Mathematics Readiness of First-Year University Students

By Francis Atuahene and Tammy A. Russell

The majority of under-represented minority students are attending high schools located in under-resourced school districts.

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ABSTRACT: The majority of high school students, particularly underrepresented minorities (URMs) from low socioeconomic backgrounds are graduating from high school less prepared academically for advanced-level college mathematics. Using 2009 and 2010 course enrollment data, several statistical analyses (multiple linear regression, Cochran Mantel Haenszel [CMH] Chi-square test, and independent t*-test) were conducted to examine students' readiness in select college mathematics courses in a four-year public university in the United States. A multiple regression analysis shows that SAT-Math scores marginally contribute to students' performance in college-level mathematics. The CMH* χ^2_{MH} *test shows a statistically significant difference in the row means score between male and female students and regular and special admitted students. The results of the independent* t*-test shows significant difference between majority White and URMs' performance in select math courses.*

The persistent decline in mathematics performance of students who transition into college is a phenomenon that continues to be a national concern in the United States. A plethora of studies have shown that many high school graduates, particularly ethnic minorities students, are academically underprepared for college mathematics and science courses (ACT 2008). Green and Winter (2005) reported in a study that only 34% of 2002 graduating high school students had acquired the necessary skills for college-level work, and "only 23% of African-American students and 20% of Hispanic students left school college ready, compared with 40% of White students" (p. 7). In a similar study, the ACT (2008) calculated the benchmark of four score areas to determine the academic readiness of students by ethnicity. In Pennsylvania, the study found that 36% of White students met the ACT college readiness benchmark compared to 46% Asians, 20% Hispanics, and 5% Africa-American students.

Factors associated with mathematics skill deficiency have been widely studied. Lewis (1998) acknowledged that many students are admitted to universities with low mathematics skills. More rigorous high school math curriculum continues to show positive outcomes for student success in college math courses, as well as overall college graduation rates. However, not all students, particularly underrepresented minorities attend high schools with equally rigorous math curriculum. The widening academic preparation and achievement gap between ethnic minorities and White students has been attributed among other factors to socioeconomic status of high school district and the quality of education students received (Sterling, 2004). The majority of underrepresented minority students are attending high schools located in under-resourced school districts that lack the quality of teaching and instruction needed to prepare them with the competencies and skills to be successful in math and science disciplines. High poverty schools have mathematics teachers who may hold both a license and a degree in the field they are teaching (Sterling, 2004). Yet many colleges use high school math completion as a predictor for success in college. Although some entering college students may have completed similar levels of mathematics in their respective high schools, the rigorousness of the curriculum in each school may not be the same due to various factors such as the location and district of the high school, the quality of instruction received by students, and the pedigree of high school teachers. Students who did not attend high quality high schools may not have the opportunity to take advanced-level courses and typically are not ready for college-level mathematics (Boylan, 1995; Sterling, 2004). For such students, their needs for developmental-level mathematics become paramount at the college level.

The magnitude of this problem is evidenced by the existing enrollment disparity in the Science, Technology, Engineering, and Mathematics (STEM) fields between gender and among different ethnicities. Currently, whites make up 82.3% of the science, mathematics, and engineering workforce compared to 10.4% Asian Americans, 3.4% African Americans, 3.1% Hispanics, and 0.3% American Indians (National Science Board, 2000). Despite national efforts to close this gap, majority populations continue to dominate math-based career fields. Realizing the importance of math preparedness to academic success and the impact of student success on college persistence and retention, this study examines first-time, full-time students' readiness for college mathematics as measured by their performance in select mathematics courses taken during their first semester of enrollment at a four-year comprehensive public university.

Literature Review

Various studies have examined success in college-level math (Benbow & Arjmand, 1990; Spade, Columba, & Vanfossen, 1997) using a range of variables including gender differences in math (Boaler, 1997), gender and minority comparisons (Clewell, Anderson, & Thorpe, 1992), gender comparisons in general (Adelman, 1998; Arnold, 1993; Astin & Sax, 1996; National Research Council, 1991; NSF, 1996; Schaefers, Epperson, & Nauta, 1997; Yauch, 1999) and first-generation and socioeconomic status (Ting, 1998). Other studies that focused on success in specific college majors such as science and engineering degrees (Hewitt & Seymour, 1991; Huang, Taddese, Walter, & Peng, 2000) incorporated similar variables in their analysis.

These studies suggest that minority students enroll in four-year degree programs academically less prepared than nonminority students. High school academic variables such as SAT and ACT that include both verbal and math scores and high school GPA may not adequately determine whether students are equally prepared academically. Although high school academic preparation may have a strong association with college math performance and graduation from bachelor's degree programs (Trusty, 2002; Trusty & Niles, 2003), high school grades do not necessarily guarantee that a student is prepared for college-level work (Choy, Henke, Alt, Medrich, & Bobbit, 1993; Dillworth, 1990; Henke, Choy, Geis, & Broughman, 1996; Horn, Hafner, & Owings, 1992). Although Bailey, Jeong and Cho (2008) have suggested that math is the subject in which skill-deficient students are less likely to successfully progress through college level, there are certainly possible factors other than skill deficiency that contribute to a student's failure, such as the rigorousness of high school curriculum.

