Importance of Postsecondary Precollege Mathematics Courses- A Case Study of Prince Sultan University

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Abstract: *Prince Sultan University is a non-profit private university located in Riyadh—the capital city of the Kingdom of Saudi Arabia. Students admitted to Prince Sultan University are required to complete a preparatory year program before joining any academic program. The preparatory program includes two preparatory mathematics courses. This study examined the correlation between students' performance in each preparatory mathematics course and their performance at the end of the preparatory year program—as measured by the overall Grade Point Average. Data included admitted students during Academic years 2010–2013. The findings indicated that nearly 60% of the variation in the overall performance is explained by one of the preparatory mathematics courses, and around 54% of the variation is explained by the other mathematics course.*
Key Words: *Grade point average, higher education, mathematical skills, preparatory year program.*

Introduction

Educators and policy makers around the nation acknowledge the importance of mathematical skills for any individual. There is a world-wide agreement that mathematics is one of the core compulsory subjects that should be addressed in all primary school grades. This is due to the "indispensable role it plays in the advancement of science and technology of any nation" (Matawal, 2013, p. 42). In addition, mathematics is believed to be the foundation of the other subjects studied by students in their school years (Awodun & Ojo, 2013). On the other hand, acquiring mathematical skills and competencies is important not only to complete primary education, but is important and essential to join higher education institutions, such as colleges and universities. Tremendous numbers of research results have suggested that mathematical ability is one major factor that influences academic performance of university students (Uyal & Güngörmüş, 2011). The importance of acquiring mathematical knowledge and skills is demonstrated in the fact that most admission decisions to higher education institutions are grounded upon evidence that supports students' mathematical abilities. For example, the *Scholastic Aptitude Test* (SAT) evaluates students' mathematical skills and provides evidence on students' mathematical competencies. SAT is widely used as an admission criterion by a number of prestigious universities. The *American College Test* (ACT) is another assessment process that is used as an admission criterion for higher education institutions in the U.S. and that takes into accounts

student's mathematical skills. On the other hand, most institutions around the world that have their own admission indicators examine students' mathematical ability (Khoshaim & Ali, 2015). In fact, mathematical skills and English acquisition are the two major components of most admission tests used by higher education institutions in the world (Khoshaim & Ali, 2015).

The above discussion suggests that academic leaders believe that mathematical knowledge provides students with the essential tools to succeed in their higher education academic programs. Other researchers examined the stated suggestion. For example, research results supported the correlation between ACT or SAT scores and students' performance when they join the institution (Geiser & Studley, 2002; Kobrin, Patterson, Shaw, Mattern, & Barbuti, 2008; Patterson, Mattern, & Kobrin, 2009). Other research findings indicated that business students should complete one or more pre-requisite mathematics courses prior to their business major requirements (Green, Stone, Zegebe, & Charles, 2007). Ballard and Johnson (2004) and Johnson and Kuennen (2004) argued that all mathematical skills are important factors that affect students' achievement in economics, whereas Grillo, Latif, and Stolte (2001) stated the same for pharmacology students. Al-Twaijry (2010) found that mathematical knowledge plays a major role in the performance of students in management classes. Ely and Hittle (1990) and Awodun and Ojo (2013) argued the same for finance students. Byrne and Flood (2008) indicated that pre-accounting knowledge influences performance. On the other hand, Shrestha and Mani (2014) examined the correlation of mathematics courses GPA with the overall GPA after graduation. The researchers concluded that although mathematics courses constitute only 15% of the overall credit hours, it influenced the overall GPA.

For some subjects, or majors, the effect of mathematical abilities is almost given. For example, it is convincing that students specializing in accounting should be comfortable with numbers and arithmetic operations (Yunker, Yunker, & Krull, 2009). On the other hand, Pritchard, Potter and Saccucci (2004) argued that those who are specialized in accounting or finance perform better in a given mathematics test—showing their strong mathematical skills over their partners in other programs such as marketing and management in the same college. In fact, the authors stated that mathematical skills affect students' decisions to choose their specialty among business programs. In other words, students themselves are aware of the importance of mathematical skills and they choose their future career accordingly.

