Calculus and success in a business school

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ABSTRACT

Many business schools or colleges require calculus as a prerequisite for certain classes or for continuing to upper division courses. While there are many studies investigating the relationship between performance in calculus and performance in a single course, such as economics, statistics, and finance, there are very few studies investigating the relationship between calculus and performance in upper division as a whole. In this paper, a general linear model was used to assess this less studied relationship. The findings suggest a positive relationship between calculus and upper division performance and gender differences in the relationship between the number of tries to pass calculus and upper division performance.

Keywords: calculus, gender, performance, calculus, ANCOVA, GLM

INTRODUCTION

Many colleges and universities require mathematics as a prerequisite for certain classes or for continuing to upper division courses. At Dalton State College (DSC), undergraduate students who wish to take upper division business courses (i.e., 3000 and 4000 level classes) need to be admitted to upper division of the School of Business. There are multiple requirements for admission to upper division, and one of them is to pass MATH 2181: Applied Calculus or a more rigorous calculus class with a grade of C or better. This is also the prerequisite for BUSA 3050: Business Statistics.

DSC is an open-access, small liberal arts state college with an enrollment of about 5700 students. More than 30% of these students are 25 years old or older, who can be classified as non-traditional students. The School of Business enrolls about 800 students in one associate degree and six bachelor degree programs.

Like many who take a calculus course in other colleges and universities, some students at DSC find MATH 2181 difficult, and consequently they often drop or fail the course and retake it in subsequent semester(s). Such students may question the need of MATH 2181 for admission to upper division. The link between the performance in calculus and the performance in upper division has not been studied very often. As a result, it is unclear whether or not there is any relationship between the two. On the other hand, the relationships between math perquisites and performance in a course, such as statistics (Green, Stone, Zegeye, & Charles, 2007; Islam, Gygi, Gardner, & Gooch, 2005; M. Johnson & Kuennen, 2006; Rochelle & Dotterweich, 2007), economics (Ballard & Johnson, 2004; Brasfield, McCoy, & Milkman, 1992; Butler, Finegan, & Siegfried, 1998; Von Allmen, 1996), and finance (Alcock, Cockcroft, & Finn, 2008; Blaylock & Lacewell, 2008; Ely & Hittle, 1990; Pritchard, Romeo, & Saccucci, 2000), have been studied extensively. Most of these studies found a strong positive relationship between the performance in calculus or general mathematics and performance in a later course.

For example, Johnson and Kuennen (2006) studied the relationship between basic math skills of students and the class performance measured by the student grade in an introductory statistics course. They found that gender, GPA, study hours per week, professor, score on the math quiz that they administered by the questionnaire, and the science portion of the ACT exam were significantly related to the performance. Ballard and Johnson (2004) studied the impact of math skills on the performance in economics courses. They found that mastery of very elementary math skills, measured by their own exam, is of utmost importance.

Green et al. (2007) studied the effect of relaxing, but not completely abolishing, the mathematics prerequisite for a business statistics class on the probability of passing the latter class. According to their probit model, a more relaxed (i.e., easier) mathematics requirement leads to higher probability of failing the business statistics class.

Based on these past studies, performance in calculus seems to be a decent predictor of how student might do in some upper level courses in specific areas, such as economics, finance and statistics.

In this paper, the authors question whether or not relaxing the mathematics requirement adversely affects students' performance in the whole upper division classes, not in a single course. Analysis of this issue is important because it might have policy implications for the School of Business at DSC, and in a broader scale, for business schools at other colleges or universities of a similar size and student body. There is no easy way to study this question, however, because the calculus prerequisite has remained unchanged for years at DSC. Ideally, this relationship can be studied best if two groups of undergraduate business students are available—those who graduated with the calculus requirement and those who graduated without. Since such two groups of students were not available, the authors examined in this paper the relationship between performance in the calculus class (MATH 2181) and performance in upper division classes. By exploring these relationships the authors would like to see whether or not performance in calculus can help us predict students' performance in upper division business courses.

METHODOLOGY

Data and Variables

Initially, the data was collected from 331 students who graduated from DSC with a Bachelor's degree in business between 2006 and 2010.[1] For the analysis, only data used were from students who passed MATH 2181 and who had a record of a high school GPA in file. That is, students who did not take MATH 2181, but took more rigorous calculus class were not included in the analysis. Two hundred fifty eight students passed MATH 2181, of which 53 students did not have a high school GPA on the college record. [2] As a result, the final dataset contained 205 students (101 females).