Quality of High School Math

A number of studies have investigated how the quality of high school math preparation impacts success at college-level mathematics (Adelman, 1999; Boaler, 1997; Choy et al., 1993; Dillworth, 1990; Henke et al., 1996; Horn et al., 1992; National Center for Education Statistics, 1995; Weiss, Matti, & Smith, 1994). Several studies have shown that some students are completing high school mathematics courses assuming that those courses are comparable to similar courses offered to other students in different schools. Horn et al. (1992) emphasized the discouraging numbers of less qualified teachers who are more likely to instruct students from the lowest academic and socioeconomic backgrounds. Even if students have completed a math course titled trigonometry or calculus, higher level high school math course enrollment does not translate into high quality and rigorous math curriculum to potentially support success in college-level math.

Of considerable importance in the study by Horn et al. (1992) is the comparison made about different student populations and the type of 8th-grade math completed by each student group. In their study, 47% of high-income students were enrolled in 8th-grade algebra as compared to 15.2% of low-income students. Furthermore, 50% of low-income students were more likely to have math teachers who majored in general education bachelor's degree programs compared to 39% of high-income students (Horn et al., 1992). All of these factors related to the likelihood of whether or not students were placed in college developmental math curriculum.

High school grades do not necessarily guarantee that a student is prepared for college-level work.

Remedial Course Completion

In 1995, 29% of first-year students attending four-year institutions enrolled in at least one remedial course (Lewis & Farris, 1996). A study by the National Center for Education Statistics (2003) also reported that 22% of students who enrolled in remedial courses enrolled in math remediation and 14% enrolled in writing remediation. According to Hoyt and Sorenson (2001), despite the large number of students enrolling in remedial education courses some states education departments have tried to reduce or eliminate remedial course offerings due to cost. Although it may take some students longer to complete a degree, the elimination of remedial education courses would further hinder the prospects of student populations who need the courses to prepare them to complete bachelor's degree programs (Long, 2005). Missing from this data are comparison studies focusing on students' high school math completion and other high school background information, including the percentage of students considered math proficient and/or economically disadvantaged at each of the high schools and how that relates to remedial course completion in college.

Students from low socioeconomic backgrounds tend to complete vocational curriculum more often than college-level curriculum (Rojewski, 1997). Studies by May and Chubin (2003); Tyson, Lee, Borman, and Hanson (2007); and Perna, Lundy-Wagner, Drezner, Gasman, Yoon, Bose, and Gary (2009) have reported that African-American and Hispanic students are more likely to attend high schools that do not offer advanced math and science courses, supporting the need for more federally structured high school curriculum requirements. More so, some of these students attend high schools that offer vocational and technical training for easy entry into the job market. However, although vocational and technical curriculum are helpful with addressing high school students' career interests, most of these schools lack rigorous curriculum that academically prepares students for college-level work.

In an analysis of survey results of approximately 6,000 teachers in 1,200 public and private high schools which appeared in a report entitled *Multiplying Inequalities*, Oakes (1990) argues that "[a]s the proportion of low-income and minority students at a school increases, the relative proportion of college-preparatory and advanced course sections decreases" (p. 35). In this analysis Oakes indicates the number of calculus sections available per student in high-income schools to be approximately four times greater than that of low-income schools.

Chaney (1995) also found that math courses taken beyond the minimum high school math requirements tend to have a stronger relationship with achievement in college mathematics. Chaney, Burgdorf, and Atash (1997) estimated that increased high school math requirements resulted in increased numbers of math and science courses completed but not an increase in the level of courses. They contended that, although students completed more math and science coursework in high school, the majority of the courses completed were introductory courses.

Much of the research incorporating variables similar to this study emphasized the importance of high school curriculum completion in relation to preparation for college and university curriculum. Several studies focus on factors of college students' persistence (Adelman, 1999; Choy, 2002; Clewell, Anderson, & Thorpe, 1992; however, a considerable number of these studies concentrate on the rigorousness of high school curriculum in relation to the type of mathematics courses students completed in high school.

In a similar study, Lee, Burkam, Chow-Hoy, Smerdon, and Geverdt (1998) claimed that specific types of high school math courses are strongly associated with college mathematics performance (e.g., academic math courses). Lee et al. hypothesized a constrained math curriculum, that is, a math curriculum that requires students to complete the same type of math classes, would be evenly distributed among different student groups (e.g. low-income students and students of color) across math classes. Research questions posed in the Lee et al. study focused on the interrelationship of high school math structure and its influence on student math course choice, math achievement, and equitable distribution of student background characteristics. By using hierarchical linear modeling, researchers found that Black and Hispanic students, low-income students, female students, and students who received lower grades in earlier math courses did not progress into more intensive math courses in high school as often as their counterparts who performed well academically. The researchers argue that a constrained curriculum is more advantageous to students than having a high school curriculum that offers a wide array of math courses. This wide math distribution unknowingly set the students up for later slow math progression. However, missing from Lee et al.'s study was information pertaining to students' SAT math scores. Understanding the relationship between high school math completion and SAT math scores in relation to later college math achievement can also help clarify if SAT math scores are good predictors for college entrance, college math placement, and college math grade outcomes.

