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B. Yushau & M. H. Omar

DHAHRAN 31261 ● SAUDI ARABIA ● www.kfupm.edu.sa/math/ ● E-mail: mathdept@kfupm.edu.sa

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B. Yushau & M. H. Omar

Department of Mathematical Sciences

King Fahd University of Petroleum and Mineral.

Dhahran, Saudi Arabia.

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* Corresponding author: Full Contact Address:

Snail mail

P. O. Box 1154

KFUPM, Dhahran, 31261,

Saudi Arabia

e-mail: byushau@kfupm.edu.sa

Fax: 966-03-860 2979

Tel # 966-03-860-1081/5023

Abstract

This study investigates the effect of the preparatory year program courses on the first calculus course. The data consists of grade records of more than two thousands students tracked over seven semesters, and comes from a bilingual Arab students studying at an English medium university. A multinomial logistic regression analyses was used as the method of scientific inquiry. It was found that the best model in explaining success in Calculus I course is the refined two-way interaction model. The model appears to suggest that at KFUPM the success on Calculus I course depends on the two preparatory year Math courses. The interaction between these two math courses was found to be the most important predictor of Calculus I performance. Other factors that contributed significantly in the model include the interaction of Math 002 with the semester Term followed by Engl 002. Furthermore, it was found that the old math placement requirement produces higher probabilities for performance in Calculus I compared to the new requirement.

1. Background of the study

It is now a common trend in many Middle Eastern universities that university courses are mostly taught in English in place of the native Arabic language, also the language of instruction from primary to secondary school level. The reason for the increase of this phenomenon is not unconnected with dominance of English in the scientific world. Different universities use different programs to bridge the psychological and/or academic gap that this language switch may cause. The most commonly used approach in the Middle Eastern universities is a one year preparatory (two-semester orientation) program. In addition to bridging the language barrier, the program also aims at creating conducive atmosphere for smooth transition from high school to the university.

King Fahd University of Petroleum & Minerals (KFUPM) is one of the few universities in Saudi Arabia in which the language of instruction is officially English. Therefore, in principle, all students admitted to KFUPM are required to complete a one-year preparatory program before starting their undergraduate studies. This program mainly consists of an intensive English language program consisting of Engl 001 and Engl 002, and a review of some basic high school mathematics comprising of Math 001 and Math 002. In addition, students take courses related to Graphics, Mechanical Engineering Workshop, and Physical Education during the preparatory year.

According to the Undergraduate Bulletin of KFUPM (2001-2003), the main aim of the preparatory year program is to prepare students for undergraduate study, in particular to achieve the following goals:

a) to improve the English language proficiency of students before they undertake undergraduate study;
b) to develop and improve students’ knowledge of mathematical and analytical techniques through the medium of English;
c) to introduce students to new subject areas and techniques such as workshop and graphics, thus improving their mental and manual skills;
d) to familiarize students with various majors available at the University;

e) to improve students' physical health and stamina through the Physical Education program;

f) to familiarize students with the requirements of undergraduate study, including study skills and discipline in all its forms.

(KFUPM Undergraduate Bulletin, 2001-2003:29-30).

However, the system is flexible in the sense that students may be exempted from the entire or a part of the preparatory program by taking promotion exams in either English, mathematics or both. The promotion exams are conducted at the start of each term. In the case of English, students with acceptable good points in TOEFL may also be exempted from taking English.

As earlier stated, the KFUPM preparatory year program is a two-semester program. However, students are given a maximum of three semesters to complete the program. The grades earned by the students in the program are not considered in the calculation of the students' cumulative grade point average (CGPA) for the undergraduate program. Nevertheless, the grades are recorded in the students' transcript together with the semester grade point average (GPA) and CGPA. More notably, a students' performance at the preparatory year program is largely considered as a predictor of his success in the undergraduate program (c.f. Al-Doghan, 1985).

