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P-16 Partnership to Improve Students' Postsecondary Mathematics Achievement

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Abstract

Increasing students' academic success in postsecondary endeavors is an important goal for both high school and college institutions today. However, the standards for high school graduation and college readiness are not well aligned, and successful transition from high school to college is problematic for many students, particularly in math. This article describes a P-16 collaborative effort to examine high school math achievement in relation to college math placement and how the results informed policies and practices in both organizations.

Keywords: high-school, mathematics, postsecondary, placement

P-16 Partnership to Improve Students' Postsecondary Mathematics Achievement

Academic achievement and college success are important to both an individual's future well-being and for our country's economic health. Baum, Ma, and Payea (2013) report college graduates' (bachelor's degree) median annual earnings of $56,000 in 2011 compared to a high school diploma on with median annual earnings of $35,000. Over the course of a lifetime, the difference in earning potential is dramatic. Similarly, health statistics (Baum, et al., 2013) indicate college educated individuals experience less significant chronic health problems (smoking and obesity). Finally, the poverty rate of college-educated individuals is lower than non-college educated individuals, federal public assistance program participation is lower, and federal income tax dollars generated by individuals with a bachelor's degree are higher (Baum, et al., 2013). While these are just a few examples, overall, individuals and our nation as a whole, benefit from increased educational attainment.

Adequate high school preparation is critical for subsequent successful college and career experiences. High school graduation rates have been one metric of a school system's success for many years, and when the No Child Left Behind Act (2002a) included graduation rates in the federal accountability system, the focus and emphasis on increasing graduation rates was heightened. Nationally, high school graduation rates increased more than 10 percentage points from 2000 to 2013 (Deming & Figlio, 2016 p. 35). In 2013, New Jersey had an overall graduation rate of 87.5%, demonstrating an increase of 4.4% from 2011 (DePaoli, Fox, Ingram, Maushard, Bridgeland, & Balfanz, 2015).

More recent efforts have focused not only on dropout prevention to increase graduation rates, but also on increasing the number of students graduating college and career ready. One of

the stated goals of the Race to the Top federal education initiative (2009) was for all students to graduate from high school, college and career-ready. However, the definition of college readiness has varied depending on the source. For example, as reported in 2008, four leading college readiness standards sets differed significantly (Rolfhus, Decker, Brite, & Gregory, 2010). The American Diploma Project (ADP) had 62 ELA standards, ACT had 191, the College Board had 115, and Standards for Success had 73, and when ELA content and rigor of these four college readiness standards sets was systematically compared, the alignment varied considerably.

The development of the Common Core State Standards (CCSS) was initiated around 2001 by the Chief Council of State School Officers (CCSSO) with the intent to create a national set of K-12 standards with sufficient rigor to prepare students to be successful in college and careers. Conceptually these standards would essentially provide a consistent definition of college readiness across the states that adopted them (Tepe, 2014, p. 4).

Despite graduation rate gains and some increased consensus about the definition of college and career readiness, the New York Times (Rich, 2015) recently questioned graduates' readiness to successfully engage in college-level academic work. The lack of alignment between student proficiency levels required to graduate from high school and those required for success in college has been described in multiple studies (Venezia, Callan, Finney, Kirst, & Usdan, 2005; Venezia, Kirst, & Antonio, 2003; Wilkins, Hartman, Howland, & Sharma, 2010).). Lack of communication and collaboration across K-12 school districts and post-secondary institutions to align efforts to adequately prepare high school graduates for college-level coursework has been called out as a problem by numerous researchers (Venezia, et al., 2005; Venezia, et al., 2003). Venezia, et al. (2003) describe the lack of post-secondary understanding of K-12 academic standards and performance levels as well as high school administrators' and counselors' lack of

understanding of post-secondary placement practices as key barriers to ensuring students are placed in the most appropriate college courses (the highest courses in which they are likely to succeed).

