Predicting Successful Mathematics Remediation among Latina/o Students

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Abstract

The majority of Latina/o students who require math remediation do not successfully attain college-level math skills. The present study provides an examination of Latina/o students' remedial math needs and outcomes. Data were drawn from a national sample of Latina/o students in the Beginning Postsecondary Students Longitudinal Study (BPS: 04/09) (n = 640). Hierarchical generalized linear modeling (HGLM) techniques were used to identify socio-demographic and pre-college variables, degree expectations, academic experiences and pull-factors, and institutional level characteristics that predict successful remediation outcomes. Results highlight the importance of providing academic support to students, especially those who have the highest remediation needs. Findings also have direct implications for policy and practice by providing a means for targeting developmental students who are at greatest risk of not successfully remediating.

Keywords: Latina/o students, developmental education, remediation, mathematics, STEM

Predicting Successful Mathematics Remediation among Latina/o Students

Increasing degree completion rates for Latina/o students is critical for the U.S. to meet its future workforce and societal needs (Santiago, 2011). Latina/os are projected to make up one-fourth of the total population by 2050 (Llagas & Snyder, 2003) and yet this group continues to lag behind others in terms of degree completion (Fry & Lopez, 2012; U.S. Census Bureau, 2012) in what has been referred to as "the Latina/o educational crisis" (Gándara & Contreras, 2009). Although Latina/os comprise over 16 percent of the U.S. population (Ennis, Ríos-Vargas, & Albert, 2011), this group earned only 12 percent of the total number of Associate's degrees, eight percent of the total number of Bachelor's degrees, six percent of the total number of Master's degrees, and four percent of the total number of doctoral degrees conferred during the 2008-2009 academic year (U.S. Department of Education, 2011). There is a particular need to increase the number of Latina/os earning undergraduate degrees in science, technology, engineering and mathematics (STEM) fields (Chen & Weko, 2009). Unfortunately, substantial gaps exist with regard to how institutions can effectively promote equity in degree completion, both in and outside of STEM fields, among Latina/o students (Crisp & Nora, 2012).

Overlapping economic, structural and cultural conditions prior to and during college, including but not limited to poverty, racism, and cultural dissonance in school norms, serve as barriers to degree completion for Latina/o students (Aud, Fox, & KewalRamani, 2010; Boykin, Tyler, & Miller, 2005; Caldwell & Siwatu, 2003; Foster, Lewis, & Onafowora, 2003; Ladson-Billings, 1995). Latina/o students disproportionally attend under-resourced public schools (Gándara & Contreras, 2009) that may negatively impact instruction quality (Vartanian & Gleason, 1999) and equitable access to college-level preparatory coursework, including advanced mathematics courses (Adelman, 2006). There is also evidence to suggest that Latina/o

students are more likely to be tracked into vocational or lower-level coursework when compared to White students (Meier & Stewart, 1991; National Assessment of Educational Progress, 2005). As a result, Latina/o students often begin postsecondary education with lower levels of college readiness. At the same time, Latina/o students are more likely than their White student counterparts to be first-generation college students (Saenz, Hurtado, Barrera, Wolf, & Yeung, 2007) and/or to postpone enrolling in college after high school (Santiago & Stettner, 2013), which are two factors that may negatively impact student success.

Given these conditions, it may not be unexpected that Latina/o students are overrepresented in developmental courses in college (Bettinger & Long, 2005; Sparks & Malkus, 2013). Developmental education, also referred to as remedial or basic skills education (Bailey, Jeong, & Cho, 2010; Dotzler, Jr., 2003, Ignash, 1997), includes courses and services designed to provide underprepared students with the skills they need to successfully pass college-level coursework (Bettinger & Long, 2005; Boylan & Saxon, 2000; Boylan & Bonham, 2007). Many view developmental education as an opportunity that opens doors to economic and educational advancement for traditionally underrepresented groups (Bahr, 2010), including Latina/os (e.g., Grimes & David, 1999; Penny & White, 1998). However, with the exception of findings by Crisp and Nora (2010) and Bahr (2010), there is a dearth of evidence documenting the role of developmental courses in promoting academic success for Latina/o students (Nora & Crisp, 2012).

An understanding of the role of remediation in shaping Latina/o students' postsecondary choices and outcomes is imperative (Howell, 2011). Since students enroll in remedial math courses more than any other subject area (Bahr, 2007), there is a particular need to understand the obstacles faced by students who require remediation in mathematics (Bahr, 2008b). Further,

there is evidence that successful remediation in math may be a substantial barrier to college-level courses and transfer for Latina/o community college students in particular. For instance, a recent policy brief by Solórzano, Acevedo-Gil, and Santos (2013) reported that, out of 100 Latina/o community college students in California who placed into developmental math, only 14 successfully completed a college-level transferable course within three academic years.

Regrettably, findings reveal that the majority of students requiring math remediation do not successfully attain college-level math skills (Bahr, 2008b) and that Latina/o students are even less likely than White and Asian American students to remediate successfully (Bahr, 2010). With the exception of a white paper by Nora and Crisp (2012), very little is known regarding the characteristics and outcomes of Latina/o students who remediate in mathematics. Moreover, no study to date has modeled the characteristics associated with successful math remediation among Latina/o college students.