Determining Students' Math Abilities Using SAT and ACT Math Scores

College and university admission practices vary nationally (Cabrera, La Nasa, & Burkum, 2001). Some colleges and universities rely on SAT and ACT test scores in admission decisions. Unfortunately, standard tests alone are not good predictors of success at the university. As a result some institutions are developing better admission evaluation criteria (Adelman, 1999) in response to the recommendations by the President of the University of California system to stop requiring high school students to complete the SAT I. Subsections of the SAT and ACT tests require students to have certain background knowledge to have a better chance at success on these standardized tests. For example, the math section of the SAT requires arithmetic, algebra, and geometry, and the ACT's math section requires pre-algebra, algebra, geometry, and trigonometry (Adelman, 1999). Students who have not completed these math courses prior to the exam may be less prepared compared to students who have completed trigonometry or higher prior to the completion of the exam. In order for students to have the opportunity to complete geometry or algebra II prior to taking the exam, for example, students would need to complete algebra I in the 8th grade in most instances because many students attempt the SAT at the beginning of 11th grade. Even if students complete a rigorous high school math curriculum according to their high schools' course descriptions, the curriculum completed may not have academically prepared them for their future academic goals, specifically bachelor's degree attainment.

Purpose of the Study

This study analyzed first-year, full-time students' readiness for college-level mathematics courses in a four-year public university. Up until the beginning of the 2014/2015 academic year, the university determines students' mathematics readiness by their SAT math scores and/or their performance on an exam administered by the department of mathematics for students who want to challenge their placements by SAT. Students who score lower than 480 on the SAT math section are placed in a developmental course. Students who score between 480 and 580 are placed in one of the university's General Education math courses. These include, Introduction to Mathematics, Applied Mathematics, College Algebra, Algebra and Trigonometry, and Pre-Calculus. Students whose SAT math score is 590 or higher are allowed to take Calculus I if they prove their ability by passing an institutionally designed math challenge test. Over the years the number of students earning D and F grades and withdrawing from courses such as algebra, trigonometry, and calculus-based math courses, have increased. Not only has this dismal performance raised concerns about the appropriateness of using SAT math scores as the main determinant of college math placement, but also students' math skills proficiency has been questioned. Various academic support services such as tutoring and the Early Alert Program have been used to provide supplementary out of class support for students academically challenged in their math classes.

A constrained curriculum is more advantageous to students than having a high school curriculum that offers a wide array of math courses.

Assessments by the Early Alert Program have shown that 53% of first-year Fall 2010 students who enrolled in Pre-Calculus, were on the D, F, and W list at the end of the semester, and for Fall semesters 2007 through 2009 the total D, F, and W rate ranged from 44.8% to 52.9%. The D, F, and W rate for total student enrollment in Applied Mathematics in Fall 2010 was 66.4% and from 2007 through 2009 rates ranged from 50.7% to 57.3% respectively. Using 2009 and 2010 entering freshmen course enrollment data available at the Office of Institutional Research, this study was undertaken to answer the following research questions:

1. Is SAT-Math score a good predictor of students' success in college-level mathematics courses?
2. How does student performance in select mathematics courses differ across gender and admission groups (i.e., Regular versus Students in Transition)?
3. How does student performance in select mathematics courses differ across ethnicity (Majority White versus Underrepresented Minority, URM)?

Method

Sample and Study Participants

This study examined students' academic preparedness in select college-level mathematics courses. The study utilized Fall 2009 and Fall 2010 data of entering freshmen received from the Office of Institutional Research. There were 1315 participants in the data who completed at least one mathematics course: developmental mathematics, introduction to mathematics, calculus-based courses (i.e., Pre-Calculus and Brief Calculus), algebra and trigonometry, college algebra mathematics, and introduction to statistics. Demographically, there were 726 (55%) female and 589 (45%) male students in the dataset. Ethnically, there were 1043 (80%) majority white students and 264 (20%) underrepresented minority (URM) – this included Asian, Black, Hispanic, multi-racial students, and other ethnic minorities. There were eight students in the dataset whose ethnic identity was unidentified. In terms of mathematics enrollment, there were 224 (17.03%) students in calculus-based math, 225 (17.11%) in developmental or remedial level math courses, 382 (29.05%) in introduction to statistics course, and 484 (36.81%) in algebra and trigonometry, and college algebra.

The university admits students based on various factors, including SAT test scores and high school grade point average (HSGPA). Students who have an SAT score of 1020 or higher on combined critical reading and math, have cumulative high school GPA of B or better in a college preparatory curriculum, and rank in the top 40% of their graduating class can be admitted as regular status. However, students whose SAT composite score falls below the cut-off point but meet certain defined criteria can gain admission as Special Admit (motivational students) who are academically less prepared for college and who tend to place into developmental English and math courses. In addition to these two options is the Academic Development Program (ADP) and Act 101 group. The ADP is a special admissions program for students who do not meet current admissions criteria but who demonstrate the potential to succeed in college. Students admitted to the program complete a 5-week summer session to assist them in developing academic skills in reading, writing, and mathematics. Successful completion of the summer session leads to fall enrollment. Act 101 students are low-income ADP students, who receive financial assistance for the summer session, and additional academic support such as tutoring. The majority of the ADP and Act 101 students are minority students who are mostly placed in developmental classes. The ADP and Special Admit students were grouped under transitional students. There were 840 (64%) regular students and 475 (36%) students in transition.

