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Revisiting the Efficacy of Postsecondary Remediation: The Moderating Effects of Depth/Breadth of Deficiency

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Background

Prior Research

One would do well to avoid the topic of postsecondary remediation in casual conversation. Postsecondary remediation—commonly known as developmental or basic skills education—has been for some time, and remains today, a topic of considerable controversy. At the heart of this controversy lie vital policy questions concerning educational access, equity, and social

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mobility for a sizeable segment of the population (Attewell, Lavin, Domina, & Levey, 2006; Bahr, 2008a; Davis & Palmer, n.d.; McMillan, Parke, & Lanning, 1997; Mills, 1998; Shaw, 1997).

The arguments for and against the continuation of remedial programs have been detailed extensively and repeatedly in the literature (Bahr, 2008a). Stated briefly, proponents point to the importance of providing students with opportunities to acquire the prerequisite competencies that are necessary for negotiating college-level coursework successfully (Brothen & Wambach, 2004; McCusker, 1999; Tomlinson, 1989). Moreover, supporters note that the U.S. economy and democracy depend on a populace with at least minimum reading, writing, and math skills (Kozeracki, 2002; McCabe, 2003). Conversely, critics contend that taxpayers are being "double billed" for education (Grimes & David, 1999; Saxon & Boylan, 2001) and that secondary-level coursework has no place in *post*secondary institutions (Oudenhoven, 2002).

In the midst of these ongoing and often heated debates, major changes are occurring in educational policies pertaining to postsecondary remediation (Bastedo & Gumport, 2003; Breneman & Haarlow, 1998; Jenkins & Boswell, 2002; Mazzeo, 2002; Murray, 2008). For example, Parker (2007) notes that 22 states and systems of higher education have substantially reduced remedial coursework or even eliminated it. But, the stakes involved in such dramatic changes are by no means small. Nationally, more than 41% of college students enroll in remedial coursework at some point in their postsecondary pursuits (Adelman, 2004a, p. 92). Hence, remediation is an important, yet divisive, issue in which educators, administrators, taxpayers, policymakers and, most importantly, students all have a vested interest.

At the forefront of this debate is one vital question: Does remediation work? Interestingly, the body of empirical evidence to answer this question is surprisingly limited. Although many evaluations of remediation have been published over the last several decades (Bahr, 2008a), most have been plagued with methodological problems of various sorts, leading to findings of questionable value or relevance to the question at hand (Boylan & Saxon, 1999a; Levin & Calcagno, 2008; Perin & Charron, 2006). In fact, one of the stronger critiques of the higher education literature is the dearth of methodologically sound, comprehensive, multi-institutional evaluations of remedial programs (Bahr, 2008a; Grubb, 2001; Koski & Levin, 1998; Phipps, 1998; Roueche & Roueche, 1999).

However, four recent studies sought to address this weakness in the literature (Attewell et al., 2006; Bahr, 2008a; Bettinger & Long, 2004, 2008), each drawing on large-scale statewide or national data, and each employing methodologically sophisticated analyses. The findings of these studies generally agree that postsecondary remediation is beneficial to the long-term

attainment of skill-deficient students, when compared to students who do not participate in remediation or who participate but do not complete the remedial process successfully. Collectively, these studies provide a foundation of evidentiary support for the efficacy of postsecondary remediation with respect to students' attainment.

Scope of This Study

Despite the strengths of these recent studies, a number of questions remain. One set of questions, in particular, concerns the relationship between the depth and breadth of underpreparation and the effectiveness of postsecondary remediation. Depth of underpreparation refers to the degree of deficiency in a given subject area, while breadth of underpreparation refers to the number of basic skill areas in which a student requires remedial assistance (Bahr, 2007).

A number of studies have documented the importance of depth and breadth of underpreparation in predicting the likelihood that a student will or will not remediate successfully (i.e., achieve college-level competency in a given subject matter) (Adelman, 1996; Bahr, 2007; Bailey, Jeong, & Cho, 2008; McCabe, 2000; Weissman, Silk, & Bulakowski, 1997). These relationships correspond to the well-documented "Matthew Effect" (Bahr, 2007; Kerckhoff & Glennie, 1999; Rigney, 2010; Stanovich, 1986), referring to the biblical passage, "to everyone who has, more shall be given, and he will have an abundance; but from the one who does not have, even what he does have shall be taken away" (Matt. 25:29, *New American Standard Bible*). That is, although intended to reduce disparities between advantaged and disadvantaged groups, in the end those who most need remediation are the least likely to remediate successfully.