As such, the purpose of the following study was to examine Latina/o students' developmental math needs and outcomes using national data from the Beginning Postsecondary Students Longitudinal Study (BPS: 04/09) and recent BPS Postsecondary Education Transcript Study (PETS). Our analysis addressed the following research questions:

(1) What characteristics, behaviors and experiences describe Latina/o students who enroll in developmental mathematics courses?

(2) What socio-demographic characteristics, pre-college experiences, academic goals, environmental pull-factors, college experiences, and institutional characteristics predict successful math remediation among Latina/o students?

Literature Review

The following section provides context and empirical grounding to the conceptual framework and analyses by synthesizing work to date specific to developmental characteristics and outcomes for Latina/os and/or students who enroll in developmental courses. Descriptive findings by Nora and Crisp (2012) suggest there may be substantial differences between the characteristics and outcomes of Latina/o students who do and do not enroll in developmental coursework. In particular, data revealed that Latina/o students who enrolled in developmental courses were more likely to be female, to be Mexican American, to have a lower high school grade point average (GPA), to have taken less rigorous math courses in high school, and to receive lower levels of financial aid when compared to their non-remedial counterparts. Results also indicated that the majority of Latina/o students enrolled in developmental education were enrolled in one or more mathematics courses. It is notable that among students enrolled in developmental courses, Latina/os who began college at a four-year institution were shown to be more likely to earn a college degree or persist to the end of the second or third year of college when compared to students who began their postsecondary education at a community college.

Although not specific to Latina/o students, there is a growing body of work documenting the characteristics of students who remediate in mathematics. In sum, findings indicate that developmental math students are systematically different from students who do not require remediation in terms of gender, ethnicity, and high school GPA (Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999). Calcagno, Crosta, Bailey, and Jenkins (2007) have also found that older students may be overrepresented in developmental math courses. Additionally, Bahr's (2010) analysis of students in California found that Latina/o students were more likely than White students to place into the highest level of developmental math upon entering college. Bahr

concluded that the degree of math deficiency entering college likely contributed to the overrepresentation of Latina/o students in remediation. Yet little is known regarding the characteristics, behaviors, and experiences of Latina/o students who enroll in developmental math courses. As such, additional work is needed to describe Latina/o students who enroll in post-secondary education unprepared to take college-level mathematics coursework.

Bailey (2009) notes that the large majority of studies published within the developmental literature have not controlled for systematic differences between students who do and do not enroll in developmental courses. Additionally, a critical literature review by Melguizo, Bos, and Prather (2011) highlights the absence of research on the impact of enrolling in developmental mathematics that properly controls for student characteristics and pre-college experiences. Notable exceptions include research by Bettinger and Long (2005), who found that, among a sample of community college students in Ohio, those who enrolled in remedial math courses were 15 percent more likely to transfer to a four-year institution than those with similar test scores and pre-college academic preparation who did not enroll in remedial math. Moreover, work by Bahr (2008b, 2010) indicated that long-term academic outcomes among remedial students who earn college-level math credit were comparable to non-remedial students. Findings by Bahr (2008b), however, also revealed that the majority of students requiring math remediation did not successfully attain college-level math skills.

Despite the prevalence of Latina/o students in developmental courses and inequity in outcomes, there is little evidence to understand the role of remedial education in promoting or hindering academic success outcomes among Latina/o students (Nora & Crisp, 2012). Existing evidence indicates that, among Latina/o community college students, the odds of persisting in college and/or earning a degree in the second year of college may be positively related to

enrolling in remedial courses. No relationship was found, however, between remediation and outcomes in the students' third year of college. Results suggest that Latina/o developmental students' persistence and/or degree outcomes may be positively related to parental education, not working more than 20 hours per week off campus, receiving enough financial aid to pay for college, and enrolling full-time (Crisp & Nora, 2010).

Even less empirical work has been conducted to measure or predict successful math remediation, defined as passing developmental courses, enrolling in a college-level math course after remediating in that subject, and/or successfully passing a college-level math course after remediating. Existing research by Roksa, Jenkins, Jaggars, Zeidenberg and Cho (2009) identified characteristics associated with successful completion of developmental and college-level gatekeeper math and English courses among students enrolled in the Virginia Community College System. According to their findings, women were more likely to complete courses. Students who were 25 years or older and those who enrolled in dual enrollment courses while in high school were also shown to be more likely to successfully pass developmental and college-level math courses when compared to students who did not dual enroll. Not surprisingly, results also identified a negative relationship between the level of remediation required and the probability of passing gatekeeper math courses.

No study to date has modeled the characteristics and experiences associated with successful math remediation among Latina/o students. Findings by Roksa and associates (2009) indicated that less than 20 percent of students from all ethnic/racial groups who enrolled in the lowest level of developmental math coursework subsequently enrolled in a college-level math course. A study by Bahr (2010) found that, among community college students in California, successful remediation was influenced by students' gender, high school math courses taken, age,

English competency, academic goals, several proxies of socioeconomic status, enrollment inconsistency, and the racial composition of the student body. However, the analysis was not run separately for Latina/o students, who only represented 34 percent of the study sample. It is therefore unclear to what extent the variables influencing successful math remediation may be similar or different among Latina/o students.

Method

Sample

Our analytic sample included the 640[1] Latina/o students attending 290 institutions in the Beginning Postsecondary Students Longitudinal Study (BPS: 04/09) dataset who: (a) enrolled in one or more remedial math courses, (b) had complete institutional data, and (b) were less than 24 years of age. The decision to limit the sample to traditional age students was based on limitations of the BPS data, which do not capture complete data for high school related data elements for older students. However, note that traditional age students represent 90 percent of the Latina/o students in the dataset. The subsample of traditional aged Latina/os was further shown to be representative of the national sample.