Procedure

Descriptive statistics including frequencies, means, course grade points established by the university were used to determine students' readiness in select math classes. SAT-Math scores were categorized into three groups: Group 1 (SATM ≤ 470), group 2 (SATM 480–580) and group 3 (SATM ≥ 590). Mathematics courses were grouped into four major categories: (a) developmental-level courses, (b) algebra and trigonometry, (c) calculus-based math courses, and (d) basic statistics course. Students' performances based on their final grades were classified into five categories: (a) scores of A and A- (excellent), (b) scores of B+, B, and B- (above average), (c) scores of C+, C, and C- (average), (d) scores of D+, D, and D- (below average), and (e) Fail grades (F and Z). The author used the corresponding grade points for each letter grade a student earned in a course to determine their performance; this was used for both regression and means test analyses instead of their cumulative GPA which included their performance in all other courses. Since the university treats F and Z grades the same, the author assigned 0.00 point for these letter grades. In calculating the mean performance of students in each class, the author treated all "Ws" as missing cases to eliminate their impact on the overall analyses. These individuals withdrew from the select classes for various reasons unaccounted for in the dataset. For the purpose of this study, admission groups were categorized into regular and transitional students. There were two categories of gender, female coded as 1 and male coded as 0. Ethnicity was coded as 1 for majority White and 0 for URM students.

Results

Determining Students Math Placement by SAT-Math Score

The level of mathematics course a first year student takes at the study institution is based on either the student's SAT or ACT math score and the requirement of the students' major. Students who wish to enroll in a math course higher than their initial placement must pass a university math challenge exam to determine their ability to succeed in that class. Students whose math SAT scores fall within 480 and 580 are placed in one of the identified general education math classes, including pre-calculus. The college-level math placement is represented in Figure 1 (p. 16). Descriptively, the data revealed the following findings:

- Approximately 76% of 1315 students were academically ready for university level general education math courses, based on their SAT scores and eligible placement levels,
- only 23.19% of 993 students who were academically prepared for college-level math courses were academically ready for Calculus I based courses,
- 67% of White students were more prepared to take college-level mathematics,
- only 8.57% of URM students were ready for university-level math course, and
- 60% (789) and 15.51% (204) of regular and transitional students respectively were ready to take college-level mathematics course.

Although underrepresented minorities (URMs) make up a small percentage of the sample size for this study, Black and Hispanic constitute the majority of this group who are placed in developmental math courses. The probability that an African American and a Hispanic student admitted into this university will be placed in remedial math class is 60.43% and 42% respectively compared to 8.5% of White students. There were about 91.5% White students placed in university- level mathematics course compared to 39.6% of Black students, 58.1% Hispanics and 66.7%. Thus, if the rigorousness of a student's high school math curriculum determines his/her ability to perform at college-level mathematics then, the majority of African American and Hispanic students are disadvantaged and are more likely to be behind in their math sequence than White students in the same cohort at this university. Yet, it is usually difficult to judge if the SAT-Math score is a good predictor of student success in college-level mathematics.

However, to answer the question, is SAT-Math score a good predictor of students' success in college-level mathematics controlling for gender, ethnicity, and admission group, a multiple linear regression analysis was conducted. We developed a model for predicting students' college-level mathematics grades (using grade points) from their SAT-Math scores controlling for gender (coded 1 = female and 0 = male), ethnicity (1 = majority and 0 = URM), and admission type (1 = regular and 0 = transition). All the relevant assumptions of this statistical analysis were tested. The assumption of singularity was met as the independent variables were not a combination of other independent variables. An examination of correlations revealed that none of the variables was highly correlated. Additionally, the collinearity statistics, such as tolerance and VIF, were all within accepted limits. The assumption of multicollinearity was deemed to have been met. Residual and scatter plots indicated the assumptions of normality, linearity and homoscedasticity were all satisfied. The Shapiro-Wilk statistics, W = 0.97, indicates the normality assumption was met. The Durbin Watson value of 1.9 indicates lack of first order autocorrelation.

In order to select the model that provided the best prediction of students' math grades, given SAT-Math, gender, ethnicity, and admission group, three model diagnostics were performed utilizing the Akaike Information Criterion (AIC), Bayesian Information Criteria (BIC), and Schwarz Bayesian Criteria (SBC). In all of the three model diagnostics, the best fit model for predicting students' performance in college-level mathematics was a linear combination of SAT-Math, ethnicity, and gender. Based on the results of the model diagnostics, students' grade points was regressed on SAT-Math, gender, and ethnicity. The results show that a unit increase in SATM score will predict a 0.01 increase in student score in mathematics holding other variables constant. Overall, the three predictor model accounts for 17% of the variance in students' scores, $F(3, 1315) = 89.02$, $p < .001$ 90% CI [-2.45, -1.32]. The beta coefficients for the three predictors are shown in Table 1.