Moreover, Hoag and Benedict (2007) indicated that "Mathematical maturity" (p. 1) is a clear factor that affects students' performance in their first-year university courses. Hoag and Benedict stressed that the results of many studies over the years supported that mathematical skills are essential factors that influence students' success in their studies. Other researchers even stated that "mathematics habits limb in virtually all fields of study whichever mathematical or non-mathematical" (Awodun & Ojo, 2013, p. 391). Researchers have also suggested that the influence of mathematics abilities is not limited to a short period of time; Rose and Betts (2001), for example, indicated

that students' mathematical knowledge in high school affects their future, either the level of education they achieve or the earning they reach in their career. Some will even see mathematical skills as the basis for the development of society in general (Gegbe & Koroma, 2014). The authors argued that "a competent mathematical population forms a basis for national growth and development" (p. 240).

The Goal of the Study

This manuscript argues that obtaining mathematical skills not only affects a student's future grades, or future academic performance, or even future careers, but mathematical skills influence a student's performance in other courses taken almost simultaneously with the mathematics course. This study suggests that the grades and attainment of a student in mathematics courses positively influence the attainment in other courses. In other words, the grade point average of a mathematics course correlates with the general grade point average of all courses.

The Context

Prince Sultan University (PSU) is a private university in the capital city of Riyadh, Saudi Arabia. All students admitted to PSU should complete a preparatory program for one full academic year before joining any of its academic programs. In PSU, the *Preparatory Year Program* (PYP) consists of 12 courses with a total of 30 credit hours. Among the 12 courses, two are mathematics introductory courses with a total of eight credit hours. These courses are Math001 and Math002. Other courses in PYP include four English proficiency courses (16 credits), two health education courses (two credits),

two computer skill courses (two credits) and two personal development courses (two credits).The aim of the PYP is to ensure that students obtain basic skills and competencies required to succeed in their academic programs.

The two preparatory courses—Math001 and Math002—provide basic, yet essential mathematical foundation skills in algebra and trigonometry. The courses' learning outcomes include developing critical thinking and fostering problem-solving methods allowing students to use mathematics to model and solve real-world problems. Upon completing the two courses, students are able to solve equations and inequalities, know basic knowledge of functions and their properties, obtain different skills to deal with functions and their graphs, solve problems related to trigonometric functions, and use matrices to solve linear systems.

Research Hypotheses

This study hypothesizes that although each preparatory mathematics course worth only 13% of the total credits, a student's attainment in each course positively correlates with the overall attainment of all courses. Meaning, students who perform well in the preparatory mathematics courses, will perform well in the other courses, including English proficiency, health education, computer skills and personal development courses. The study uses three variables of Math001 GPA, Math002 GPA and the overall PYP GPAs. Math001 and Math002 GPAs are considered independent variables and the overall PYP GPA is considered as a dependent variable.

The research hypotheses are:

$$H_a^1 : \text{There is a positive correlation between Math001 GPA and the overall PYP GPA} \qquad (1)$$

$$H_a^2 : \text{There is a positive correlation between Math002 GPA and the overall PYP GPA} \qquad (2)$$

Significance of Research

In this study, we believe that students' performance in preparatory mathematics courses (measured by the GPA attained upon successful completion of these courses) positively correlates with the overall performance of a student (measured by the GPA upon completion of all PYP courses). This is especially important as recent statistical data on PSU students showed that failing preparatory mathematics courses created an obstacle to complete the PYP, and hence delayed the starting of the academic program (PSU statistical reports). A high percentage of students fail Math001 and/or Math002 and consequently, were not able to join the academic program. Hence, it is essential to understand the effect of preparatory mathematics courses on a student's performance in the PYP. Moreover, as per PSU regulations, students who fail to successfully complete all PYP courses in four semesters will be dismissed from the university. Therefore, PYP is a vital stage in a student's higher studies that might have major consequences on the student's future. Hence, it is important to understand the factors that affect students' performance during this year. Furthermore, retention rate is a high-risk concern that influences an institution's reputation, not to mention income.

It is important to consider each course separately and examine its effect for several reasons. First, Math001 is the first mathematics course after high school. Given the change in the educational environment between secondary education and higher education, and considering that mathematics is taught in Arabic in secondary schools in Saudi Arabia but in English at PSU, it is convincing that students might struggle to successfully complete it. On the other hand, the mathematical contents of Math002 are at a more complexity level than Math001. Math001 addresses only basic pre-algebra concepts, whereas Math002 tackles trigonometry and some linear algebra concepts. PYP regulations state that students cannot be admitted to any program in the College of Computer Science and Information Systems (CCIS) unless they achieve a minimum grade of (C) in Math002, indicating that the contents of Math002 are more important and vital than the contents of Math001 to students' success in the CCIS academic programs. Hence, the results of this study provide effective information to higher management at PSU about the influence of each of the two courses.