Variables/Conceptual Model

A survey item in the Postsecondary Education Transcript Study (PETS) for BPS was used to flag students who enrolled in remedial math coursework within six academic years. Developmental courses were identified using the 2010 College Course Map, which provides a taxonomy system for coding classes. Consistent with the above-mentioned research on developmental education, three measures of "successful remediation" were examined including:

[1] All raw data are rounded to the nearest 10 per IES guidelines.

(1) earning a passing grade in all developmental math courses taken, (2) enrolling in a college-level math course within six academic years, and (3) earning a passing grade in a college-level math course within six academic years. A broad range of courses was coded by NCES as college-level, including algebra, geometry, applied mathematics, statistics, Algebra for teachers, and business math (Bryan & Simone, 2012).

The conceptual model guiding the HGLM analyses was developed from studies predicting developmental math success outcomes as well as empirical work more broadly focused on Latina/o remedial success (i.e., Bahr, 2008b, Bahr, 2010; Bettinger & Long, 2005; Crisp & Nora, 2010; Roksa, Jenkins, Jaggars, Zeidenberg & Cho, 2009). As shown in Appendix A, the model posits that, among Latina/o students, successful remediation is influenced by a combination of *socio-demographic and pre-college variables*, *degree expectations*, *academic experiences and pull-factors*, and *institutional level characteristics*. As suggested by Melguizo, Bos, and Prather (2011), our model accounts for various characteristics and pre-college experiences. In particular, students' gender, age, Latina/o ethnic subgroup, first generation status, high school grade point average (GPA), highest math course taken in high school, and whether or not college-level credit was earned prior to enrolling in college are hypothesized to be in some way related to Latina/o students' odds of successfully remediating in math. It is also expected that students' degree expectations during the first year of college will be significantly related to remediation outcomes.

Several college experiences and pull-factors are assumed to increase or decrease the odds that students will successfully remediate, including the number of developmental math courses taken, working off-campus, the amount of financial aid (i.e., loans, grants) received during the first year of college, enrolling in college full-time, stopping out of college, and enrolling in one

or more developmental English courses. Although not previously examined in the developmental education literature, research specific to Latina/o students provides evidence that support from faculty and/or peers may serve to positively influence success outcomes (e.g., Arellano & Padilla, 1996; Bordes, Sand, Arredondo, Robinson-Kurpius, & Rayle, 2006; Castellanos & Jones, 2004; Crisp, 2011). As such, a composite measure of support from faculty and/or peers is hypothesized to be an academic experience related to successful remediation among Latina/o students. With the exception of work by Bahr (2010), very little empirical work has been done to identify institutional-level characteristics related to students' individual success in remedial courses. However, the research on Latina/o students (e.g., Alfonso, 2006; Cerna, Pérez, & Saenz, 2009; Crisp & Nora, 2010; Melguizo, 2009) would suggest that remedial success might be influenced by institutional level variables. The conceptual model thus posits that institutional characteristics, including level, type (public or private), enrollment size, the percent of Latina/o students attending the institution, and the percentage of the student body that received federal aid, serve to influence Latina/o students' remedial outcomes.

Analysis

Percentages were used to describe the characteristics and experiences of Latina/o students who enroll in remedial mathematics courses. Missing data (2.14 percent) were handled using multiple imputations (MI) (Enders, 2008). As a test of multicollinearity within the model, the variance inflation factor (VIF) was examined for each of the predictor variables. All variables were found to have a VIF equal to or less than 2.5 and were therefore retained for subsequent analysis. Hierarchical generalized linear modeling (HGLM) techniques were then utilized to account for the impact of student and institutional characteristics on successful remediation. Given the binary outcomes (e.g., passing versus not passing developmental math) and the nested

nature of students within postsecondary institutions in the BPS data, HGLM was the appropriate analytic technique to use (Raudenbush & Bryk, 2002). We ran an unconditional model to provide a measure of estimated remedial success rates for the sample of 290 institutions. According to Raudenbush and Bryk (2002), the dichotomous nature of the outcomes makes calculating the intra-class correlation (ICC) non-instructive. In turn, we evaluated box plots estimated from empirical Bayes residuals. We then added student-level predictors to estimate the variables that were significantly related to our three measures of successful remediation. All equations were fixed to constrain the effect of the within-institutional predictors to be the same for all institutions and variables were grand-mean centered to ease interpretation of parameter estimates and control for differences in student-level characteristics and experiences between institutions (Raudenbush & Bryk, 2002). The level 1 structural model took the form:

$$\begin{aligned}\log[\varphi_{1j}/1-\varphi_{1j})] = {} & \beta_{0j} + \beta_{1j}(\text{MALE})_{ij} + \beta_{2j}(\text{AGE})_{ij} + \beta_{3j}(\text{CUBAN})_{ij} + \beta_{4j}(\text{PUERIC})_{ij} \\ & + \beta_{5j}(\text{MIXOTH})_{ij} + \beta_{6j}(\text{CONTCOL})_{ij} + \beta_{7j}(\text{GPA1})_{ij} + \beta_{8j}(\text{GPA2})_{ij} \\ & + \beta_{9j}(\text{GPA3})_{ij} + \beta_{10j}(\text{GPA4})_{ij}, + \beta_{11j}(\text{TRIG})_{ij+} + \beta_{12j}(\text{PRECAL})_{ij}, \\ & + \beta_{13j}(\text{CALCULUS})_{ij} + \beta_{14j}(\text{COLCRED})_{ij} + \beta_{15j}(\text{BACH})_{ij} \\ & + \beta_{16j}(\text{MASTER})_{ij} + \beta_{17j}(\text{DOCTORAL})_{ij} + \beta_{18j}(\text{AMTDEMA})_{ij} \\ & + \beta_{19j}(\text{WKPART})_{ij} + \beta_{20j}(\text{NOWORK})_{ij} + \beta_{21j}(\text{FINAID1})_{ij} \\ & + \beta_{22j}(\text{FINAID2})_{ij} + \beta_{23j}(\text{FINAID3})_{ij} + \beta_{24j}(\text{FINAID4})_{ij}, \\ & + \beta_{25j}(\text{FULLTIME})_{ij}, + \beta_{26j}(\text{ACASUP})_{ij}, + \beta_{27j}(\text{NOSTOP})_{ij} \\ & + \beta_{28j}(\text{NOREMENG})_{ij} \end{aligned} \quad [1]$$

Level 2 predictors were then added to measure hypothesized contextual influences on the three measures of successful remediation. Following practice by Porchea, Allen, Robbins, and Phelps (2010), only institution-specific random intercepts were specified. The level 2 structural model was estimated as follows:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(4YEAR)_j + \gamma_{02}(PUBLIC)_j + \gamma_{03}(SIZE)_j + \gamma_{04}(PERLATINO)_j + \gamma_{05}(INSTAID)_j + u_{0j}$$

$$\beta_{1j} = \gamma_{10}$$

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$$\beta_{17j} = \gamma_{280} \quad [2]$$

The sampling model was Bernoulli:

$$\text{Prob}\,(Yjj = 1/\beta ij) = \varphi ij \quad [3]$$

Our models were estimated using a high-order Laplace approximation of maximum likelihood (ML) because approach has been shown to produce accurate approximations to ML for all parameters (Raudenbush, Yang, & Yosef, 1998). We compared unit-specific, model-based, and robust standard errors to identify possible misspecification of the distribution of random effects (Raudenbush & Bryk, 2002). Logit coefficients were then interpreted using odds-ratios (Peng, So, Stage, & St. John, 2002).

Limitations

Several data limitations should be taken into consideration when interpreting the results. First, the Beginning Postsecondary Students Longitudinal Study (BPS: 04/09) data do not account for variation in the levels of remediation, as research suggests that students may enroll in more than three levels of remediation (Bailey, Jeong, & Cho, 2010). The database also does not include information about state or institutional developmental policy, making it unclear whether students were required or chose to enroll in the developmental math courses taken. Third, little information was available regarding the classroom environment including instructional quality, pedagogical strategies, or whether courses were connected with a learning community or other form of student support programming such as supplemental instruction. Finally, although the

present study properly controls for the institutional context, it was not possible given data limitations to conduct a three level HLM to account for students nested in developmental math courses.

Results

Description of Latina/o Developmental Math Students

Among the national sample of 640 Latina/o students ages 17 to 23 who enrolled in a developmental math course in the 2003-04 academic year, 61 percent successfully passed developmental math, 54 percent successfully enrolled in a college-level mathematics course, and 46 percent successfully earned college-level math credit within six academic years. Only 37 percent of students were male and nearly half identified as being of Mexican American or Chicano decent (45%). A fifth (20%) were Puerto Rican, three percent identified as Cuban, and the remaining 32 percent of the sample identified as being of mixed or "other" Latino/a origin. The overwhelming majority of Latina/o students who enrolled in developmental math did not have a parent who had earned a college degree (77%).

Sixty two percent of the sample earned a high school grade point average of 3.0 (B) or higher. Nearly half (43%) of students completed Algebra 2 as the highest math course in high school, 39 percent took a course that covered Algebra 2 and trigonometry, and only 19 percent had completed a pre-calculus or calculus course prior to college. Roughly a fourth (22%) of students earned college credit during high school. During the first year of college, over half (57%) of the sample indicated that they expected to earn a bachelors *and* graduate degree.

Twenty six percent of the national sample received no financial aid (including grants, loans and other forms of support) and only 19 percent reported receiving more than 10,000 dollars of aid from any source during the first year of college. More than a third (35%) of the

Latina/o students who enrolled in a developmental math course worked full-time and another nearly half (45%) reported working part-time during the first year in college. Slightly less than half (49%) of students were able to enroll in college exclusively full-time and 51 percent stopped out, defined as a break in enrollment for five or more consecutive months of college, at some point during their undergraduate career. Forty four percent of students enrolled in only one developmental math course, while 23 percent enrolled in two courses and the remaining third (33%) enrolled in three courses. Only eight percent of students who enrolled in remedial math also enrolled in a developmental English course.

Two thirds (68%) of the Latina/o students enrolled in developmental math did not begin college at a four-year institution. The large majority of the sample attended a public institution (69%) while 19 percent attended a private non-profit institution and 12 percent attended a private institution classified as a for-profit. The average size of the first institution the student attended was 10,451 students. Although some Latina/o students attended an institution where only one percent of the student body identified as Latina/o and some attended institutions where 100 percent of students were Latina/o, the average was 35 percent.