For White or majority students, the predicted grade was 0.29 points higher than underrepresented minority students (URMs). As shown in the respective predicted regression equations: $\hat{Y}$ Majority = 1.58 + 0.01 (SAT-Math) + 0.51 (Female) and $\hat{Y}$URMs= -1.87 + 0.01(SAT-Math) + 0.51(Female). This indicates that for all the courses considered White students performed better than URMs in the same type of courses holding other variables constant. For gender, the results indicate that for female students, a unit increase in their SAT-Math scores could lead to an increase in their college-level math grades (see Table 1). The differences between the predicted value for female and male students are expressed by $\hat{Y}$ Female = -1.36 + 0.01 (SAT-Math) + 0.29 (Ethnicity) and $\hat{Y}$ Male = -1.87 +0.01 (SAT-Math) + 0.29 (Ethnicity) respectively.

A unit increase in SATM score will predict a 0.01 increase in student score in mathematics.

To answer the second research question, how does student performance in select mathematics courses differ across gender and admission groups, a Cochran Mantel Haenszel (CMH) chi-square test was performed to determine if there is any difference in performance of select college-level mathematics (algebra and trigonometry, calculus, developmental, and statistics) courses between first, female and male students and second the two admission groups (see Table 2, p. 19). The CMH χ^2_{MH} test showed a significant difference between female and male performance in some of the courses. For algebra and trigonometry, the relation between female and male performance was significant, $\chi^2_{MH}(1, N = 410) = 24.02, p <.000$. For calculus, the relation between female and male performance was not significant, $\chi^2_{MH}(1, N = 188) = 0.04, p = 0.84$. For developmental math courses, the relation between female and male performance was significant, χ^2_{MH} (1, N = 221) = 4.533, p <.032. For statistics, the relation between female and male students' performance was significant, χ^2_{MH} (1, N = 365) = 7.68, p <.01. The χ^2_{MH} test results show that overall female students tend to perform better than male students in algebra and trigonometry, developmental courses, and statistics. Although statistically, there is no significant difference between female and male performance in calculus, descriptively the proportion of male students who scored lower grades (i.e., Ds and Fs) in calculus was higher than female students.

To determine the difference in students' performance by admission group, the CMH χ^2_{MH} test was conducted for algebra and trigonometry, calculus, developmental, and statistics. The results (see Table 3) showed a statistically significant difference between regular and transitional students for algebra and trigonometry, χ^2_{MH} (1, N = 410) = 13.08, p <.00; developmental math, χ^2_{MH} (1, N = 221) = 5.89, p < 0.02; and statistics, χ^2_{MH} (1, N = 365) = 12.63, p < 0.00. However, the results showed no statistically significant difference across admission groups in calculus, χ^2_{MH} (1, N=188) = 3.38, p = 0.07. Overall regular students tended to perform slightly better than transitional students in algebra and trigonometry, and statistics (see Figure 2, p. 18). However, students in transition performed better than regular students in developmental math courses in terms of the proportion who earned A, B, and C grades.

To answer the research question, how do students' performances differ across ethnicity (majority versus URM), an independent t-test was conducted for algebra and trigonometry,

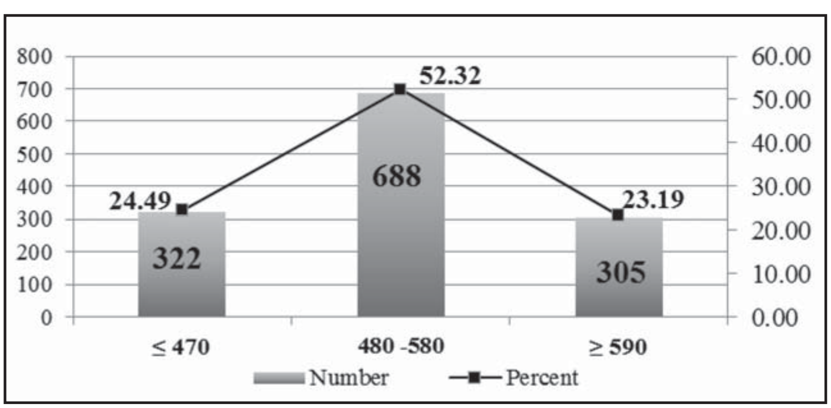

***Figure 1.* SAT scores by college math placement category.**

Table 1

Summary of Regression Analysis for SAT-Math Predicting Student Success in College-Level Mathematics

Variables	β	*SE*	*t*	*p*
Constant	–1.87	0.28	–6.75	<.0001
SAT-Math	0.01	0.00	13.75	<.0001
Ethnicity (majority)	0.29	0.09	3.26	.0012
Gender (female)	0.51	0.06	8.38	<.0001

calculus-based mathematics, developmental math courses, and introduction to statistics (see Table 4, p. 19). Given the existence of equality of variance, the *t*-test was calculated for algebra and trigonometry. The result of the *t*-test indicated a significant difference between majority and URM students in algebra and trigonometry, $t(408) = 4.11$, $p = 0.0001$, with majority students ($M = 2.47$, $SD = 1.22$) performing better than URM ($M = 1.76$, $SD = 1.34$) in algebra and trigonometry. The size of this effect ($d = 0.55$), as indexed by Cohen's coefficient d, was found to be medium ($d = 0.5$). The *t*-test for developmental math courses showed that there was no statistically significant difference between majority and URM students, $t(219) = 0.66$, $p = 0.$ 0.51; majority student performance ($M = 2.58$, $SD = 1.25$) was statistically indistinguishable from the performance of URM ($M = 2.48$, $SD = 1.15$). This is also evident by the size of this effect ($d = 0.09$), as indexed by Cohen's coefficient d, which was found to be a very small effect ($d = 0.2$).