It should be noted that though KFUPM is engineering and science oriented university, it is not automatic for all admitted students to secure a place in engineering and computer science courses after completing orientation program. For a student to go for any academic program of his choice, he has to meet some minimum grade requirement in both preparatory-year mathematics and English courses. Initially, the requirement was that student must have a minimum grade of C in both mathematics (Math 001 and Math 002) and English (Engl 001 and Engl 002) courses. The requirement now is a bit relaxed in mathematics. Students must pass Math 001 with at least D, and must have a minimum of grade C in Math 002. The consequence of not satisfying any of these criteria, students are "forced" to go to either Management or Environmental Colleges.

The debate or rather the quest for the best criterion to be used at the preparatory year level that will produce best engineering students is still at large. It is worthy of note that the criterion that has been and is being used at best appear to be pragmatic in nature. There seems not to be, to the best of our knowledge, statistical support for any of the criterion being used.

After passing the preparatory year courses, students follow two different mathematics strands. Those students posted to college of sciences, engineering, and computer sciences are required to take Calculus I, while others go for different set of mathematics courses. Our concern in this paper is on those students taking Calculus I. The aim is to examine the effect of the four major preparatory year courses (English 001 and 002, Math 001 and 002) on students' performance in the first calculus course at King Fahd University of Petroleum & Minerals (KFUPM) in Dhahran Saudi Arabia. The study also intends to shed some light on the statistical validity, or lack of it, on the criterion used for placing students into engineering and computer related courses.

Calculus I is considered to be the backbone of the Calculus series, while the calculus series are the nucleus of modern mathematics and are fundamental for any science and engineering related courses. Like in many other college algebra and pre-calculus courses, the aim of the preparatory mathematics (Math 001 and 002) at KFUPM is to prepare students for these calculus courses. However, not much is known on how much the students are prepared for the calculus series after completing the preparatory year program. The first calculus course at KFUPM consists of standard material of limits and differentiation followed by some application. It is usually taught in the traditional way, with concentration more on the techniques and procedures, and less emphasis on proofs.

2. Literature Review

Selection processes for admission from one level of education to the next is a routine that is practiced globally. The process is more rigorous from high school to university. The aim of the selection is largely to assist in finding a better way of maximizing the minimum resources. In other words, the selection is a way of determining the potential candidates that will most probably benefit from a program. Different universities used different criterion. This include both standardized criterion like SAT (Scholastic Aptitude Test), and a non-standardized like student’s previous academic records such as high school GPA (grade point average), teacher’s recommendations, etc. In either case the rationale is to help in predicting future performance of a particular candidate.

Several variables have been established and identified as predictors of success in mathematics (Pugh, 1969; Elgamal, 1987; Blansett, 1988; Eshenroder, 1987; Bridgeman & Wendler, 1989; Shaughnessy, 1993; Armstrong, 1997; Buerman, 1998). In most cases, these variables fall into one of three categories: affective, cognitive and non-intellective variables. Among these, cognitive variables have been found to have high predictive validity than others (Begle,1979, AL-Doghan, 1985). Some of the academic variables frequently considered in predicting mathematics achievement, especially in the Western universities, include: Various American College Test (ACT) scores, Scholastic Aptitude Test (SAT) scores, high school or college grade point average (GPA), high school rank, and placement scores. Although there are numerous studies in which the emphasis is on the discovery of those variables that predict some form of mathematical achievement, there are very few studies that deal specifically with predicting success in first calculus course (Edge & Friedberg, 1984). In particular, not much is known if the independent variables are the preparatory year courses and the student cohort consists largely of bilingual Arabs.

From the review of literature, it has been shown that previous mathematics grades are better predictors of success than most standard aptitude examinations (Siglin & Edeburn, 1978; Begle, 1979; Al-Doghan, 1985; Bridgeman & Wendler, 1989; Hebert, 1997, Bridgeman, Pollack & Burton, 2004). However, there are a lot of complaints recently of escalation of marks in high school grade. This is gradually eroding the reliability of high school GPA. As a result of all these complaintis, some researchers are suggesting some different criterion for more valid selection measure (Bridgeman, Pollack,Burton 2004).