Two performance measures for calculus were incorporated as independent variables: letter grades earned in MATH 2181 (CAL) and the number of attempts to pass (ATT). In addition, gender was used as an additional independent variable. Of the 205 students in the dataset, 41 students earned an A in MATH 2181; 77 earned a B or TB[3]; and 87 earned a C or TC. The number of attempts to pass MATH 2181 was extracted from the official transcript of each student. Note that ATT did not capture the number attempts not shown on the transcript. If students drop a course within 1 week from the beginning of the semester, there will be no record of such attempts. Of the 205 students, 142 students got a C or better (i.e., passed) the course in the first try and the other 63 needed more than one try.

Age and high school GPA (HGPA), the characteristics often used in studies of students' performance, were used as covariates. The mean and the standard deviation of HGPA was 3.148 and 0.523, respectively. The overall mean age at the time of admission to upper division status was 25.10, and the standard deviation was 7.31.

The dependent variable of the study is the performance in the upper division measured by upper division GPA (UDGPA). This GPA is calculated solely based on the grades of upper division—3000 and 4000 level—*business* courses, which are the ones that students need to take once they got admitted to upper division. For each student, a grade of A and TA was converted to 4 points; a B and TB to 3 points; a C and TC to 2 points; a D and TD to 1 point; and an F and TF to 0 point. If students took the same upper division business classes more than once, only the

[1] Fifty four of the 331 students obtained an Associate's degree in business before getting a Bachelor's degree. During the same period, 130 students graduated with an Associate's degree in business without obtaining a Bachelors' degree.

[2] DSC Admission policies do not require recording of high school GPAs from transfer students who are transferring in at least 30 core-credit hours, from students who have graduated with a General Equivalency Diploma, or from non-traditional students who have not attended high school or college in the past 5 years.

[3] The prefix T indicates that grades are transferred in from other institutions. DSC does not have a plus or minus grading system.

highest grade was used in calculating UDGPA. The mean UDGPA was 3.275, and the standard deviation was 0.42. The minimum was 2.2; the maximum was 4.00.

The authors anticipated that there would be interaction effects between gender and CAL and between gender and ATT (Figure 1). This means that the relationship between the performance in calculus (measured by CAL and ATT) and the upper division GPA would be different for male and female students. There are studies that suggest female students do worse than their male counterparts in the STEM (science, technology, engineering, and math) disciplines (e.g., Coley, 2001; Kahl, Fleming, & Malone, 1982; Zerega, Haertel, Tsai, & Walberg, 1986). Specifically the model is

$$\text{UDGPA} = \beta_0 + \beta_1\text{HGPA} + \beta_2\text{Age} + \beta_3\text{Gender} + \beta_4\text{CAL} + \beta_5\text{ATT} + \beta_6\text{CAL}\times\text{Gender} + \beta_7\text{ATT}\times\text{Gender} + \varepsilon.$$

A general linear model (GLM) was run to test the model using SPSS ver. 19.

Analysis

First, gender differences for UDGPA, CAL, and ATT were checked. The results are shown in Table 1. None of the independent and dependent variables were significantly different between male and female students.

The results from GLM analysis are shown in Table 2. Both covariates, age and high school GPA, were significant and positively related to the upper division GPA (based on the estimated slopes for each of the covariates). That is, the older students were, the better they did in upper division; the better they had done in high school, the better they did in upper division.

The main effect of calculus grade (Calfinalgrade in Table 2) was significant ($p < .000$), but the interaction effect between calculus and gender (GENDER × Calfinalgrade) was not. Therefore, it is concluded that there was no significant difference between male and female students concerning the relationship between calculus and upper division performance. The pattern shown in Figure 2 also suggests the same conclusion; no gender difference in the effect of calculus on upper division performance. The pattern indicates that there is a positive relationship between a letter grade and upper division GPA, that is, the better the calculus grade the higher upper division GPA regardless of their gender.

Controlling for the two covariates, the mean upper division GPA's of students who earned an A, B, and C in MATH 2181 were calculated separately. Since the interaction between gender and calculus was insignificant, male and female students were combined to calculate these means. An estimated marginal mean of upper division GPA of students who earned an A was 3.492; who earned a B was 3.289; and who earned a C was 3.125. Pairwise comparisons revealed that the mean upper division GPA of students who earned an A in calculus was significantly greater than that of students who earned a B (difference = 0.203; $p < .01$). In turn, the mean upper division GPA of students who earned a B was significantly greater than that of students who earned a C (difference = 0.164; $p < .01$). Also, the mean upper division GPA of students who earned an A and that of students who earned a C were significantly different (difference = 0.367; $p < .01$).