Table 2

Results of Chi-Square Test and Descriptive Statistics for Performance in Select Math Course by Gender

		Grades							
Course	Gender	A	B	C	D	F	*df*	χ^2_{MH}	*p*
Algebra and Trig.	Female	64 (15.61)	68 (16.59)	38 (9.27)	17 (4.15)	17 (4.15)	1	24.023	<.000
	Male	26 (6.34)	63 (15.37)	55 (13.41)	27 (6.59)	35 (8.54)			
Calculus-based	Female	13 (6.91)	18 (9.57)	17 (9.04)	17 (9.04)	16 (8.51)	1	0.038	.845
	Male	18 (9.57)	27 (14.36)	16 (8.51)	18 (9.57)	28 (14.89)			
Developmental	Female	44 (19.91)	44 (19.91)	40 (18.10)	11 (4.98)	10 (4.52)	1	4.533	.032
	Male	11 (4.98)	28 (12.67)	17 (7.69)	4 (1.81)	12 (5.43)			
Statistics	Female	71 (19.45)	80 (21.92)	53 (14.52)	8 (2.19)	9 (2.47)	1	7.686	.005
	Male	31 (8.49)	58 (15.89)	31 (8.49)	8 (2.19)	16 (4.38)			

Note. Percentages are in parenthesis.

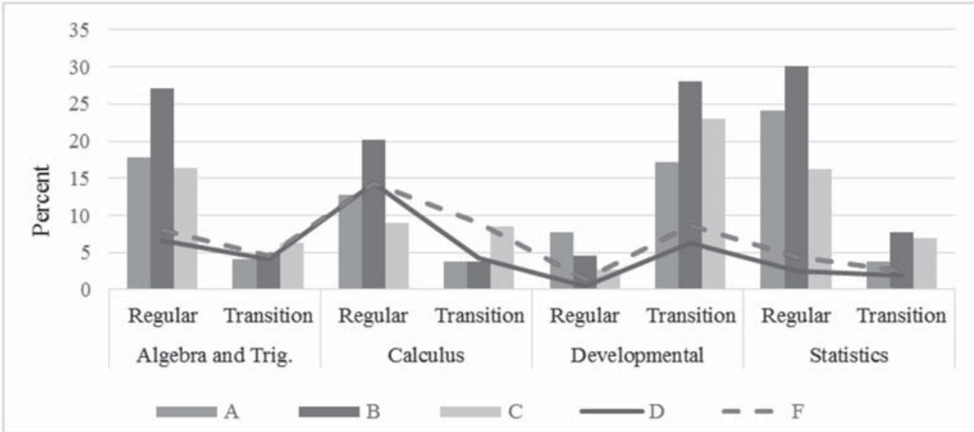

Figure 2. **Grade distribution by admission group in select math courses.**

Discussion

This study analyzed students' preparedness for college mathematics courses by examining their performance in select courses. Academically, female students are better prepared for the select college-level mathematics such as algebra and trigonometry, and statistics than male students. Relatively, regular students are better prepared for college mathematics than Special Admits. However, it is important to note that students in transition, particularly ADP/Act 101 students, receive mandatory tutoring and other academic support services to enhance their performance. This may contribute to their higher performance in developmental courses than regular students who are not required to attend tutoring as part of the requirement for completing those courses. The findings of the study also provide evidence that SAT-Math score is not a strong predictor of students' success in college-level mathematics. Although this study did not specifically look into students' high school type and the type of math courses completed, it should be noted that the quality of school plays a major role in the quality of education that students received. Generally, the majority of URMs, especially African-American and Hispanic students, are considered most at-risk when enrolling in college-level mathematics courses. Most of these students attended high schools located in low socioeconomic districts, which have flexible mathematics curriculum, under-resourced educational facilities, and, most importantly, limited number of quality math teachers to challenge them to enroll in advance-level classes.

Although the majority of students have the SAT scores that qualify them to take college-level mathematics courses, a higher percentage of them score below "C" grade in algebra and trigonometry at college. Most students are also graduating from high school without taking a single course in algebra or trigonometry, which is vital preparation for college-level math courses. This is partly explained by the flexibility students have in picking and choosing the math courses they prefer to take in high school. Most high schools in the U.S. do not have standard mathematics curriculum that all students have to complete.