Bridging from this observation, one of the remaining unanswered questions about the efficacy of postsecondary remediation concerns the extent to which remediating successfully in a given subject area resolves the inherent academic disadvantage faced by the poorest skilled students. The one earlier study that sought to address this issue found that, regardless of initial level of deficiency in math, students who achieve college-level math skill exhibit similar levels of attainment (Bahr, 2008a). This is an encouraging finding, but it remains to be determined if the same effect holds for English, the second most common area of skill deficiency after math (Adelman, 2004b).

In fact, there are sound reasons to anticipate that students who face severe English deficiencies (i.e., deficiencies in reading skills) may not gain the same benefit from remediating successfully in English as students who face moderate deficiencies in English (i.e., deficiencies in writing skills). As Adelman (1996) explains:

> Deficiencies in reading skills are indicators of comprehensive literacy problems, and they significantly lower the odds of a student's completing any

> degree. . . . The comprehensive literacy problems that force students to take remedial reading courses require solutions more far-reaching than even community colleges can provide. (p. A56)

Following a similar line of reasoning, Murray (2008) argues that "the need for remedial reading is perhaps the most serious barrier to degree completion" (p. 25). In other words, severe English deficiencies constitute a unique obstacle in the skill acquisition process (Adelman, 1998), and one that may hinder significantly students' attainment, possibly even among those students who remediate successfully. Consequently, a more thorough examination is needed to determine if students whose English deficiencies are the most severe benefit as much from remediating successfully as do students whose English deficiencies are mild or moderate. In other words, one might ask, to what extent does *depth* of underpreparation in English at college entry moderate the effect of successful remediation in English on academic attainment? Stated another way, is remediation in English equally efficacious at every level of English deficiency?

A second unanswered question regarding the efficacy of postsecondary remediation concerns the extent to which multiple deficiencies interact in predicting attainment. The four prior large-scale studies discussed earlier all analyzed the effect of successful remediation in particular subject areas in isolation from other core subjects. Yet it is clear that students' actual deficiencies are seldom so conveniently isolated. Instead, students who have the poorest math skills tend also to have poor English skills, and vice versa (Adelman, 1996; Murray, 2008). Although skill deficiencies in English do not bear heavily on the acquisition of math skills among remedial math students (Bahr, 2007), it nevertheless follows that efforts to evaluate fully the efficacy of remediation should account for differences between students who need remediation in a single subject and those who have multiple skill deficiencies. Thus, the question posed here is: To what extent does *breadth* of underpreparation at college entry moderate the effect of successful remediation on academic attainment? Said another way, is postsecondary remediation equally efficacious across varying numbers of subject matter deficiencies?

HYPOTHESES

To summarize, it is clear that important questions regarding the efficacy of postsecondary remediation remain to be addressed. In particular, further research is needed to address the relationship between depth and breadth of underpreparation, successful remediation, and academic attainment. Consequently, this study seeks to answer two questions:

1. To what extent does *depth* of underpreparation at college entry moderate the effect of successful remediation on academic attainment?

2. To what extent does *breadth* of underpreparation at college entry moderate the effect of successful remediation on academic attainment?

Here I focus specifically on underpreparation in English and math because these are the core subjects in which remediation most often is required (Adelman, 2004b), and I focus on community colleges because such institutions comprise the principal venue in which remediation is performed (Adelman, 2004b; Day & McCabe, 1997; Parsad, Lewis, & Greene, 2003).

Assuming for research purposes that remediation is equally efficacious across various depths and breadths of underpreparation, I propose the following four hypotheses, which correspond to the preceding two questions:

1A. At each level of initial English deficiency, students who remediate successfully in English (attain college-level English skill) experience academic outcomes (credential completion and upward transfer) that are comparable to those of students who attain college-level English skill without remedial assistance, after adjustment for attainment in math.