The other two-way interaction effect, GENDER × ATT, was significant. According to Figure 3, not being able to pass MATH 2181 in the first attempt seemed to be detrimental to the upper division performance of female students. That is, the mean upper division GPA of female students who failed to pass calculus in the first attempt was lower than that of females who passed in the first attempt. The estimated marginal mean of female students who passed calculus in the first try was 3.400, and that of female students who passed calculus after multiple tries was 3.184; the difference was significant ($p < .01$). Such a pattern was not found for male students, however. In fact, upper division GPA of male students who took MATH 2181 more than once was slightly higher than that of male students who pass MATH 2181 in one try (3.330 vs. 3.295), but the difference was not significant ($p = 0.65$).

DISCUSSION

This paper studies the relationship between performance in calculus and performance in overall upper division business courses. The results suggest a positive relationship between calculus grade and upper division performance. That is, the better the calculus grades, the better performance in upper division business courses. This relationship is consistent for both male and female students. In short, grades in a calculus course can help us predict students' performance in upper division. In addition, a significant gender difference was found in the relationship between the number of tries students take to pass calculus and their performance in upper division. Female students who had to take MATH 2181 more than once to pass performed worse in upper division business courses than females who pass the same class in the first try. Such a pattern was not evident for male students.

There are at least two implications of these findings. First, since the students who earned lower grades in calculus are less likely to succeed in upper division, instructors need to find out how they can help such students do better in a business school. For example, more attention should be paid to those students, at the minimum. This could mean that their progress from admission to upper division to graduation should be monitored more closely.

Second, even though many students feel that they can do well in upper division despite their poor performance in calculus, such thought is not supported by the current study. This suggests that even though courses in upper division may not require use of calculus concepts directly, mathematical or analytical skills that students develop in a calculus course may positively influence proficiency in seemingly unrelated areas. Further, if such a relationship is extrapolated, one may arrive at the conclusion that students who cannot pass calculus even after multiple tries may do very poorly in upper division. Therefore, general proficiency in a quantitative area may improve overall performance in upper division. However, the last point should be understood carefully. The current study revealed a positive relationship between calculus and upper division performance, but did not claim that the relationship is causal. More work is needed to definitively prove a causal relationship.

This study shows that grades in a quantitative course (in this paper, measured by calculus grades) can play an important role in identifying those students who are likely to do well in upper division and those who are not. As a result, colleges may be able to tell which students who are in upper division need more attention from faculties. Finding of this study also informs the debate as to whether or not business schools need to have calculus as a requirement for graduation. This paper suggests that at least for schools with similar student demographics and institutional make up as DSC, quantitative skills may play a crucial role in student success as measured by their upper division GPA. Further, on a broader scale, the results may provide the basis for supporting recommendations for implementing school wide initiatives that would focus on student success in terms of academic achievement.

For future research, the relationship between performance in calculus and other measures of student success, such as post college performance, can be studied. The authors focused on performance, or student success, in terms of GPA, but student success can be defined in many ways. For example, Kuh et al. (2006, p. 7) define student success as "academic achievement, engagement in educationally purposeful activities, satisfaction, acquisition of desired knowledge, skills and competencies, persistence, attainment of educational objectives, and post college performance." Further, the authors also plan to make attempts to control for a more extensive set of covariates such as school quality and family background which would help them make more conclusive judgments about causality between the two variables.