Predictors of Successful Remediation

Results of the unconditional models predicting (a) passing development math, (b) enrolling in college level math, and (c) passing college-level math indicated that the odds of successful remediation varied significantly across institutions ($p < .05$). Moreover, an inspection of the plots suggested variation between institutions in the estimated chance of successful remediation, indicating the use of within and between institution models was appropriate. As such, we proceeded with the HGLM analysis (complete findings shown in Table 2).

The first HGLM model predicting Latina/o students' success of passing all developmental courses taken identified several student and institutional level variables associated with the odds of success. To begin with, students' odds of passing developmental math was shown to be positively related to receiving between 5,000 and 9,999 dollars in financial aid ($p<.01$, odds ratio = 2.75) or more than 10,000 dollars in aid ($p<.01$, odds ratio = 3.49). The percentage of Latina/o students attending the institution was also shown to increase the odds of passing developmental math ($p<.05$, odds ratio = 1.012). Conversely, passing developmental math was found to be negatively associated with being of mixed or "other" Latina/o origin ($p<.05$), the number of developmental math courses taken ($p<.001$), and two institutional-level variables (i.e., attending a four-year institution ($p<.01$) and the percentage students receiving financial aid ($p<.05$)).

The second and third regression models seeking to predict taking and passing college-level math within six academic years identified very few variables significantly related to Latina/o students' odds of remedial success in math. Specifically, the amount of academic support received ($p<.05$, odds ratio = 1.82) and enrolling at a public institution ($p<.05$, odds ratio = 2.17) were found to significantly increase students' odds of enrolling in college-level math courses after completing developmental math. Similar to passing developmental math, Latina/o students' odds of taking a college-level math course was shown to be negatively associated with the amount of developmental courses taken ($p<.01$). The amount of developmental math courses taken ($p<.05$) and not working ($p<.05$) were the only two variables found to be related to students' odds of passing a college-level math course.

Discussion

As this is the first study to model the characteristics associated with successful math remediation among Latina/o college students, present findings contribute to research in several notable ways. On the whole, results provide a better understanding of the role of various characteristics and experiences that promote success among Latina/o students who enter post-secondary education with academic deficiencies, highlighting the importance of providing specific types of support to this growing population of students. A wealth of research exists to provide evidence of the importance of providing various types of mentoring support and validating Latina/o college students (e.g., Arellano & Padilla, 1996; Bordes, Sand, Arredondo, Robinson-Kurpius, & Rayle, 2006; Castellanos & Jones, 2004; Crisp, 2011; Rendon, 1994; Swail, Redd, & Perna, 2003). However, the present study is the first to identify faculty and peer support as a positive predictor of remedial success for Latina/o students (in or outside of mathematics).

Our study is also the first to identify institutional characteristics associated with successful math remediation among Latina/o students. Prior work by Hagedorn, Chi, Cepeda and McLain (2007) would suggest that a "critical mass" of students is positively related to Latina/os student success outcomes. Further, recent work by Cuellar (2014) found that, although Latina/o students enroll at Hispanic Serving Institutions (HSIs) with lower self-perceptions of their academic abilities when compared to their Latina/o peers at non-HSIs, this difference is leveled after four-years in college. Current results, finding that the percentage of Latina/o students on campus is positively associated with students successfully passing developmental math courses, therefore add empirical support to the value of Latina/o students attending HSIs and/or institutions with a critical mass of Latina/os.

The present study further contributes to current knowledge regarding the behaviors and experiences of Latina/o students in developmental math courses. For instance, it is important to know that, among the national sample of Latina/o students, although 61 percent of students successfully passed developmental math, only 54 percent of students subsequently enrolled in a college-level mathematics course. Another seemingly important descriptive finding was that more than half (56%) of the national sample of Latina/o students enrolled in more than one developmental math course. This finding is particularly significant given that the amount of remediation was related to outcomes across all three HGLM models.

Implications for Research

On the whole, findings appear to be consistent with research specific to developmental education and/or Latina/o students. For instance, it comes as no surprise that receiving more financial aid was shown to increase students' odds of successfully completing developmental math courses (Gross, Torres, & Zerquera, 2013; Santiago & Cunningham, 2005). However, a few of the findings are less clear and will require additional research to understand. For example, it is unclear why passing developmental math was found to be negatively associated with being of mixed or "other" Latina/o origin. Unfortunately, very little research exists to understand the experiences of mixed heritage students (Murakami-Ramalho, Nuñez, & Cuero, 2010). Another seemingly contradictory finding was that not working was found to decrease Latina/o students' odds of passing college level math. It is possible that these students were advised to take too many hours (Bahr, 2008b) and/or were unemployed/underemployed and taking study time to pursue employment. Further, it is unclear why attending a four-year and/or a private institution was found to be negatively associated with passing developmental math. Perhaps the findings could be related to issues of institutional mission (i.e., community colleges and public

institutions valuing access) and selectivity (Attewell, Lavin, Domina, & Levey, 2006) and/or the "sorting" function of remediation that may track students into vocational programs (Bettinger & Long, 2004). Future research is recommended to explore the role of institutional type in supporting Latina/o students who enroll in developmental coursework.