1B. At each level of level of initial math deficiency, students who remediate successfully in math (attain college-level math skill) experience academic outcomes that are comparable to those of students who attain college-level math skill without remedial assistance, after adjustment for attainment in English.

2A. Students who remediate successfully in both English and math experience academic outcomes that are comparable to those of students who require remediation in only English *or* math and who attain college-level skill in both English *and* math.

2B. Students who remediate successfully in both English and math experience academic outcomes that are comparable to those of students who attain college-level skill in both English and math without remedial assistance in either skill area.

Although the moderating effect of depth of underpreparation in math on academic outcomes (Hypothesis 1B) has been explored in one prior study (Bahr, 2008a), here I reexamine this relationship using an outcome variable that is somewhat more comprehensive and, consequently, more sensitive to differences in attainment than that employed in prior research.

Data, Measures, and Methods

Data

To test these hypotheses, I draw upon data collected by the Chancellor's Office of California Community Colleges. The Chancellor's Office collects data each academic term from all of the state's community colleges, thus maintaining a census of the state's community college students. These data

include transcripts, demographics, financial aid awards, degree/certificate awards, etc. In addition, the data are cross-referenced against the enrollment records of all California public four-year postsecondary institutions and the National Student Clearinghouse database to identify students who transferred to four-year institutions, including public, private, in-state, and out-of-state (Bahr, Hom & Perry, 2005). These data have been employed in several recent studies of postsecondary remediation (Bahr, 2007, 2008a, 2008b, 2009a).

Analytical Cohort

I selected for this analysis the fall 1995 cohort of first-time college freshmen who enrolled in any of California's semester-based community colleges ($N = 167{,}982$). At the beginning of the observation period, California had 107 distinct community colleges, of which 104 were semester-based. I observed students' records across all of these semester-system colleges (regardless of the first institution of attendance) for six years, through the spring term of 2001, and retained only those students who enrolled in at least one substantive English course *and* at least one substantive math course ($N = 78{,}585$). I further reduced this cohort by dropping all students whose first English course was English as a Second Language (ESL; $N = 8{,}033$), all students whose math enrollments were composed exclusively of vocational math ($N = 750$), and all students who were missing data on sex, age, or the ID variable used to track students' records across colleges ($N = 918$), resulting in an analytical cohort composed of 68,884 students. Finally, in 2003, I refreshed the data with updated information concerning students' credential awards and transfer through the spring of 2003.

As a point of clarification, I excluded ESL students from the category of remedial English because, as Kurzet (1997) explained, these students often face substantively different challenges in skill acquisition than do students who require remedial reading or writing assistance. While agreement about the exclusion of ESL courses from the category of remedial coursework is not complete (Ignash, 1997; Martinez, Snider, & Day, 2003), the distinction that I make here is widely accepted (Bettinger & Long, 2008; Boylan & Saxon, 1999b). Following a different vein of reasoning, I excluded students whose math enrollments were composed exclusively of vocational math because such students generally are not on a math track that leads to college-level skill.

Outcome Variable

A number of different outcome measures have been employed in testing the efficacy of remediation. (For a detailed discussion, see Bahr, 2008a.) One of the most persuasive measures is students' long-term attainment (Grubb, 2001), which is the focus here. In the context of the community

college, two expressions of long-term attainment are widely accepted: the award of a credential and upward transfer to a four-year institution. Three categories of credentials are available: academic associate degrees, vocational associate degrees, and certificates (Chancellor's Office, 2004). When the three credentials are combined with the possibility of transfer, six mutually exclusive attainment outcomes may be derived, based on the highest credential earned and whether transfer occurred: "no credential and no transfer," "certificate," "terminal vocational associate's degree," "terminal academic associate's degree," "upward transfer without a credential," and "upward transfer with a credential." Note, however, that it is possible for a student to complete both a vocational associate's degree and an academic associate's degree, blurring the distinction between the third and fourth categories. Consequently, I focus here on the student's first associate's degree and give preference to the academic degree when both a first vocational degree and a first academic degree were completed in the same semester.