One of the most obvious areas of difficulty for the bilingual students in learning calculus in foreign language is found to be lack of proficiency in the language of instruction (Edwards, undated). Consequently, the attention of many educators and researchers is now focusing on the language issues in relation to mathematics teaching and learning (Ellerton & Clarkson, 1996). The main reason for this is the fact that many students are currently learning mathematics in their second or third language (Austin & Howson, 1979; Ellerton & Clarkson, 1996). And the phenomenon is gradually becoming the norm rather than the exception (Secada, 1991). Although studies on the consequences of this bilingualism and multilingualism on student mathematics learning are inconclusive (Morrison & McIntyre, 1972; Austin & Howson,1979; Davidenko, 2000), it is now clear that sudden language switch did have impact on students performance in mathematics (c.f. Secada, 1992; Barton & Neville-Barton, 2003). Studies have shown that students whom are found to be very weak in the language of instruction have the tendency toward ill-comprehension as well as poor participation in classroom discourse (c.f. Setati, 2002). Consequently, they cannot meet the desired objectives of their studies due to lack of communication skills.

Thus in this study, students' performance in the two English language courses at the preparatory year program is considered in addition to the two preparatory year mathematics courses, which are taught in English. Therefore, this makes the setting of this study completely different from others especially in western universities. This makes our data invariably unique. Similarly, the data was collected in a longitudinal mode with a large sample size, which will make generalization better.

3. Methods

The participants of this study comprises of male students with an average age of 18 years, mostly fresh from high school. KFUPM is a highly competitive and selective institution within the Kingdom of Saudi Arabia. The majority of the students admitted at KFUPM are mostly above the 90th percentile of their national high school final examinations. In addition, they must have passed with high scores in the two admission tests known as RAM 1 and RAM 2. These entrance exams are conducted throughout the Kingdom by KFUPM. Therefore, the newly admitted students are largely considered as the "cream" of the Saudi high school graduates. Almost all of these students have Arabic as their first language as well as the language of instruction in their high schooling. Most of them have very little English background at the time of admission. A large number of the students comes from far distant and remote areas of the country, and so, are accommodated on the campus. The language of instruction is changed to English, and the rigor of the program is far higher than what they were used to in the high schools.

3.1 Data

The data for this study was collected longitudinally from the spring 2001 to the fall 2004 terms, comprising of 7 semesters. Letter grades for all English and mathematics courses in the preparatory year program were recorded for each student. In addition, the grades for the differential calculus course were recorded for each semester. All students who went through orientation program at KFUPM and progressed through the differential calculus course comprised the data for this study. Included in this data were students who obtain a grade of Denial (DN) for excessive unexcused absences and failing to drop the course. Inline with the university policy, these students are treated in the same fashion as those who fail the course.

Because of the large number of students enrolling in the University orientation program, the longitudinal data collected for this study is also large. The number of students participating in this study from each term is given in Table 1.

3.2 Procedure

To investigate the relationship between orientation program variables with success in differential calculus course at KFUPM, a Logistic Regression procedure (Hosmer & Lemeshow, 2000) was utilized in this study. The use of the logistic regression procedure was mainly due to the fact that the dependent variable, Grade Point Average (GPA) of the differential calculus course is ordinal in nature. In this case, the frequently utilized method of multiple linear regression is inappropriate since one major assumption of this procedure, that is normality which requires the dependent variable to be continuous and interval measured data, cannot be met.

Table 1. Number of students from each Term

Term	frequency
21	561
22	161
23	104
31	450
32	201
33	114
41	491
Total	2082

Terms 21, 22 and 23 refer to the Fall, Spring, and Summer, respectively of 2000-2001 academic session.

The dependent variable for the multinomial logistic regression is the Letter grade in the differential Calculus course. The number of students with these letter grades, the corresponding numerical grades, and the ordered value of these grades in the logistic regression analyses are given in Table 2.