This lack of communication and consistency from high school to post-secondary institutions has led to varying practices of placing students in first year college courses. The challenge is to identify a process by which students take the highest course in which they will be successful and avoid taking courses for which they are not prepared and will likely fail (Venezia, Kirst, Antonio, 2013). Many colleges use student performance on standardized tests such as the SAT or ACT to determine placement in initial courses (Bracco, Dadgar, Austin, Klarin, Broed, Finkelstein, Mundry, & Bugler, 2014; Hodara & Cox, 2016). Other institutions rely on placement tests administered quickly and inexpensively to students as part of their registration process (Scott-Clayton, Crosta, Belfield, 2014; Jaggars & Hodara, 2013). The accuracy of these assessments to predict future success has been questioned by a number of research teams (Bracco, et al., 2014; Hughes & Scott-Clayton 2011; Kirst, 2007; Latterell & Regal, 2003; Scott-Clayton, 2012). In particular, the over-placement of students in remedial courses is described as a more frequent problem than the over-placement of students in higher courses where they struggle (Scott-Clayton, et al., 2014). A number of studies recommend the use of multiple measures, including high school math course-taking and success, as a way to increase the accuracy of placing students in the courses which will be most beneficial (Hughes & Scott-Clayton, 2011).

Numerous research studies have been conducted to examine high school students' mathematics performance as it relates to their subsequent performance at the postsecondary level (Adelman, 1999, 2004, 2006, Adelman, Danie, & Berkovits, 2003). Postsecondary students who

are not prepared for college-level mathematics and are required to enroll in developmental math (DM) courses (non-credit bearing) have consistently reported lower college completion rates (Hodara, 2013). Postsecondary assessment and placement practices have consequences for students' ultimate success and completion in college. Taking courses that do not ultimately count towards degree completion costs students in both time and expense incurred (Scott-Clayton, et al., 2014; Kirst, 2007; Venezia, et al., 2003, p. 9). As a result, examining placement practices and student success, with the goal of increasing the rate of placing students in higher-level courses in which they will likely succeed, is a worthwhile endeavor. This study focused specifically on K-12 mathematics achievement and post-secondary initial math course placement and success in a small urban university serving a significant percentage of first generation college-going students..

A collaborative effort between a 4-yr. university (University) and a local K-12 district (District) provided the context to examine the links between mastery of specific math concepts and courses (K-12 achievement), post-secondary enrollment in developmental or credit-bearing math courses, and subsequent success in the math courses. The research collaboration required a legal data sharing agreement and represents an important cross-organizational effort to improve student outcomes.

Research Question

The study question was: Does mastery of specific mathematics courses and content (such as Algebra II) lead to first-year placement and success in credit-bearing post-secondary mathematics courses? The goal for the District was to better understand how to prepare students for success in college and careers, and the goal for the University was to enroll increased

numbers of students in credit-bearing entry-level college mathematics courses (decreased numbers of students enrolled in DM courses) who subsequently pass credit-bearing courses.

Methodology

To better understand the problem and potential solutions the study examined extant data on first-year University students who had attended and graduated from a local feeder school district. As an initial attempt to understand the alignment (or lack of alignment) between high school and college mathematics success, the methodology in this study involved collecting and analyzing descriptive data. There were three primary steps in developing the University/District partnership and conducting the study:

1. Identify the required data elements and the data system from which to extract each. For each student the following data were used:
    a. from the District - high school standardized test scores and mathematics courses taken with corresponding grades earned; and,
    b. from the University - SAT scores, university math placement test (MPT) scores, first semester math course placement and related first semester math course grades.
2. Conduct descriptive analyses of relationships between K-12 mathematics performance and college mathematics course enrollment and performance. The primary analysis was a Pearson correlation in which high school math course taking, grades and SAT scores were the independent variables and first-semester university mathematics course enrollment and grades were the dependent variables.

3. Synthesize results and identify how results can inform intervention to improve student outcomes. Initially, the researcher and district administrator intended to examine the relationship between high school achievement and college success to begin to examine programs the high school had implemented to improve student achievement. The university achievement data would serve as an additional data point to examine in combination with the individual student data the district had been collecting over time. The researcher also worked collaboratively with the university institutional effectiveness office to examine results and implications for improved course placement practices.

As described, the data collected for this analysis was confidential student data. Sharing confidential information across the two agencies is limited by Federal Education Right to Privacy Act (FERPA) regulations, and a legal counsel-approved Data Sharing Agreement (DSA) was developed to address these issues. It outlined the roles and responsibilities of each organization, defined the data collection requirements, and described the logistics and protocols for ensuring student confidentiality.