Explanatory Variables

The primary explanatory variables of interest in this study are students' initial level of competency and ultimate level of attainment in math and English. The most robust operationalization of initial competency in math and English employs scores on placement exams administered when the student first enrolls in college (Bahr, 2008a). Unfortunately, matriculation processes at the 104 colleges included here are quite varied, and the only consistent means of classifying students' initial level of competency is the skill level of a given student's first math and English course enrollments, respectively. Likewise, attainment in math and English is categorized in accordance with the skill-level of a given student's highest successfully completed course in math and English, respectively.

To categorize math courses, I used course catalogs to determine the skill-level of each math course in which any member of the cohort enrolled at any time during the observation period and collapsed them into five categories ranging from lowest to highest: arithmetic, pre-algebra, beginning algebra, intermediate algebra/geometry, and college-level. The category of "college-level math" encompasses all courses of a skill equal to, or greater than, college algebra. I ignored nonsubstantive math courses (e.g., math "labs") and vocational math, except when a given vocational course was part of the remedial sequence or otherwise was categorized as college-level.

I categorized English courses similarly, collapsing them into three categories: remedial reading (the lowest level), remedial writing, and college-level English. As noted earlier, I excluded students whose first English course was ESL.

Concerning students' ultimate attainment in math and English, the only measure of interest is college-level competency, which I define as a passing grade (A, B, C, or "credit") in a college-level course in that subject.

Multiplicative Interactions

A test of the hypotheses proposed in this study requires a set of interaction terms composed of various combinations of English skill at college entry, math skill at college entry, and whether a student attained college-level English and math skill, respectively. Hypotheses 1A and 1B predict that, regardless of the initial level of skill deficiency, students who remediate successfully in a given subject matter experience academic outcomes that are, on average, comparable to those of students who attain college-level skill without remediation. Testing these hypotheses requires two sets of two-way interactions: six interaction terms for English skill at college entry and whether the student attained college-level English competency, and a separate set of 10 interaction terms for math skill at college entry and whether the student attained college-level math competency.

Hypotheses 2A and 2B predict that students who have skill deficiencies in both English and math, but who remediate successfully in both subjects, experience academic outcomes that are comparable to those of students who have only a single deficiency that is successfully remediated, and, likewise, comparable to those of students who attain college-level skill without remediation. A test of these two hypotheses requires a four-way interaction of English skill at college entry, math skill at college entry, attainment of college-level English competency, and attainment of college-level math competency. Because a four-way interaction generates an inordinate number of variables, I collapsed English skill at college entry and math skill at college entry each into two categories: remedial versus college-level.

Control Variables

I include a number of student- and college-level statistical controls in this analysis. At the level of the student, I control for sex, age, race/ethnicity, three proxies of socioeconomic status (SES), academic goal, grade in first English course, grade in first math course, and four measures of enrollment patterns. Sex is treated as a dichotomous variable. Age (years) is treated as continuous. The three proxies of SES include a dummy variable that indicates receipt of a fee waiver during the first year of attendance, a dummy variable that indicates receipt of any grants during the first year, and a continuous variable that indicates the total value of any grants received during the first year (Calcagno, Crosta, Bailey, & Jenkins, 2007; Koski & Levin, 1998). Race/ethnicity, first English grade, and first math grade each include nine nominal attributes, and each is treated as a set of dummy variables. Academic goal is a self-reported measure of a student's primary objective, collected at the time of application, which I collapsed into 10 nominal categories, and which I treat as a set of dummy variables.

Finally, the set of variables that measure aspects of enrollment patterns includes persistence, enrollment inconsistency, delay of first English

enrollment, and delay of first math enrollment, all of which are treated as continuous. Persistence is operationalized as the number of terms (including summer terms, but excluding winter intersessions) in which a student enrolled in courses from fall 1995 through spring 2001. Enrollment inconsistency is operationalized as the percentage of terms in which a student did not enroll in courses from fall 1995 through the last term that the student was observed in the system. Delay of first English enrollment is operationalized as the number of semesters in which a given student enrolled in the community college system prior to the semester of his or her first English enrollment, plus one. In other words, it is the semester of first English enrollment, adjusted for any semesters in which the student did not enroll in the community college system. Delay of first math enrollment is operationalized in the same manner.