There are six independent variables in this study. They are: grades in (1) Math 001, (2) Math 002, (3) Engl 001 and (4) Engl 002 (ordered as DN or F, D, D+, C, C+, B, B+, A, and A+), (5) Academic Term (021, 022, 023, 031, 032, 033, and 041), and (6) Students' Age (RO: regular versus older).

Table 2. Calculus I Response Profile

Ordered	Grade		Frequency
Value	Letter	Numerical	
1	**DN or F**	0.00	69
2	**D**	1.00	201
3	**D+**	1.50	221
4	**C**	2.00	385
5	**C+**	2.50	357
6	**B**	3.00	328
7	**B+**	3.50	227
8	**A**	3.75	197
9	**A+**	4.00	97
	Total		2082

3.3 *<u>Logistic Regression</u>*

Unlike the multiple regression procedure, the multinomial logistic regression procedure does not have a closed form solution for the set of estimates for its parameters. As a result, we employed the maximum likelihood estimation algorithm in SAS 9.1 to carry out the estimation. For this, we used SAS 9.1 default criterion (GCONV) of 0.00000001 for convergence of the numerical algorithm for the multinomial logistic regression.

The aforementioned independent variables and their interactions were used in explaining the dependent variable - Calculus I GPA. There can conceivably be as many competing models as there are distinct combinations of these interaction variables. Therefore, systematic analyses of these competing models were conducted. The following hierarchy of models was tested to find which provides the best model that is parsimonious (less parameterized) and at the same time explanatory:

1. 5-Way Interaction effects model
2. 4-Way Interaction effects model
3. 3-Way Interaction effects model
4. 2-Way Interaction effects model
5. Preparation-Year Program Main effects model
6. Limited Main effects (Intercept, Term, and RO only) model

Unlike the step-wise method, the best model was systematically extracted through this hierarchical modeling method. This is because the higher-order interaction terms need to be considered first before the lower-order interaction terms and main effects.

Two main indices that were helpful in distinguishing between models in this study were the chi-squared fit family of indices and the percent of concordance index for the model. The family of chi-squared fit indices provides statistical criteria for judging the quality of model-to-data fit. The negative-two-times-log-likelihood-ratio fit statistics shows the overall fit of the model, with lower values signifying better fit. The Wald's chi-square statistics, which is distributed asymptotically as a chi-square, provide significance of the model in explaining the data. The Residual chi-squared statistics, which is distributed as a chi-square as well, provide a statistical comparison of models and factors in the hierarchy. The percent concordance index, on the other hand, complements statistical criteria by providing a practical criterion for judging the value of the model in predicting outcomes associated with the data.

Furthermore, a more refined best model was introduced by checking to see which variables in the model were not significant and thus can be removed from the model. In this refined best model, the most significant predictor variable was identified for further study and explanation.

In addition to explaining the effects of the preparatory-year courses to Calculus I performance, another major research question addressed in this study is the effect of the minimum requirements in mathematics course placement at the preparatory year. As discussed earlier, for students to proceed to engineering and computer science courses, students must have a minimum of C grades in both Math 001 and Math 002 under the old requirement. However, the new requirement relaxed the minimum grades for Math 001 to at least D. Now, the question is which one of these placement criteria can provide a better prediction of higher Calculus I GPA.

To answer this question, predicted probability of success was calculated with the refined best model and examined with the Old and New minimum requirements. The expected values for the old and new requirements on the Calculus I GPA were also compared. The expected values were found by averaging the probabilities of success for all semesters and using these probabilities for finding the average Calculus I GPA.

4. Results and Discussion

The results of this study are summarized in Tables 3 through 7. In particular, Table 3 gives the summary of the results of the best model search analyses.

All these models were fitted to the data using the maximum likelihood algorithm and satisfied the default SAS 9.1 convergence criteria. Table 3 reports (1) the hierarchical model examined, (2) the factors not in lower hierarchical model, (3) the negative-two-times-log-likelihood goodness-of-fit statistic, (4) the Wald’s chi-square for the model with associated degrees of freedom and *P*-value, and (5) Residual chi-square for comparing between model hierarchy with accompanying degrees of freedom and *P*-value and (6) the Percent concordance index.