Collecting Student-Level Data

The researcher met several times with an IT programmer to generate a list of the specified first-year university students who had attended the K-12 school District with the following data elements: student name, birthdate (for ensuring K-12 record match), SAT scores (if available), university MPT scores, first semester math course enrollment and first semester math course grade. The query generated a list of 55 students in an Excel spreadsheet.

The data elements added by the district were: High School Proficiency Assessment (HSPA) scores[1]; 8th grade standardized test math scores; 9th, 10th, 11th and 12th grade math courses taken with grades for each. The final dataset contained 54 students (one student was dropped due to inactive high school status).

Data Analyses

The researcher initially sorted the completed data set by several different variables: by SAT score, by MPT score, by first semester college course placement. While it was assumed that the University math department used multiple criteria for placing students in first-semester math courses, as a result of doing these different sorts of the data, it became clear that 98% of the students enrolled in a math course, were placed in developmental (two options - one lower and one higher) or credit-bearing courses on the basis of their MPT scores regardless of what other math achievement data were available.

Students were placed in first semester math courses as follows:

1. If the student scored <=67 on the ARITH test, s/he was placed in the lowest DM course (non-credit bearing);
2. If the student scored >67 and <77 on the ALGE text, s/he was placed in a higher DM course (non-credit bearing);
3. If the student scored >=77 on the ALGE text, s/he was placed in a credit-bearing math course.

As a result of relying predominately on the MPT score as the placement criteria, the original statistical correlation analysis planned (examining high school courses taken in

[1] The HSPA is a state standardized test designed to assess mastery of 11th grade state standards in Mathematics and Language Arts Literacy. Students take the test in the spring of grade 11 and must score 200 on each section to graduate from high school.

relationship to first-semester math placement and success) was not as meaningful as expected. Summary observations (see Table 1) indicate that, of the students who took Algebra II (AlgII)[2] in 11th grade (almost all received passing grades) but did not take a math course in 12th grade, 78% were placed in a DM course. This is in comparison to 33% of the students who took Probability&Statistics (P&S), Pre-Calculus (Pre-Calc) or Calculus (Calc) in 11th or 12th grade who were placed in DM courses.

Given the limited findings as a result of examining the relationship between high school course-taking and first semester college math course placement, other measures of high school success were examined. SAT scores have been validated as a predictor of first-year college grade point average (CollegeBoard, 2008), and can be considered one measure of high school math achievement in lieu of high school course taking. The collected data were examined using the SAT math scores as a proxy for high school math achievement. Summary observations indicate of the 54 students in the data set, 17% were not placed in first semester math courses. All of these students had SAT scores above 400[3] and three had taken and passed Pre-calculus in high school.

Of the students placed in first semester math courses, 69% were enrolled in DM courses. For those students, SAT scores and DM course placement are presented in Table 2. Approximately 70% of the students placed in developmental math courses had SAT math scores above 400, and about 50% had scores of 450 or above. Logically, one would expect that as SAT scores increase, fewer students would be placed in the lowest DM course and increasingly placed in higher courses; however, students who scored between 450 and 499 were placed in the lowest

[2] Typical sequencing of HS math courses from lowest to highest (in this study) is Alg 2, P&S, Pre-Calc, Calc.
[3] The state DOE had defined a SAT score of =>400 as one indicator of sufficient proficiency for high school graduation (12/2/14).

DM course at more than twice the rate of students scoring lower (400- 449). The reverse is true for the same SAT score ranges and placement in the higher DM course.

Regarding student success in first semester math courses, as reflected in grades earned, too few students were in each grade category for each course to draw any conclusions.

Correlation of math SAT scores with MPT & HSPA scores and first year math college course placement. Using a Pearson p measure to examine the correlation between students' SAT scores and MPT scores, HSPA scores and first year college course placement (lowest developmental to highest credit-bearing), the analyses indicated statistically significant (.01 level) correlations for each (see Table 3). In addition, the strongest correlation was between the SAT score and the math score on the high school exit exam (0.6475, $p<.0001$). The weakest correlation was between the SAT and the ALGE score (0.5005, $p=.0057$)

Summary statistics describing the relationship of the Math SAT and course placement (as determined by use of both MPT scores) provide additional information (see Table 4 and Figure 1). For the lowest DM course the range of SAT scores is the highest (220), and for the highest CB course the range of SAT scores is the lowest (80). For the highest DM course and the lowest CB course the mean, minimum, and maximum scores, as well as the range are similar.