In addition, I include two college-level controls: the concentration of remedial English students and the concentration of remedial math students. These two variables are operationalized as the percentage of the fall 1995 first-time freshmen cohort at a given college whose first course in English or math, respectively, was remedial in nature. The latter of the two is squared to approximate normality.

Method of Analysis

I use two-level hierarchical multinomial logistic regression (Raudenbush & Bryk, 2002) to model natural variation in the probability of each of the six categories of attainment detailed earlier. I estimate two separate models, corresponding to the two research questions detailed previously, and each is specified as follows:

$$\ln\left(\frac{P(y_{ij}=m)}{P(y_{ij}=1)}\right)=\beta_{0j}+\beta_{kj}\left(Student\ Level\ Variables\right)_{ij}$$
$$\beta_{0j}=C_{00}+C_{0q}\left(College\ Level\ Variables\right)_{j}+\varepsilon_{0j}$$
$$\beta_{kj}=C_{k0}$$

Students are assigned to the college in which they were observed to be enrolled in the fall term of 1995, or, in the case of multiple institutions, to the college in which a given student enrolled in the greatest number of courses in that term. Although movement between colleges is not uncommon among community college students (Bahr, 2009b), the statistical model employed here cannot capture these changes. An alternative specification that employs a cross-classified data structure would allow the college in which a given student is enrolled to vary but would treat a student enrolled in multiple colleges as different students (Raudenbush & Bryk, 2002).

Strengths and Weaknesses of the Data

The data that I have assembled for this study have a number of strengths and weaknesses, which are detailed elsewhere (Bahr, 2008a) and summarized

here. Among the strengths are access to a population rather than a sample, the noteworthy size of the population, the length of time over which students are observed, the capacity to distinguish between temporary breaks in enrollment and long-term exit from the postsecondary system, and the capacity to observe course enrollments and outcomes despite student movement across the community college system.

Five weaknesses of the data must also be noted. First, the definitions of "skill-deficient student" and "college-ready student" employed in this study assume perfect placement of students into particular skill-levels of coursework. This assumption is unavoidable in this case because the data do not contain high school transcripts and because matriculation processes vary across the colleges.

Second, in terms of successfully completing a college-level math and/or a college-level English course, the data do not account for academic progress accomplished outside California's semester-based community colleges. That is, students who begin the remedial sequence and then transfer out of the California community college system effectively are treated as unsuccessful with respect to attaining college-level skill since these data do not provide information about students' academic progress at other institutions.

Third, excessive procrastination with respect to starting the remedial English or math sequence may place a student's successful attainment of college-level skill outside the six-year window of observation. However, it seems unlikely that many students are affected by this limitation because the vast majority enrolled in their first English or math courses within the first four years of enrollment (97.8% of remedial English students and 96.6% of remedial math students). Thus, the majority of students who are included in this analysis, including those who faced severe math or English deficiencies, were observed for a period of time that was more than sufficient for college-level skill to be attained.

Fourth, the data do not address four control variables that prior studies have found to be important predictors of educational outcomes. These include credit course load (Hoyt, 1999; O'Toole, Stratton, & Wetzel, 2003; Stratton, O'Toole, & Wetzel, 2007; Szafran, 2001), employment intensity (American Council on Education, 2003; Carter, 1999; Hoyt, 1999; Titus, 2004; Toutkoushian & Smart, 2001), parenting status (e.g., Adelman, 1999; DesJardins, McCall, Ahlburg, & Moye, 2002), and first-generation status (Ishitani, 2003).

Finally, some limitations regarding the generalizability of the results should be mentioned. Although these data address a population rather than a sample, which is advantageous for a number of reasons, the population addressed here was drawn exclusively from California's community colleges and consists of first-time college freshmen only. Consequently, inferences

about other segments of the community college student population (e.g., returning students) and inferences to other state community college systems should be made cautiously and with due consideration for the constraints of these data.