Methods

This study looks at the effect of the Grade Point Average of Math001 and the Grade Point Average of Math002 on the overall performance of PYP students. The researchers first investigate the correlation between Math001 and Math002 GPAs and the overall PYP GPA. This is done by examining research hypotheses one and two, H_a^1, H_a^2. The second part of the study examines how much variation in the overall PYP performance can be explained by Math001 and Math002 GPAs. A linear regression model is suggested for this purpose and is tested by examining a third research hypothesis.

$H_a^3 :$ The multiple linear regression model is useful   (3)

The targeted population of this research is PSU students. Data was obtained from the Deanship of Admission and Registration. The initial sample consisted of 1426 newly admitted PSU male students and 1253 newly admitted PSU female students for the academic years $2010-2011$, $2011-2012$, and $2012-2013$. The researchers attained each student's Math001 GPA, Math002 GPA, and overall GPA. For better representation of the two groups, the researchers divided the sample into two strata: male and female students using stratified random sampling method.

First, screening of the data was performed and all none applicable cases were excluded. For example, students admitted in the *Law, Applied Linguistic,* or *Translation* programs were omitted because such programs do not have mathematical courses in their PYP. Moreover, students who withdraw from the university before completing the PYP were also excluded from the sample. In addition, transfer students who waive some or all PYP courses were also excluded from the sample. This screening

process resulted in a sample of 749 female students and 455 male students.

Then, all statistical assumptions were tested to fit the model of regression. Graphical and numerical descriptive statistics were used to best represent the sample data. The researchers computed the mean, standard deviation, range and other suitable measures for all the variables of PSU female and male students. The researchers used Excel Data Analysis Plus, SPSS, and XLSTAT, to test the correlation coefficient and develop the linear regression model.

Results

This study examines the effect of students' performance in the preparatory mathematics courses on their overall performance in the PYP. The sample data consists of 1204 male and female students who were admitted to PSU over the period 2010–2013. Considering Math001 GPA and Math002 GPA as the independent variables and the overall performance by the end of PYP as the dependent variable, the research hypotheses stated in (1) and (2) are now mathematically stated as:

$$H_a^1 : \rho \neq 0 \qquad\qquad\qquad (4)$$
$$H_a^2 : \rho \neq 0 \qquad\qquad\qquad (5)$$

Next, if the results show a strong positive correlation between these variables, then the linear regression model can be suggested and the research hypothesis (3) could be tested.

Table 1 shows the descriptive statistics. It indicates that students are performing slightly better in Math002 with smaller standard deviation. Overall, all three variables have a smaller magnitude of variation. Table 2 shows the correlation matrix. It seems that there is a strong positive correlation individually between Math001 and Math002 with the overall PYP.

Table 1
Descriptive Statistics

	Average	Median	Standard Deviation
PYPGPA	2.785	2.87	0.7702
Math001GPA	2.778	3	1.0106
Math002GPA	2.854	3	0.9471

Table 2
Correlation Matrix

	PYPGPA	Math001GPA	Math002GPA
PYPGPA	1	0.787	0.732
Math001GPA	0.787	1	0.660
Math002GPA	0.732	0.660	1

The strong positive correlation suggests using a *t*-test to examine the significant correlation between the given set of variables. When calculating the coefficient of determination between the dependent and independent variables, from Table 3 one can say that nearly 62% of the variation in the overall PYP GPA can be explained by Math001 GPA. Similarly, 54% of the variation in the overall PYP GPA can be explained by Math002.

Table 3
Coefficient of Determination

	PYPGPA	Math001GPA	Math002GPA
PYPGPA	1	0.619	0.536
Math001GPA	0.619	1	0.436
Math002GPA	0.536	0.436	1

Table 4 shows the results of the above two research hypotheses when tested at 5% level of significance. There is a significant correlation between Math001 and overall PYP; also, there is a strong evidence for a significant correlation between Math002 and overall PYP. This indicates that an increase in Math001 GPA results in an increase in the overall PYP GPA and an increase in Math002 GPA causes an increase in the overall PYP GPA.