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APPENDIX

Figure 1. Research model used in the paper

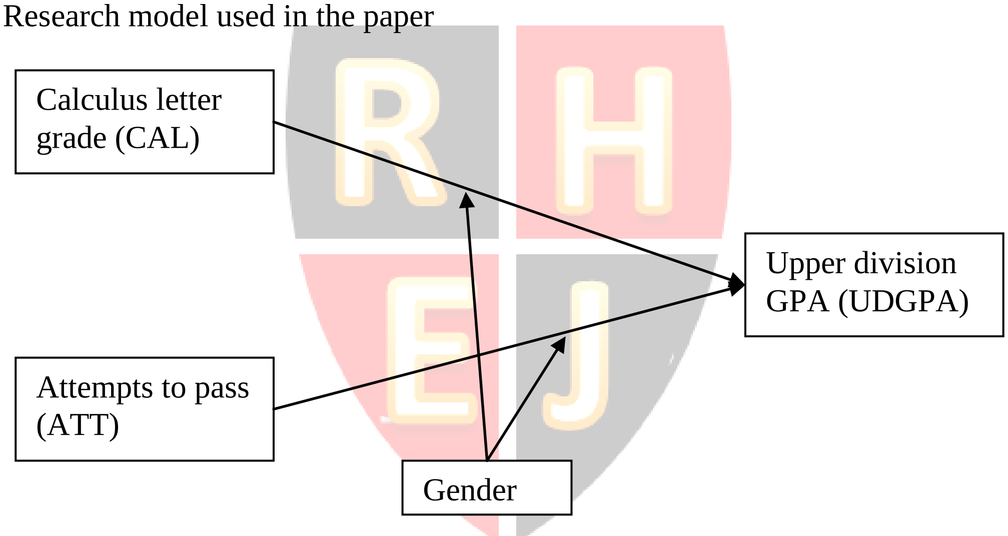


Table 1. Descriptive statistics of key variables

		Female	Male	Significance
UDGPA		3.31	3.24	NS (*t*=-1.298, *df*=203, *p*=.196)
CAL		2.80	2.75	NS (*t*=-0.489, *df*=203, *p*=.625)
ATT	Single	67 (count)	75	NS (χ^2=0.8, *df*=1, *p*=.370)
	Multiple	34	29	

Table 2. Analysis output

Tests of Between-Subjects Effects

Dependent Variable:Upper division GPA

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	10.738[a]	9	1.193	10.187	.000
Intercept	11.880	1	11.880	101.422	.000
H_GPA	2.012	1	2.012	17.174	.000
Age	1.479	1	1.479	12.623	.000
GENDER	.015	1	.015	.131	.718
Calfinalgrade	3.414	2	1.707	14.575	.000
ATT	.325	1	.325	2.777	.097
GENDER * Calfinalgrade	.230	2	.115	.981	.377
GENDER * ATT	.638	1	.638	5.449	.021
Error	22.840	195	.117		
Total	2232.298	205			
Corrected Total	33.579	204			

a. R Squared = .320 (Adjusted R Squared = .288)

Figure 2. Interaction between calculus and gender on upper division GPA

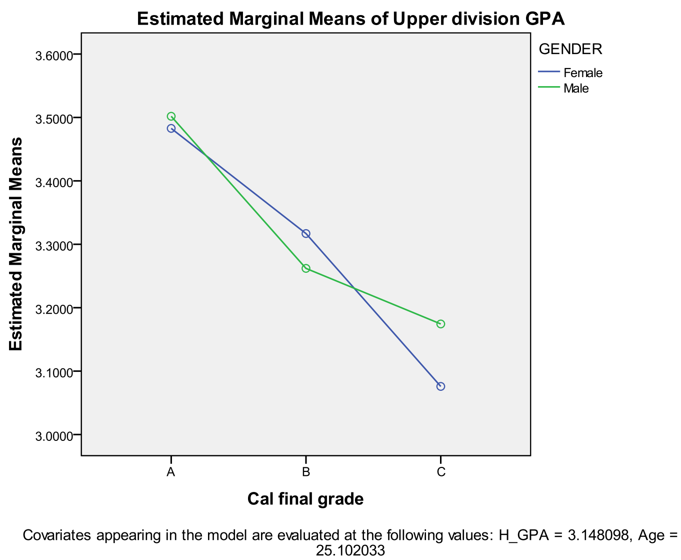
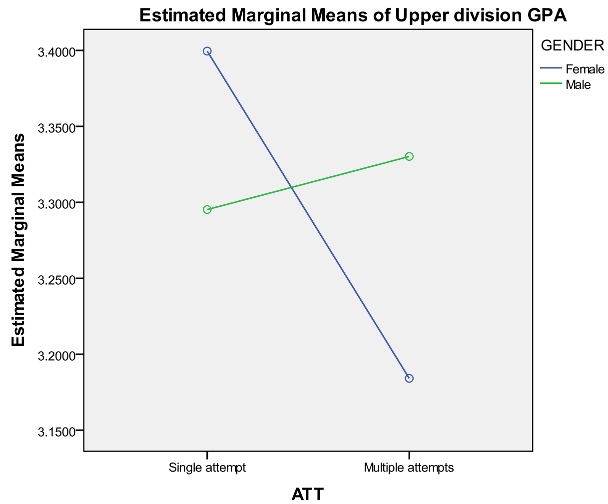


Figure 3. Interaction between attempts and gender on upper division GPA



Covariates appearing in the model are evaluated at the following values: H_GPA = 3.148098, Age = 25.102033