The negative-two-times-log-likelihood statistics reported in Table 3 shows the overall goodness of fit for the model. Generally, the more factors in a model the smaller the value of this index, with smaller values indicating better model-to-data fit. In Table 3, the biggest decrease occurs between the Limited Main effects model and the Preparatory-Year Main effects model, moderate reduction from the latter model to the 2-Way Interaction model, and comparable fit from then onwards.

The fit of each model to the data was further examined through the Wald's chi-square statistic, its associated degree of freedom (df) and its corresponding *P*-value. A significant Wald's chi-squared statistic indicates that a model is statistically important and cannot be dismissed without good cause. It appears from Table 3 that when judging from the *P*-value that are lower than the more stringent alpha significance level of 0.01, all models considered are statistically significant. A close examination of Table 3 indicates a huge jump in Wald's chi-square between the Limited Main effects model and the Preparatory-Year Main effects model. This appears to highlight the statistical importance of the preparatory-year variables as predictors of Calculus I grades.

At this juncture, the statistically best model among those considered is not very apparent. So, a comparison between models is needed. In some applications, a chi-squared statistic can be subtracted from adjacent models to see the effects of the additional variables in an expanded model. But, a simple difference in Wald's chi-square statistics is not recommended for comparing between model when models examined contain a mixture of qualitative variables, such as RO and Term, and quantitative ones, such as the preparatory-year courses (SAS Institute, 2003).

An alternative statistic called the Residual chi-square, which is calculated by SAS and follows a chi-square distribution, is more appropriate. Table 3 also reports this statistic in the model hierarchy examined for adjacent-model comparison. For example, when comparing the Limited Main and the Preparatory-Year Main effects models, the residual chi-square statistic of 712.32 with 4 degree of freedom show significant addition (*P*-value of less than 0.0001 for this statistic) of the preparatory year variables into the model. The same holds true when a 2-Way Interaction model is compared against the Preparatory Year Main effects model. Table 3 also shows that the higher order interaction models not significant when compared to the lower interaction model (i.e. 5-way versus 4-way interaction model) and when compared to the 2-way interaction model. This is indicated by high *P*-values of Residual chi-squared statistic for the higher order interaction model and small *P*-values for the 2-Way Interaction model where only small *P*-values indicates significance. Rather the cause of the significance of these higher-order interaction models is the preparatory year main effects and the 2-way interaction of these effects. So, it appears from Table 3 that the 2-Way Interaction model is statistically the best fitting model.

Table 3. Competing Multinomial Logistic Regression Models

Model	Factors not in Lower Models	- 2 Log Likelihood Fit	All Model factors: Wald's chi-square	df[a]	*P*-value	Additional Factors: Residual chi-square	df diff	*P*-value for diff	% concordance
5-way interaction	E1*E2*M1*M2*Term	7577.37	946.69	120	<.0001	6.62	6	0.3576	75.1
4-way interaction	E1*E2*M1*Term, E1*M1*M2*Term, E1*E2*M2*Term, E2*M1*M2*Term, & E1*E2*M1*M2	7583.43	941.43	114	<.0001	23.76	25	0.5333	75.0
3-way interaction	E1*E2*M1, E1*E2*M2, E1*M1*M2, E2*M1*M2, M1*M2*Term, E1*E2*Term, E1*M1*Term, E1*M2*Term, E2*M1*Term, & E2*M2*Term	7607.56	926.84	89	<.0001	38.70	40	0.5289	75.0
2-way interaction	E1*E2, E1*M1, E1*M2, E2*M1, E2*M2, M1*M2, E1*Term, E2*Term, M1*Term, & M2*Term	7648.58	898.47	49	<.0001	90.66	30	<.0001	74.5
Prep-year Main effects	E1, E2, M1, & M2	7742.96	842.55	19	<.0001	712.32	4	<.0001	73.8
Limited Main effects	Intercept, Term & RO	8631.41	69.88	15	<.0001				46.0