Analysis

Correspondence between Skill Deficiencies

As a preliminary step in this analysis, I present in Figure 1 the distribution of English skill at college entry as a function of math skill at college entry. Figure 1 illustrates two important points. First, skill deficiencies in English and math go hand in hand. Two-thirds (69%) of students who evidenced no deficiencies in math also evidenced no deficiencies in English, but only one-eighth (12%) of the students who evidenced the poorest math skills (arithmetic) evidenced no deficiencies in English. In fact, reading across the chart, there is a nearly linear relationship between declining math skills and the shrinking likelihood of *not* requiring some type of remedial English assistance.

The second important point to draw from Figure 1 is that the severity of skill deficiencies in English and math are correlated. For example, while fewer than one in 25 (3%) of the students who enrolled initially in the highest-level remedial math courses (intermediate algebra or geometry) required remedial reading assistance, one in six (16%) of arithmetic students did so. In other words, the more severe a student's math skill deficiency at college entry, the more likely the student will be to have an English deficiency *and* the more likely it is that the deficiency will be severe. These two observations highlight the importance of accounting for the depth and breadth of skill deficiencies in testing the efficacy of remediation.

In Figure 2, I present the unadjusted distribution of college-level skill attainment in math and English as a function of the number of skill deficiencies at college entry. Figure 2 demonstrates one implication of breadth of skill deficiency, namely, that the number of initial skill deficiencies is correlated negatively with attaining college-level skill. For example, nearly four-fifths of students who entered college with no skill deficiencies ultimately attained college-level skills in both math and English. In contrast, less than one-fifth of students who entered college with two skill deficiencies (both math and English) attained college-level skills in both math and English.

Depth of Skill Deficiency

In Table 1, I present the net effects of the interaction of English skill at college entry and attainment of college-level English skill, and the net effects of the interaction of math skill at college entry and attainment of college-level

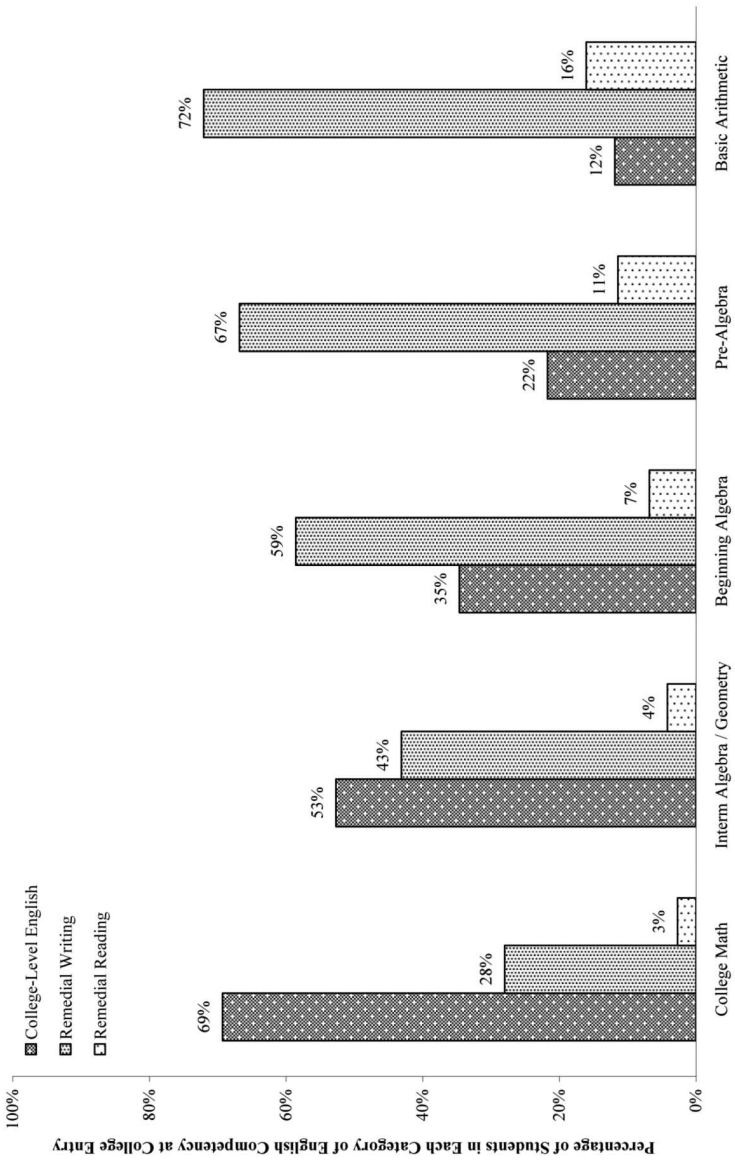

Figure 1. Unadjusted distribution of initial competency in English, by initial competency in math ($N_{students}$ = 68,884; $N_{colleges}$ = 104)