Based on the admission criteria of the university under study, it is expected that regular admit students are better prepared academically than students admitted in transition. Demographically, the majority of students in transition are primarily ethnic minorities and are placed in developmental-level mathematics courses. Students in transition earned grades 1.05 standard deviation points below regular students in statistics, 1.37 standard deviation points below regular students in calculus, and 1.22 standard deviation points below regular students in algebra and trigonometry. Nonetheless, although students in transition may not be as academically prepared for university-level course work as their regular status peers, the academic support services such as tutoring, academic advising, and counseling enhance their success.

It is important to note that students in transition... receive mandatory tutoring.

Table 3

Results of Chi-Square Test and Descriptive Statistics for Select Math Course Grades by Admission Group

Course	Admit Group	Grades A	B	C	D	F	*df*	χ^2_{MH}	*p*
Algebra and Trig.	Regular	73 (17.80)	111(27.07)	67 (16.34)	27 (6.59)	33 (8.05)	1	13.08	.000
	Transition	17 (4.15)	20 (4.88)	26 (6.34)	17 (4.15)	19 (4.63)			
Calculus-based	Regular	24 (12.77)	38 (20.21)	17 (9.04)	27 (14.36)	27 (14.36)	1	3.38	.070
	Transition	7 (3.72)	7 (3.72)	16 (8.51)	8 (4.26)	17 (9.04)			
Develop-mental	Regular	17 (7.69)	10 (4.52)	6 (2.71)	1 (0.45)	3 (1.36)	1	5.89	.020
	Transition	38 (17.19)	62 (28.05)	51(23.08)	14 (6.33)	19 (8.60)			
Statistics	Regular	88 (24.11)	110 (30.14)	59 (16.16)	9 (2.47)	16 (4.38)	1	12.63	.000
	Transition	14 (3.84)	28 (7.67)	25 (6.85)	7 (1.92)	9 (2.47)			

Note. Percentages are in parenthesis.

Implications for Practice and Research

Addressing the math deficiency syndrome will require concerted efforts among all stakeholders. For example, more emphasis needs to be placed on the development of rigorous elementary and middle school academic curriculum, and ensuring timely completion of required level of mathematics classes before moving on to high school. Although states' educational policies differ, it is clear that current policies are not designed to address some of the challenges facing students in mathematics. Nationally, the lack of constrained math and science curriculum requirements means students decide what classes to take; this has not been helping with their academic preparation for college. On average every high school student should have at least a basic course in algebra and trigonometry. Unfortunately, many students are enrolling in college less prepared in these subject areas. The standard curriculum should enforce such policies whether or not the student is taking AP level classes.

A system that requires a more constrained curriculum during early grade levels will better prepare middle school students for advanced high school courses and allow more high school students to enroll in advanced mathematics courses. This will possibly improve students' chances to enter college better prepared to take advanced-level mathematics courses and attain bachelor degree completion. Having more minority students enroll in advanced level math courses will prepare them academically, which increases their odds for entering math-based (Science Technology Engineering and Mathematics) career fields and potential for higher salaries. However, historically, minority students predominantly attend schools located in underfunded districts with a limited supply of qualified mathematics teachers, minority students' underachievement in mathematics must be perceived and approached conceptually as lack of opportunity (Flores, 2007).

Adelman (1999) emphasizes the predictive power of academic variables when studying college degree completion yet criticizes the use of high school class rank as a college admission tool. Adelman (1999) reiterates the difference of the type of high school courses completed and their impacts on high school grade point average. The use of Carnegie units (the number of years of high school curriculum) completed determines the number of years students spend in a particular type of curriculum but not students' level of preparedness for college mathematics. This study contends that, a student is deemed better prepared for university-level mathematics if he/she has completed specific levels of high school math beyond basic algebra II, including calculus, for example. Completing 3 years of high school mathematics courses, a college admission criteria, does not correlate to advanced-level and rigorous curriculum that will enhance success in mathematics at the university and degree completion.

Access to college transcript information is sparse due to the high level of confidentiality that protects the rights of their enrolled students rightfully maintained by colleges and universities. But how can researchers obtain accurate information with regard to high school and college curriculum completion that adequately allows them to make predictions regarding the factors associated with students' preparation for college-level math? How do researchers discern what type of math courses students actually complete in high school when relying on the number of years of high school math classes (e.g., three years of high school Carnegie units of math)? Did the student complete 2 years of algebra and 1 year of geometry, or did the student begin algebra in 8th grade and then have the opportunity to complete advanced high school calculus? Researchers can begin by following studies that have incorporated specific information related to the types of high school math courses students complete in relation to college mathematics performance. Furthermore, researchers employed at colleges and universities can study student outcomes at their own institutions.

A horizontally aligned curriculum provides the opportunity for teachers... to have uniform content, irrespective of their school district.

Although the Carnegie classification sets standards for math course curriculum and sequences of high school students leading to college-level work, there is no uniform enforcement of these standards among schools, resulting in disparities of student academic preparation for college. Thus, having a system of education that promotes curricular alignment could potentially address some of the gaps between secondary and postsecondary educational preparedness. Effective curriculum alignment promotes coherency between secondary and tertiary education mathematics curriculum while ensuring synergy of learning outcomes at different stages and levels of education (Anderson, 2002). This process can be both vertical and horizontal.