Although present findings identified several student and institutional levels associated with successful math remediation for Latina/o students, much work remains to be done. It is notable that very few of the variables that have been previously found to be related to successful math remediation among all racial/ethnic groups (e.g., gender, age, first generation college status, high school GPA) were significant for a national sample of Latina/os in this study. Additional quantitative work is therefore recommended to be able to better predict success for this growing and arguably overlooked and undervalued group of students. Results of the present study would suggest there is a crucial need to study Latina/o students who have the highest remedial need, as it remains unclear why students who place in the lowest levels of remediation do not successfully complete college-level courses (Bahr, 2010).

We also recommend work to understand the developmental and college-level classroom experiences of Latina/o developmental students. For instance, prior work by Hagedorn, Siadat, Fogel, Nora, and Pascarella (1999) would suggest that students who do not require remediation report more positive perceptions of their instructors when compared to developmental students. However, there is little qualitative work to explain how or why Latina/o remedial students may perceive faculty or the college experience more generally, differently than their peers. Similarly, Nora and colleagues' (i.e., Nora & Garcia, 1999) work would suggest that students' negative attitudes toward remediation may contribute to negative outcomes, but additional work is needed to understand if and why this may be the case for Latina/o students in particular. Finally,

research is recommended to explore the role of broader college experiences such as discrimination, negative climate, and stereotype threat as barriers to success for Latina/o students in and outside of math, both at the developmental and credit-bearing levels.

Implications for Policy and Practice

Results of the present study have direct implications for policy and practice by providing means of targeting developmental students who are at risk of not successfully remediating. Findings are also relevant to initiatives designed to retain Latina/o students' interest and participation in STEM fields, as college-level math can serve as a "gatekeeper" to student access to STEM majors. To begin with, results highlight the importance of targeting efforts toward Latina/o students who require the most remediation, as this group of students was found across the models to be the least likely to successfully remediate. Findings support the value of considering alternative approaches to remediation (Levin & Calcagno, 2008) that show evidence of improving progress through multiple levels of developmental education, such as accelerated programs, mixed delivery methods, or self-paced instruction (see Rutschow & Schneider, 2011).

Present findings also highlight the importance of institutional, state and federal policy that provides additional financial support to Latina/o students. Notably, a third of the national sample of Latina/o students who enrolled in math remediation received no form of financial aid, including grants, loans or other forms of support. It is assumed that a lack of financial support may serve as a connected barrier to low-income and/or minority students (Leisenring, Santos, & Orfield, 2011) who enroll in developmental courses, as remedial level courses do not typically count toward a certificate or degree and result in additional educational costs and forgone earnings (Bailey & Cho, 2010; Hughes & Scott-Clayton, 2011; Levin & Calcagno, 2008). Findings also bring attention to the importance of providing Latina/o developmental students'

academic support outside of class that encourages interactions between students, faculty, and peers (Merisotis & Phipps, 2000), such as mentoring, “intrusive” advising, and/or supplemental instruction. Additionally, it is important that advisors make it clear to students that developmental courses do not count for credit and typically do not count toward their degree plan, as not all Latina/o students in the BPS dataset who successfully passed developmental math subsequently enrolled in a college-level math course (61 percent vs. 54 percent).

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Figure 1. *Conceptual Model*

