$ level of significance. However, Physics with a T value of 1.909 is significant at $\alpha = 0.0649$ level of significance. The two least significant subjects are English and Additional Mathematics which show that if the students have low grades or even fail the subjects at SPM level, these subjects will not significantly affect their GPA.

After the Multiple Regression Analysis was run, the equation which relates the GPA to the SPM subjects is as follows:-

$$Y = 0.087412X_1 + 0.018128X_2 + 0.240461X_3 + 0.193644X_4 - 0.013926X_5 + 0.350043X_6 + 0.337100X_7 - 0.119901X_8 - 0.250972$$

The statistical measure used as an overall indicator of the goodness of fit of the multiple regression model is the Sample Coefficient of Multiple Determination. The multiple correlation coefficient is defined as the square root of the coefficient of multiple determination. In the analysis, the value of R Square is 0.43697 which implies that 43.7% of the total variation in the GPA may be explained by the knowledge of the regressive hyper plane and the values of the eight SPM subjects. In other words, using the students' SPM subject performance as a predictor, about 43.7% of their performance in ITM can be explained. The other 56.3% of the total variation in GPA is estimated to be due to other causes such as chance variations, socio-economic background of the students, teaching methodology, experience of lecturers, class size, etc. This also implies

that the Pre-Science course provides the avenue for students to improve in subjects which are relevant to the diploma courses that they intend to take.

TABLE 4: MULTIPLE REGRESSION ANALYSIS OF GPA IN RELATION TO SPM RESULTS

VARIABLES	UNADJUSTED REGRESSION COEFFICIENT (β)	ADJUSTED REGRESSION COEFFICIENT (BETA)	MEAN SCORE	STANDARD DEVIATION	T	SIG T
MODERN MATHEMATICS	0.337100	0.429539	3.6429	0.8785	2.673	0.0116
ADDITIONAL MATHEMATICS	-0.013926	-0.011652	1.3571	0.5768	-0.076	0.9400
PHYSICS	0.350043	0.297941	2.2619	0.5868	1.909	0.0649
BAHASA MALAYSIA	0.193644	0.276844	3.1667	0.9857	1.858	0.0721
CHEMISTRY	0.240461	0.221734	1.7143	0.6358	1.590	0.1213
GEOGRAPHY	0.087412	0.122516	2.5714	0.9663	0.682	0.4997
BIOLOGY	-0.119901	-0.138235	2.3810	0.7949	-0.708	0.4837
ENGLISH	0.018128	0.033100	2.9762	1.2589	0.235	0.8155

5.0 RELATIVE IMPORTANCE OF THE SELECTED SPM SUBJECTS IN RELATION TO THE GPA OF THE STUDENTS

The actual coefficients (β_p) of the independent variables (X_{pi}) from the multiple regression equation may not reflect their relative importance in relation to the dependent variable (Y) because the units and magnitude of each independent variable may be different. To overcome such problem the Beta weights are used. These are the coefficients of the independent variables when all variables are expressed in standardised (Z-Score) form. However, the values of the Beta coefficients, like the linear regression coefficients, are dependent on the other variables in the equation. Hence, they may not in any absolute sense reflect the importance of the various independent variables.

Another way of assessing the relative importance of independent variables is to consider the increase in R square when a variable is entered into an equation that already contains the other independent variables.

The change in R square is:

$$\textbf{Reduction in } R^2 = R^2 - R_i^2$$

where R_i^2 is the square of the multiple correlation coefficient when all the independent

variables except the i^{th} are in the equation. A large change in R^2 indicates that a variable provides unique information about the dependent variable that is not available from the other independent variables in the equation.

This method is used to determine the relative importance of the eight SPM subjects in relation to GPA. Each SPM subject is removed from the overall multiple regression model to compute the R square (R_i^2) in the absence of that particular (i^{th}) subject. The reduction of R square in the new model will indicate the contribution of the subject to the R square of the overall model. Table 5 shows that the individual contribution of the eight subjects account for 84.63% of the original R square. The remainder 15.37% may be due to chance variations or interaction effects of the subjects.

Table 5 also shows that Modern Mathematics when removed from the model caused a reduction of 0.1219 in R square which represents 27.90% of the original R square. Additional Mathematics, Physics, Chemistry and Biology account for 46.73% of the total R square respectively of the original R square. On the other hand, for the language subjects, Bahasa Malaysia contributes 13.48% while English contributes only 0.21%. This also implies the importance of Bahasa Malaysia as a medium of instruction for the other subjects. English as a subject hardly contributes at all to the overall R square. Hence, the students' performance in English at SPM level is invariant to their subsequent GPA score because no credit point is given to the students' performance in English and the pass mark is only 40%. However, this study is confined to the Pre-Science students only. Perhaps at the higher levels of Diploma courses, another study can be done to determine if their performance in English at SPM level contributes significantly to their GPA.

TABLE 5: LEVEL-3 ANALYSIS (R^2 = 0.43697)

SUBJECT REMOVED	R_i^2	REDUCTION IN R^2	% REDUCTION
MODERN MATHEMATICS	0.31508	-0.1219	27.90
ADDITIONAL MATHEMATICS	0.34457	-0.0924	21.15
PHYSICS	0.37477	-0.0622	14.23
BAHASA MALAYSIA	0.37808	-0.0589	13.48
CHEMISTRY	0.39125	-0.0457	10.46
GEOGRAPHY	0.41371	0.0039	5.31
BIOLOGY	0.44084	0.0039	0.89
ENGLISH	0.43603	-0.0009	0.21

6.0 CONCLUDING REMARKS

Generally, the Pre-Science students have mediocre SPM results. Their Modern Mathematics grades are very important to their overall GPA performance. The other relevant subjects are Physics, Bahasa Malaysia and Chemistry. On the other hand, their SPM performance in Additional Mathematics and Arts subjects is irrelevant to their achievement. The students' performance in English is not relevant to the GPA, which gives no credit to English. However, as English is the universally accepted language of science and technology, it is imperative that the graduates of ITM for science and technology have sufficient functional literacy in the language to face the challenge of global competition.

The Multiple Regression Model obtained shows that 43.7% of the GPA performance can be explained by the SPM results. This is a very high value. However, a better model can be obtained if less important subjects from the eight used are further eliminated. In addition, more data over a longer period of time should provide a more accurate equation. A more comprehensive model incorporating other exogenous variables such as the students' socio-economic background would provide not only the predictive but also the causal factors with respect to the students' GPA performance in the Pre-Science course.

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