Further analyses of the correlation of the math SAT score with the ALGE MPT score by college course placement indicate a correlation between the SAT and ALGE MPT score for the highest DM course of .6047, though not at a significant level ($p=.064$). For the lowest credit-bearing course, the correlation coefficient between the SAT and ALGE MPTscore (.05946 at a .8888 significance level) indicates no relationship. If the SAT score (cut-off of >449) had been used to place the students in these two courses (highest developmental and lowest credit-bearing), of the students who would have been placed in different courses, 18% who took the

credit-bearing course would have taken a non-credit-bearing course (these students earned passing grades the first semester), and 88% who took a non-credit-bearing course would have taken a credit-bearing course.

Discussion of the Data Analyses

The answer to the original research question, "Does mastery of specific mathematics courses and content (such as algebra) lead to first-year placement and success in credit-bearing post-secondary mathematics courses?", was not as readily answered as expected due to the University practice of using student MPT scores for first-semester math course placement rather than prior high school mathematics course taking patterns or achievement. However, the data analyses indicated students who took Algebra II in 11th grade but no math course in 12th grade were enrolled in first semester college developmental math courses at twice the rate of students who took math courses of Probability/Statistics or higher in grades 11 or 12 (most in grade 12). High school math teachers and advisors can share this information with students and parents to help them understand the importance of enrolling in higher math courses in grade 12 as a factor that may lead to first year college success and potentially college completion.

The analysis of the data collected regarding high school mathematics achievement as measured by the SAT, and student placement and success in first-semester math courses provide insight and inform further action/investigation to improve student success. The high correlation between MPT scores and SAT scores suggest the MPT scores do not provide additional helpful information for differentiation in the college course placement process. Further, the similarity of the descriptive statistics and the lack of correlation between the SAT scores and MPT scores for the highest DM course and the lowest credit-bearing course suggest the MPT does not consistently differentiate between students placed in these courses. Further, use of the SAT

rather than MPT scores could potentially result in more students enrolled in credit-bearing courses who could likely succeed.

In terms of grades earned at the end of the first semester, too few students are in each course and grade classification to draw meaningful conclusions. It is notable that almost all students passed the math courses they took first semester.

The researcher initially met with the university director of institutional effectiveness to review the complete data set and discuss the implications for the university. The researcher subsequently reviewed the findings with additional university administration and follow-up analyses and action were discussed. Finally the data and findings were shared with the district administrator and the analyses discussed for potential district action.

Discussion of the University/District Research Partnership

The primary goal of this collaborative project was to establish a trusting working relationship between a K-12 district and a university such that confidential student achievement data could be shared to examine a current problem of practice of ensuring student success when transitioning from high school to college math. This goal was accomplished through regular, ongoing communication between the organizations; developing and adhering to the data sharing agreement; and collecting, analyzing, and sharing data related to the problem of practice examined.

While the collaboration did not have the exact outcomes expected (ability to examine the relationship between student high school course math achievement and post-secondary math placement and achievement), the data examined did provide useful, actionable information for both organizations. For the University, the study data made their placement practices more transparent and stimulated discussion regarding other methods for placing and supporting student

success in college level math courses. It also contributed to ongoing discussions between faculty and administration regarding the value, utility, and design of developmental math courses. For the District, understanding university placement practices and the impact on student course-taking can aid the District in considering various interventions (such as advisement to help students understand the importance of enrolling in higher level math courses in grade 12, make university placement practices more transparent, and increase student, parent and counsel awareness of the potentially negative effect developmental math course-taking can have on college success) to assist students in successfully transitioning to college level math. The District was considering offering another high-level math course for 12th grade students who have completed Algebra II but do not want to enroll in Pre-Calculus or Probability & Statistics. This study confirmed the potential positive effect of this action.

The outcomes of this particular data collection and analyses represent an important step in developing a cross-organization conversation and collaboration to examine how to improve successful student transitions from high school to college. The results provide useful data to inform policy development and decisions in practice.