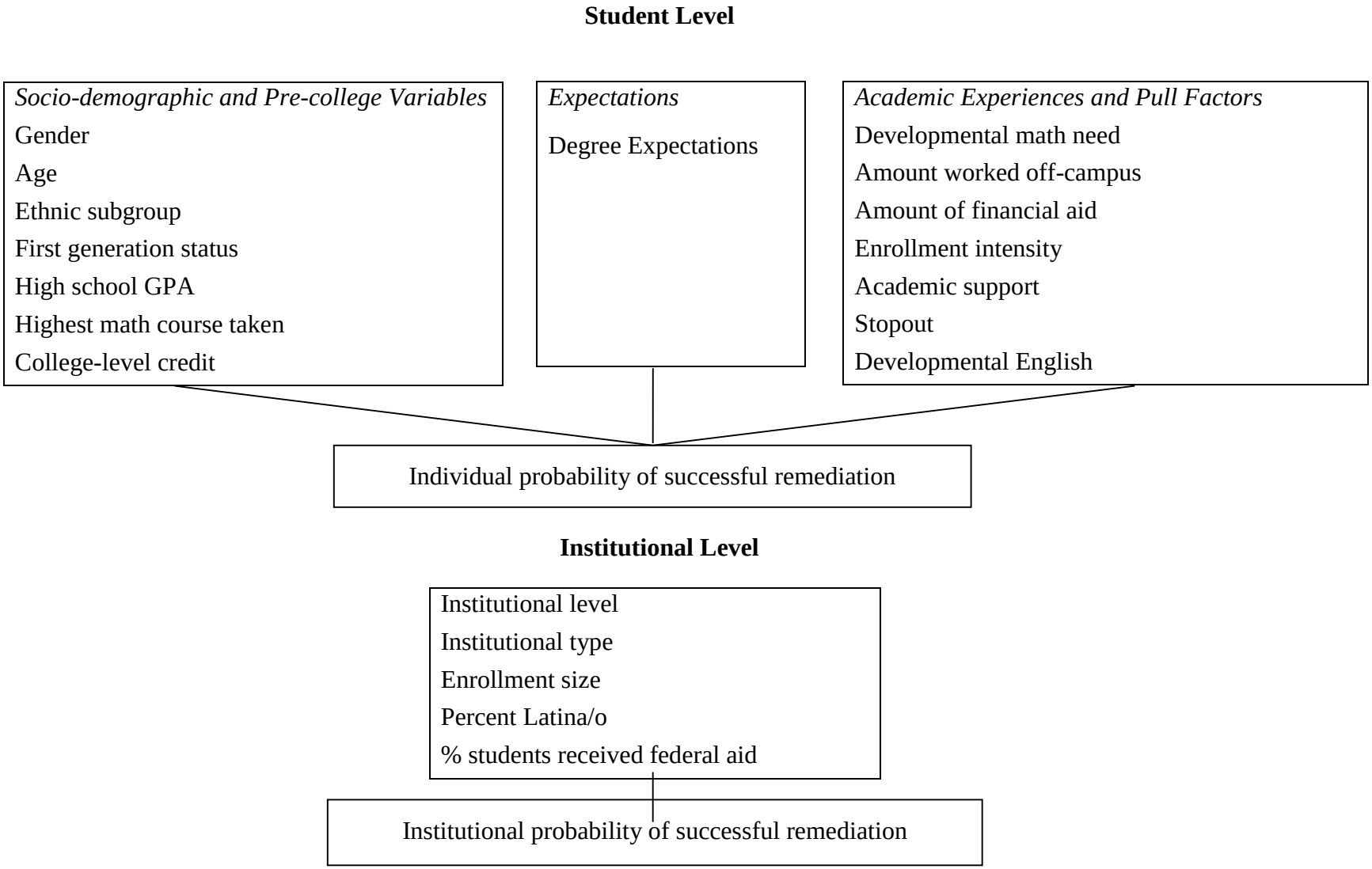

Table 1.
Descriptive Statistics

	%	*M*	*SD*	Min	Max
Socio-demographic and Precollege Variables					
Male	37.3				
Age		18.8	1.3	17.0	23.0
Ethnic Subgroup					
Mexican American or Chicano	45.2				
Cuban	2.8				
Puerto Rican	19.8				
Other or Mixed Latino origin	32.2				
Continuing generation status	23.3				
High school grade point average					
Less than 2.0	2.8				
2.0 to 2.4	15.8				
2.5 to 2.9	19.7				
3.0 to 3.4	49.2				
3.5 to 4.0	12.5				
Highest math course taken					
Algebra II or lower	42.5				
Trigonometry and Algebra	38.9				
Pre-calculus	13.8				
Calculus	4.8				
College-level credit in high school	22.3				
Highest degree expected					
Less than a bachelor's degree	10.6				
Bachelor's degree	32.0				
Master's degree	37.8				
Doctoral or professional degree	19.5				
Academic Experiences and Pull Factors					
Developmental math need					
Amount worked off-campus					
Worked full-time	35.3				
Worked part-time	45.3				
Did not work	19.4				
Amount of financial aid support					
No aid received	25.9				
Less than 2,500 dollars	15.2				
Between 2,500 and 4,999 dollars	21.3				
Between 5,000 and 9,999 dollars	19.1				
More than 10,000 dollars	18.6				
Enrolled full-time	48.8				
Academic support		0.6	0.4	0	2.0
Did not stopout	49.4				

Institutional level variables					
4-year institution	31.9				
Institutional control					
Public	68.6				
Private non-profit	18.8				
Private for-profit	12.7				
Enrollment size		10,451.8	9,473.5	75	47,952.0
Percent Latino/a students		35.4	31.2		
Percent students received aid		46.1	24.0		
Successful remediation outcomes					
Passed developmental math	61.4				
Enrolled in college-level math	54.1				
Passed college-level math	46.3				

Note: Sample includes 640 Latino/a students attending 290 institutions
Sources: BPS:04/09, PETS, and IPEDS survey data

Table 2.
Predictors of Successful Remediation among Latina/o Students

	Passed Developmental Math		Enrolled in College Mathematics		Passed College Mathematics	
	Coef. (S.E.)	Odds Ratio	Coef. (S.E.)	Odds Ratio	Coef. (S.E.)	Odds Ratio
Male	-.263(.242)	--	.089(.229)	--	-.089(.237)	--
Age	-.029(.091)	--	.013(.086)	--	-.0223(.083)	--
Ethnic Subgroup (*Mexican American*)						
Cuban	1.54(.861)	--	.034(.648)	--	.445(.681)	--
Puerto Rican	.000(.343)	--	.303(.341)	--	.151(.342)	--
Other or Mixed Latino origin	-.587(.275)*	.556	.071(.242)	--	-.169(.266)	--
Continuing generation status	-.034(.274)	--	.061(.252)	--	.069(.257)	--
High school GPA *(less than 2.0)*						
2.0 to 2.4	-.386(.558)	--	-.192(.740)	--	-.336(.691)	--
2.5 to 2.9	.376(.655)	--	-.277(.731)	--	-.332(.701)	--
3.0 to 3.4	.058(.640)	--	.195(.710)	--	.183(.661)	--
3.5 to 4.0	.883(.714)	--	.443(.739)	--	.696(.709)	--
Highest math course *(Algebra II or lower)*						
Trigonometry and Algebra	-.133(.254)	--	-.061(.251)	--	-.215(.239)	--
Pre-calculus	.356(.402)	--	.072(.364)	--	-.067(.364)	--
Calculus	-.392(.543)	--	.252(.605)	--	.338(.594)	--
College-level credit in high school	-.020(.276)	--	.009(.260)	--	.080(.267)	--
Highest degree *(less than bachelor's)*						
Bachelor's degree	.255(.371)	--	.119(.415)	--	.263(.401)	--
Master's degree	.570(.380)	--	.286(.402)	--	.517(.398)	--
Doctoral or professional degree	.102(.412)	--	.120(.472)	--	.551(.450)	--
Developmental math need	-.847(.131)***	.428	-.304(.135)*	.737	-.285(.131)*	.751
Amount worked off-campus *(full-time)*						
Worked part-time	-.027(.255)	--	-.180(.266)	--	-.150(.252)	--
Did not work	-.182(.327)	--	-.689(.351)	--	-.629(.316)*	.532