Table 4
Pearson Correlation Test

Correlation between Overall PYP with	Correlation	Test-value	Critical Value
Math 001	0.787	44.2296**	2.5799
Math 002	0.732	37.2524**	2.5799

Note. Significant at alpha =.05

As we mentioned earlier that if there exists a significant correlation between Math001 and overall PYP GPA and Math002 with the overall PYP GPA then, a

multiple regression model can be fitted to predict the overall PYP GPA with Math001 and Math002 GPAs of students (Glantz & Slinker, 2001).

$$Y = \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \varepsilon \qquad (6)$$

such that Y represents the overall GPA, X_1 represents Math001 GPA and X_2 represents Math002 GPA. Hence, mathematically:

$$H_a^3 : \text{Atleast one of the } \beta_i \neq 0 \text{ where } i = 1,2 \qquad (7)$$

We would now test the third hypothesis: Using Excel data analysis plus, Table 5 shows the multiple linear regression output indicating that there is a significant effect of MATH001 and Math002 on the overall PYP GPA.

$$Y = 0.7744 + 0.4013 * X_1 + 0.3061 * X_2 \qquad (8)$$

Table 5
Regression Estimates

	Coefficients	Standard Error	LCL	UCL	t Stat	p-level
Intercept	0.774	0.041	0.695	0.854	19.073	< .05
M001 GPA	0.410	0.016	0.379	0.442	25.549	< .05*
M002 GPA	0.306	0.017	0.272	0.340	17.862	< .05*

Note. * $p < .05$

The estimated coefficient for Math 001, $\beta_1 = 0.4013$, shows that the average overall PYP GPA is estimated to be increased by .41 GPA units for every increase in Math001 GPA holding Math002 constant. Similarly, Math002 estimated coefficient, $\beta_2 = 0.3061$, shows that the average overall GPA is estimated to be increased by .3061 GPA for every increase in Math002 GPA unit.

Table 2 shows a high correlation between the two independent variables Math001 and Math002, $r = 0.66$, which may contribute redundant information for the model and can cause an adverse affect on the regression model. The severity of multi-collinearity is measured by Variance Inflation Factor (VIF) before

a researcher decides to eliminate one or more independent variable or combining two or more independent variables into a single index (O'Brien & Robert, 2007). The result shows that VIF is less than five, hence the multi-collinearity between Math001 and Math002 is not of serious nature.

Next, the confidence intervals and the *t*-test for individual coefficients (Table 5) of Math001 and Math002 provides strong evidence that both variables are statistically significant for the suggested regression model. Moreover, the ANOVA test (Table 6) shows that overall usefulness of the model when Math001 and Math002 are included to predict the variations in the overall PYP GPA.

Table 6
ANOVA

	d.f.	*SS*	*MS*	*F*	*p-level*
Regression	2	498.97341	249.4867	1,396.47643	< .05 *
Residual	1,201	214.56397	0.17865		
Total	1,203	713.53738			

Note. * $p < .05$

Discussion and Conclusion

Admitted students to Prince Sultan University in Riyadh are required to complete a preparatory year program (PYP) prior to joining any academic program. This study examined the effect of students' performance in PYP mathematics courses on the overall performance of students in the PYP. The sample data of 1204 was collected on PSU PYP students during academic years 2010–2013 for three variables. Math001, Math002 and overall PYP GPA were used to study three hypotheses.

The first hypothesis tested against the correlation between the independent variable (Math001) and the dependent variable (overall PYP GPA). The t-test showed that a statistically significant positive correlation exists between the two variables. The second hypothesis proved that there exists a strong positive correlation between Math002 GPA and the overall PYP GPA when tested using a t-test. The last hypothesis selected both MATH001GPA and MATH002 GPA as independent variables when these two variables have multi-collinearly. Before one of the variables would have been excluded from the model, the Variance Inflation Factor, which was less than five, supported our argument to include both variables in the regression model. The bias of these variables will be discussed in the next paper. The overall and individual usefulness of these variables are statistically significant.

The findings of this study suggest that although these two courses contribute only eight credit hours out of 30 credit hours for PYP, their contribution towards the success in PYP is highly significant. The results indicate that nearly 60% of the variation in the dependent variable is explained by Math001 GPA, and nearly 54% of the variation in the dependent variable is explained by Math002 GPA.

The result of this study supports many previous research that stressed on the importance of mathematical knowledge and skills for college students. Shrestha and Mani (2014) argued that GPA for mathematics courses influenced the overall GPA, although the mathematics course constitute only 15% of the overall credit hours of other courses. The findings of this research suggest that special attention should be given to improve students' skills and competencies in mathematics during secondary education and during PYP. In addition, students themselves should be aware of the importance of improving their mathematics skills.

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