Note: [a] degrees of freedom for the model factors plus the intercept terms.
E1 = Engl 001, E2 = Engl 002, M1 = Math 001, M2 = Math 002, Term = Academic Term, RO = Regular vs Older, and diff = difference

In addition to statistical significance examined, Table 3 also reports in the last column the percent concordance index that provides a practical index of model-to-data agreement. The percent concordance balances the statistical significance criteria with a practical significance idea. That is, by indicating how much of the data is correctly classified by the model. Specifically, this index gives the percentage of the data that is correctly classified into the corresponding numerical calculus I grade with the aid of the prediction capability of the model. For instance, the Limited Main effects model appears to classify only 46% of the numerical Calculus I grades correctly. When the preparatory-year variables were added into the model, this percentage jumps to almost 74% (about a 28% increase). That is, the addition of the preparatory-year variables (as a group) appears to substantially improve the classification accuracy in explaining the calculus I grade data. Similarly, all the higher order interaction models appear to improve classification accuracy, however, only the 2-way interaction variables are statistically significant. Thus, this may not justify the addition of these many nonsignificant higher order interaction factors in the best model. Judging from both the statistical and the practical fit criteria, the best model from the hierarchy of models considered is the model with the 2-way interaction terms.

Given this general model that fitted the data best, a natural inquiry at this point is to see if a more parsimonious (less parameterized) model can work at least as good as this current one. To accomplish this, we included in the refined 2-Way Interaction model only effects that are significant or important. Therefore, the Wald's chi-square statistic for each factor was inspected with the aim of finding ones that could be removed at the same time maintaining the overall statistical significance and practical accuracy of the model.

The Maximum Likelihood Estimation algorithm for estimating the refined model converged as specified by the default SAS 9.1 convergence criterion. Table 4 summarizes the comparison of a more refined model to the 2-way interaction model reported earlier. For both models, the negative-two-times-log-likelihood-fit statistics, the Wald's chi-squared statistics, and its associated significance level are similar. But with fewer factors than the 2-Way Interaction model, a savings of 24 degrees of freedom was achieved. Some 2-way interaction factors, as specified in Table 4, did not appear to contribute to

Table 4. Refining the Best Multinomial Logistic Regression Model

Model	Factors not in Lower Models	-2 Log Likelihood Fit	df*	Wald's chi-square	*P*-value	Df diff	Residual chi-square	*P*-value for diff	% concordance
			All Model factors			Additional Factors			
2-way interaction	RO, E1*E2, E1*M1, E1*M2, E2*M1, E2*M2, E1*Term, E2*Term, & M1*Term	7648.58	49	898.47	<.0001	24	30.3456	0.1736	74.5
Refined Model	Intercept, Term, E1, E2, M1, M2, M1*M2, & M2*Term	7679.36	25	881.96	<.0001				74.2

Note: *degrees of freedom for the model factors plus the intercept terms.
E1 = Engl 001, E2 = Engl 002, M1 = Math 001, M2 = Math 002, Term = Academic Term, RO = Regular vs Older, and diff = difference

the significance of the refined model. So, the refined 2-Way Interaction model appears to be more parsimonious than the general 2-way interaction model.

Although not reported in Table 4, the percent concordance index for this refined model moves to almost 80% from 74.2% if the data were dichotomized for grades below C and those greater than or equal to C. This indicates that the percent with correctly predicted letter grade when compared to the actual data were slightly higher if only two grade categories (success versus not) were used instead of all nine categories.

All factors in the refined 2-Way Interaction model are spelt out in Table 5 with associated degree of freedom (df), estimated parameter values, standard errors, Wald's statistics, and *P*-value for this Wald's statistics. One apparent thing from this table is that a few factors do not seem to be significant (*P*-values greater than alpha significance level of 0.05).