A vertically aligned curriculum offers the opportunity for students to smoothly transition from one lesson, or course level to another. Teaching is intentionally structured to provide logical sequence so that the knowledge and skills acquired in one course or lesson will progressively prepare students for a more challenging, higher-level work (Hidden Curriculum, 2014). On the other hand, a horizontally aligned curriculum provides the opportunity for teachers in different schools teaching similar courses to have uniform content irrespective of their school district. For example, the content of one ninth-grade algebra I and trigonometry course in a horizontally coherent curriculum is not different from what other students in a different school are learning (Hidden Curriculum, 2014). The assessment methods are quite similar and reflect what teachers have actually taught the students. Postsecondary institutions could work with high schools or local school boards to align curriculum of their entry-level mathematics courses with secondary schools. Having such curriculum coherency provides, at least in theory, the mindset that all teachers ensure same quality of instruction so that their students are not left behind other students in the same level of courses taught at different schools.

Finally, mathematics teachers should expect to see the majority of their first year students, particularly minorities and students from low socioeconomic backgrounds and school districts, less prepared academically for advanced-level courses. Thus, the need to diversify and fine-tune instructional methods as well as providing tutoring support to accommodate students who are academically underprepared is paramount. Although it is difficult for college teachers to identify the characteristics and academic preparedness of their first year students who come to class, teachers can, within the first 2 weeks of the semester, engage students in

Table 4

Results of* t*-Test and Descriptive Statistics Comparing Mean Performance in Select Math Courses by Ethnicity

	Majority				URM								
Course	*N*	*M*	*SD*	*SEM*	*N*	*M*	*SD*	*SEM*	*T*	*p*	*df*	CI	Cohen's *d*
Algebra and Trig.	349	2.47	1.22	0.07	61	1.76	1.34	0.17	4.11	0.00	408	0.37, 1.05	0.55
Calculus-based	168	1.90	1.39	0.11	20	1.82	1.56	0.35	0.25	0.80	186	0.57, 0.74	0.06
Developmental	95	2.58	1.25	0.13	126	2.48	1.15	0.1	0.66	0.51	219	0.21, 0.43	0.09
Statistics	323	2.76	1.10	0.06	42	2.45	1.01	0.16	1.73	0.08	363	0.42, 0.66	0.29

a comprehensive but inclusive conversations and assessments to understand not only the socioeconomic backgrounds of their students, but also garner valuable academic information that can potentially help them to modify their teaching practices to augment the academic success of students in the class. By exploring different factors associated with students' academic preparation for and success in college math courses, researchers will be in the position to develop a model of educational attainment for minority male students with bachelor's degree goals, including math-based majors.

More research is needed to determine if the U.S. secondary education system provides an equal opportunity for all groups of students, allowing an equal opportunity for bachelor degree completion, specifically from math intensive bachelor's degree programs. Completing a minimum set standard of mathematics courses for high school graduation and meeting the current set standards for college admission to bachelor degree granting institutions do not imply all students received the same quality of high school experience.

Conclusion

This study supported that college readiness for graduating high school students differs across gender and admission group. Regular admit students are more likely to perform better in most math courses than students in transition. Although the majority of specially admitted students are URMs, more information is needed regarding the quality of high schools these students attended. As indicated in the preceding discussions, clearly high schools staffed with highly qualified mathematics teachers better prepare students for college-level work than those located at high poverty school districts. Moreover, students from higher socioeconomic backgrounds tend to take advanced-level courses designed to prepare them for college-level work than the socioeconomically disadvantaged ones. There is a huge disparity in the academic preparation and mathematics skill proficiency between White and ethnic minority students. Math skill deficiency remains a national concern (ACT 2008). Universities can play a major role to address the concern by providing the necessary academic support services for students who are considered academically underprepared for college-level mathematics; understanding and application of more accurate, in depth placement variables can assist postsecondary student success in mathematics.

By exploring different factors associated with students' academic preparation for and success in college math courses, researchers will be in the position to develop a model of educational attainment.

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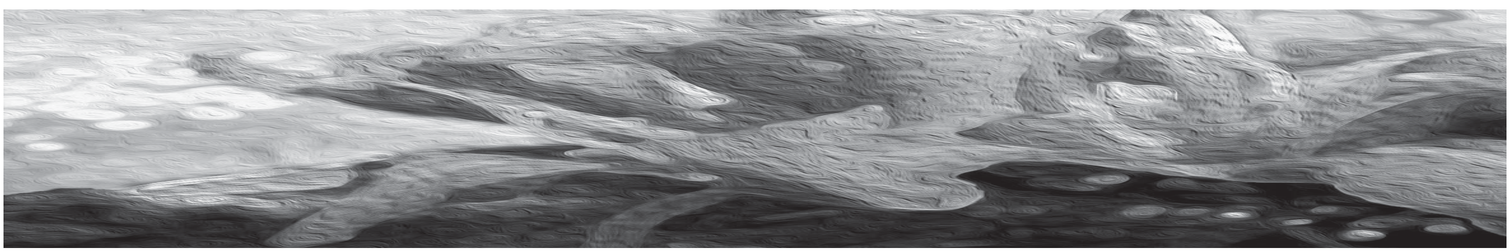

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