Limitations of the study

The primary limitation of this study is the small data set. It is difficult to draw conclusions and make recommendations for changes in policy and/or practice based on the small cohort examined. The second limitation is the timeframe for the study was relatively short (12 months). Examination of different cohorts over several years would have strengthened the findings. However, the limited findings suggest that additional data collection and analyses could provide meaningful information to add to these initial observations, and inform improved placement decisions to promote increase student success.

Additional questions for further consideration

The findings of this collaborative research study lead to additional questions for further investigation.

1. For the students in the study data set:
    a. What were their 1st year college second semester math course grades? What was their final pass rate in credit bearing math courses?
    b. How many of these students were enrolled in the university for their second year of college?
    c. How many of these students enrolled in credit-bearing math courses their second year at the university?
    d. Of the students who took and passed DM courses, how many enrolled in credit-bearing math courses their second year at the university?
2. Are the correlations between SAT scores, HSPA scores, and MPT scores evident in this data set, the same or similar for other cohorts of students from this district?
3. Are the correlations between SAT scores, HSPA scores, and MPT scores evident in this data set, the same or similar for students from other K-12 local feeder school districts?

The answers to these questions could result in findings that would either strengthen or refute the initial observations made with the existing analyses and potentially contribute to improved decision-making regarding student interventions, supports, and course placements to increase successful transition from high school to college math course-taking.

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Table 1

High school math course taking compared to first semester college course enrollment

High school course taking	First semester college developmental math	First semester college credit-bearing math
P&S, Pre-Calc, Calc in 11th or 12th grade	33%	50%
Alg 2 in 11th grade, no 12th grade math course enrollment	78%	*

*2 or fewer

Table 2

SAT score and developmental math course placement

SAT score	Lowest DM course placement	Highest DM course placement	Percentage of students placed in DM
<400	44%	56%	29%
400 – 449	29%	71%	23%
450 – 499	63%	37%	26%
=>500	14%	86%	23%

Table 3

Correlation between SAT math scores and other assessments and 1st yr. course

Variable	Correlation Coefficient
ARITH	0.5985 (<.0001)
ALGE	0.5005 (.0057)
HSPA	0.6475 (<.0001)
1st yr. college math course	0.5677 (.0002)

Table 4

Summary statistics by Math SAT and course placement

Course	% of N	Mean	Std. Dev.	Min.	Max	Median	Range
Lowest DM course	33%	423.3	59.29	280	500	440	220
Highest DM course	33%	482.5	54.79	410	560	490	150
Lowest CB course	22%	501.3	51.39	420	580	510	160
Higher CB course	12%	575	37.86	520	600	590	80

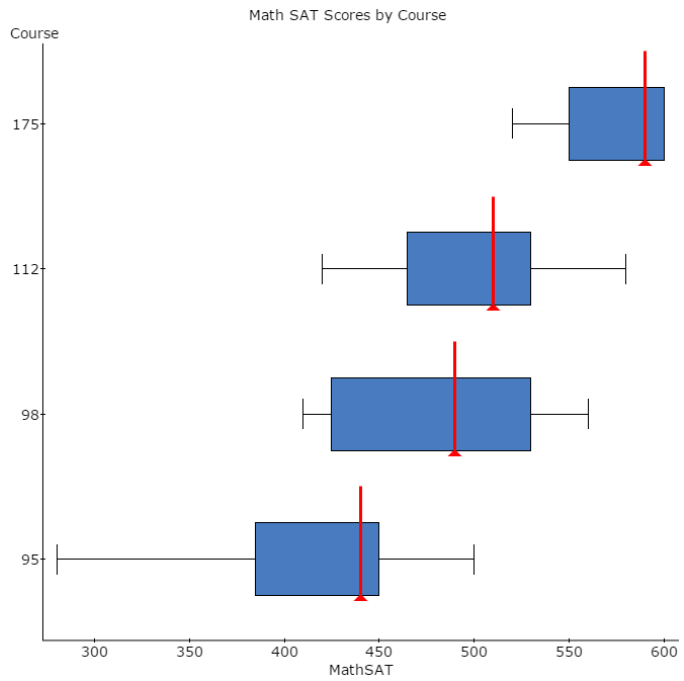

Figure 1
Summary statistics for Math SAT scores by course placement