Table 5. Estimates of the Refined Best Multinomial Logistic Regression Model

Effects		df	Estimate	Standard error	Wald chi-square	*P*-value
Intercept:	**0.00**	1	-1.9614	0.6314	9.6517	0.0019
	1.00	1	-0.3776	0.6258	0.3641	0.5462
	1.50	1	0.474	0.6273	0.5709	0.4499
	2.00	1	1.5567	0.6308	6.0892	0.0136
	2.50	1	2.4999	0.6332	15.5888	<.0001
	3.00	1	3.5278	0.6338	30.9814	<.0001
	3.50	1	4.5252	0.6334	51.0476	<.0001
	3.75	1	6.1125	0.6359	92.4084	<.0001
Term		6			20.1597	0.0026
Engl 001 (E1)		1	0.1448	0.0814	3.1629	0.0753
Engl 002 (E2)		1	-0.3152	0.0826	14.5447	0.0001
Math 001 (M1)		1	0.4578	0.2092	4.7889	0.0286
Math 002 (M2)		1	0.168	0.2105	0.6372	0.4247
M1*M2		1	-0.4689	0.0722	42.2317	<.0001
M2*Term		6			29.6547	<.0001

These are Engl 001 (E1) and Math 002 (M2) which are some of the preparatory-year variables. The variable Math 002 (M2) cannot be removed from this model because it is the basis for the significant interaction factors. On the other hand, Engl 001 is not significant and is not a basis for any significant higher order interaction factors. So, it can be removed from the model. However, to keep close fidelity to the current curse placement policies at KFUPM, this variable was kept in the model.

Now, the next question of interest as described in the last section is which of the variables reported in Table 5 contributes most to the significance of the refined 2-Way Interaction model in explaining Calculus I grades. To answer this question, several analyses were undertaken and the summary results are reported in Table 6. Here, each of the variables was added last to the model when all other factors were already included to examine its effects. It is worth noting that neither Math 001, Math 002, nor Term could be added last into the model because the interaction factors depended on these factors to coexist in the model. The Residual chi-squared statistic with corresponding degree of freedom and its associated *P*-value were reported in Table 6 for each factor that was added last into the refined model. This statistic gives the effect of each factor after other factors are already in the model. Therefore, it gives the unique contribution of each factor to the best model. Consistent with the results in Table 5, Engl 001 (E1) when added last does not uniquely contribute to the significance of the refined model in explaining calculus I grades. However, for fidelity to the course placement policies at KFUPM, this factor needs to be in the model for subsequent analyses. Table 5 also shows that Math 001 and Math 002 interaction factor (M1*M2) appears to uniquely contribute the most to the significance of this model, followed by the Math 002 with Term interaction (M2*Term) factor, and Engl 002 (E2).

Table 6. Contribution of Factors to the Best Multinomial Logistic Regression Model

Factors	df	Residual chi-square	*P*-value
M2*Term	6	27.9437	0.00010
M1*M2	1	41.365	0.00000
E1	1	2.9659	0.08504
E2	1	13.9066	0.00019

The model presented in Table 5 is now available for further use to answer our main research question of minimum requirements on preparatory math courses for course placement purposes as described earlier. To obtain an answer to this question, we

Table 7. Predicted Probabilities for each Numerical Grade of Calculus 1 and Expected Numerical grades for the "old" and "new" requirements