Amount of financial aid support *(no aid)*						
Less than 2,500 dollars	-.219(.385)	--	-.594(.375)	--	-.426(.378)	--
Between 2,500 and 4,999 dollars	-.002(.346)	--	.057(.376)	--	.104(.374)	--
Between 5,000 and 9,999 dollars	1.012(.386)**	2.751	-.112(.385)	--	.091(.379)	--
More than 10,000 dollars	1.251(.431)**	3.494	.445(.453)	--	.880(.433)	--
Enrolled full-time	.095(.227)	--	.300(.235)	--	.218(.243)	--
Amount of academic support	.103(.254)	--	.596(.284)*	1.816	.415(.278)	--
Did not stopout	.451(.237)	--	.232(.229)	--	.271(239)	--
Did not take developmental English	-.073(.459)	--	-.115(.427)	--	-.055(.416)	--
Institutional level variables						
4-year institution	-.794(.228)**	.452	.173(.300)	--	-.242(.292)	--
Public institution	-.668(.367)	--	.773(.378)*	2.169	.548(.374)	--
Enrollment size	.000(.000)	--	.000(.000)	--	.000(.000)	--
Percent Latino/a students	.012(.005)*	1.01	.000(.005)	--	.001(.005)	--
Percent students received aid	-.019(.008)*	.980	-.003(.008)	--	-.005(.008)	--

* p < .05, ** p < .01, *** p < .001

Note: Sample includes 640 Latina/o students attending 290 institutions

Source: BPS:04/09, PETS and IPEDS survey data

Appendix A.

Description of Variables and Measures

Variable Name	Description and Coding
Student Level Variables	
Socio-demographic and Precollege Variables	
Gender	Binary variable coded 0 as female 1 as male
Age	Continuous variable representing students' age in 2003-04 (range 17 to 23)
Ethnic subgroup	4 category dummy variable representing students' ethnic subgroup (*Mexican American or Chicano, Cuban, Puerto Rican, Other or Mixed Latino origin)
First generation status	Binary variable coded 0 when neither parent earned a college degree and 1 for continuing generation college students
High school GPA	5 category dummy variable representing a range of high school GPA (*less than 2.0, 2.0 to 2.4, 2.5 to 2.9, 3.0 to 3.4, 3.5 to 4.0)
Highest math course taken	4 category dummy variable indicating the highest mathematics course taken during high school (*Algebra II or lower, Trigonometry and Algebra, Pre-calculus, Calculus)
College-level credit	Binary variable coded 0 did not earn college level credits during high school or 1 did earn college level credits
Degree Expectations	4 category dummy variable representing students' highest degree expectation in 2003-04 (*less than a bachelor's degree, bachelor's degree, master's degree or post bachelor certificate, doctoral or professional degree)
Academic Experiences and Pull Factors	
Developmental math need	Continuous variable representing the number of developmental math courses taken (range 0 to 4.0)
Amount worked off-campus	3 category dummy variable representing the amount of time students' worked (excluding work-study) during the first year of college (*worked full-time, worked part-time, did not work)
Amount of financial aid	4 category dummy variable representing a range of financial aid received from all sources in 2003-04 (*no aid received, less than 2,500 dollars, between 2,500 and 4,999 dollars, between 5,000 and 9,999 dollars, more than 10,000 dollars)
Enrollment intensity	Binary variable coded 0 enrolled college part-time or a mix of part and full-time through 2009 and 1 enrolled exclusively full-time
Academic support	Composite score calculated from three BPS items (alpha = .925): (1) frequency a student met with faculty informally,

	(2) frequency of talking with faculty outside of class, and (3) frequency of participating in study groups. (range 0 to 2 representing the amount of support received)
Stopout	Binary variable coded 0 stopped out at any institution through 2009 or 1 did not stopout of college
Developmental English	Binary variable coded 0 enrolled in developmental English coursework in 2003-04 or 1 did not enroll in one or more developmental English courses
Institutional Level Variables	
Institutional level	Binary variable coded 0 for institutions that are less than or 2-year institutions and 1 for 4-year institutions
Institutional type	Binary variable coded 0 for private institutions and 1 for public institutions
Enrollment size	Average total enrollment at the institution (range 75 to 47,952)
Percent Latina/o	Percent student enrollment in 2003-04 classified as Latina/o (range 1 to 100)
% students received federal aid	Percent of students who received federal grant aid in 2003-04 (range 0 to 100)
Outcomes – Successful Remediation	
Passed developmental math	Did not pass all developmental math courses taken = 0, Successfully passed all courses taken = 1
Enrolled in college-level math	Did not enroll in a college-level math course within six academic years = 0, Successfully enrolled in a college-level math course within six years = 1
Passed college-level math	Did not pass a college-level math course within six academic years = 0, Successfully passed a college-level math course = 1

*Denotes reference category