Letter Grade	Predictors				Cumulative Probability (Letter grade) for Term								Expected Numerical grade
	Engl 001	Engl 002	Math 001	Math 002	021	022	023	031	032	033	041	all	
					New Requirement								
DN or F	2	2	1	2	0.123	0.093	0.051	0.089	0.079	0.042	0.114	0.084	
D	2	2	1	2	0.407	0.334	0.209	0.324	0.294	0.174	0.384	0.304	
D+	2	2	1	2	0.616	0.541	0.382	0.528	0.494	0.331	0.594	0.498	
C	2	2	1	2	0.826	0.777	0.646	0.768	0.742	0.594	0.812	0.738	
C+	2	2	1	2	0.924	0.899	0.824	0.895	0.881	0.79	0.917	0.876	
B	2	2	1	2	0.971	0.961	0.929	0.96	0.954	0.913	0.969	0.951	
B+	2	2	1	2	0.989	0.985	0.973	0.985	0.982	0.966	0.988	0.981	
A	2	2	1	2	0.998	0.997	0.994	0.997	0.996	0.993	0.998	0.996	
A+	2	2	1	2	1	1	1	1	1	1	1	1	1.738
					Old Requirement								
DN or F	2	2	2	2	0.080	0.060	0.032	0.057	0.05	0.026	0.073	0.054	
D	2	2	2	2	0.298	0.237	0.14	0.228	0.205	0.116	0.279	0.215	
D+	2	2	2	2	0.499	0.422	0.277	0.41	0.376	0.234	0.475	0.385	
C	2	2	2	2	0.746	0.683	0.531	0.672	0.641	0.475	0.728	0.639	
C+	2	2	2	2	0.883	0.847	0.744	0.84	0.821	0.699	0.873	0.815	
B	2	2	2	2	0.955	0.939	0.89	0.936	0.927	0.867	0.95	0.924	
B+	2	2	2	2	0.983	0.977	0.957	0.976	0.972	0.946	0.981	0.970	
A	2	2	2	2	0.996	0.995	0.991	0.995	0.994	0.989	0.996	0.994	
A+	2	2	2	2	1	1	1	1	1	1	1	1	1.966

performed a prediction analyses. Table 7 provides cumulative probabilities for examinees with the “old” and “new” minimum requirements for projected Calculus I performance. The model predicted that students meeting the “old” requirement in these orientation courses have higher probabilities of obtaining better grades in the differential Calculus course than with the “new” requirements. In addition, we also calculated an expected numerical grade for both the “old” and “new” requirements as can be seen in Table 7. When converted to the letter grade system used by KFUPM, the expected numerical grade under the “new” requirement is somewhere around D+ as opposed to the “old” requirement that translates to C. It should be noted that a C grade is the threshold for academic good standing at KFUPM.

5. Conclusion

As more Middle Eastern countries adopt English as the primary medium of instruction at the universities, a one year bridging program, popularly known as preparatory year is now a common trend. The aim of this program is to provide a smooth transition from high school to university life, especially with regards to the language shift. However, not much is known on the effect of such program to student’s performance in higher mathematics courses, which are largely considered as a backbone of science oriented courses.

Therefore, using multinomial logistic regression analyses, it was found that the best model in explaining success in Calculus I course is the refined 2-Way Interaction model containing the preparatory-year factors. The model appears to suggest that the success on Calculus I course depends on the two preparatory-year Math courses and their interaction. The interaction of these two Math courses seems to be the most important predictor of Calculus I performance. Other factors that contributed significantly in the model included Math 002 with the semester Term interaction, followed by Engl 002. Engl 001 did not contribute significantly to the model, but was included in order to be able to assess the current KFUPM preparatory-year program’s capability of predicting success in the differential calculus course.

Using this refined best model, it was found that the old requirement (discussed in 3.4) produces higher probabilities for performance in Calculus I compared to the new requirement. Furthermore, the old requirement produces a better expected grade that would translate to a letter grade of C, while the new requirement expected grade is around D+. It is worth noting that at KFUPM, a minimum grade of C is required for a student to be in good academic standing.

The study will hopefully contribute to the field of mathematics education by adding to the literature its uniquely large and longitudinal data set. In addition, the data comes from a bilingual population with Arabic as the first language while the medium of university instruction is English. It is also one of the few studies that employ multinomial logistic regression analyses as the method of scientific inquiry in this field. Furthermore, the findings in this study may help the university administration in policy making regarding student placement into academic programs after completing the preparatory year. It can also be useful for other universities with similar preparatory year program.

6. Study Limitations and Directions for Possible Future Research

This study did not look at the effect of orientation course promotion via placement tests on the probability of success in Calculus I course. It also did not address the issue of repeating one or more orientation courses on the same probability. Had these effects been examined, a different result may have been obtained. Future research may possibly look into one or more of these factors in determining their role in explaining Calculus I achievement.

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