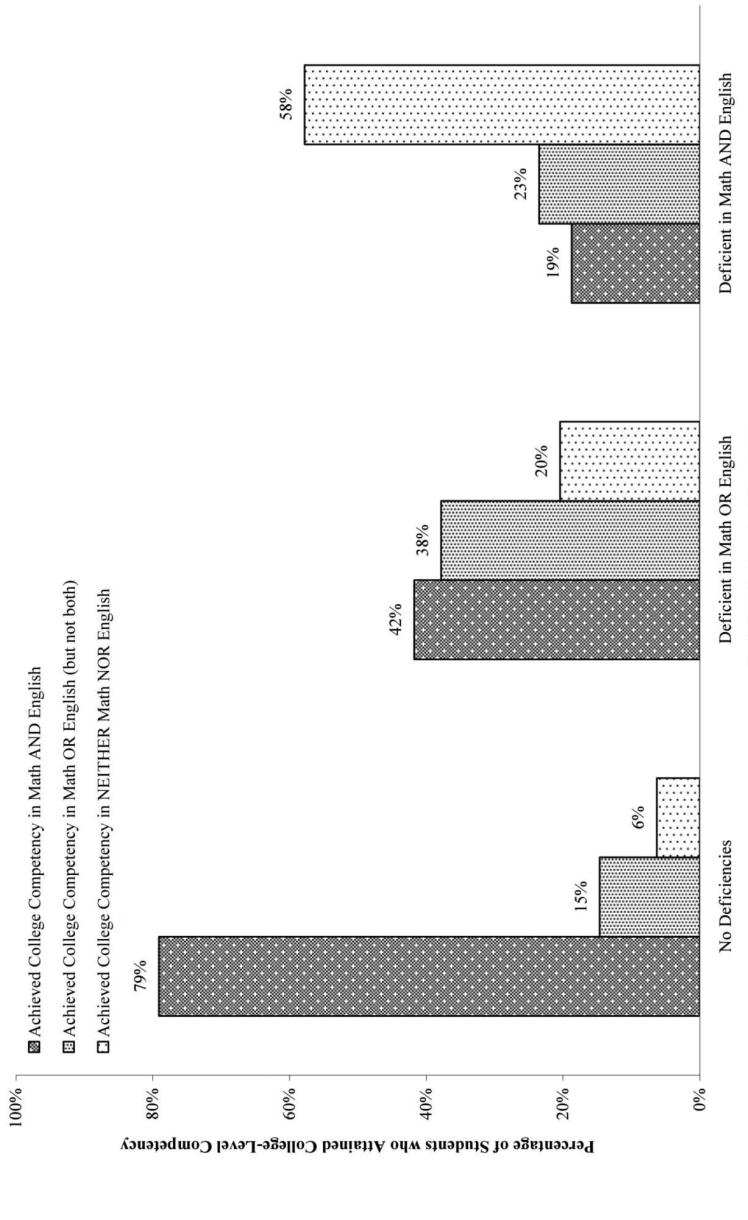

Figure 2. Unadjusted distribution of attainment in math and English, by initial deficiency ($N_{students}$ = 68,884; $N_{colleges}$ = 104)

math skill, as estimated simultaneously via two-level hierarchical multinomial logistic regression. Hypotheses 1A and 1B predict that, regardless of the initial level of deficiency in a given subject (English or math, respectively), students who attain college-level competency in that subject experience the various academic outcomes at comparable rates, net of controls. Thus, the results of primary interest in testing Hypotheses 1A and 1B are those associated with the groups who attained college-level competency in English and, separately, in math (shaded).

The findings presented in Table 1 provide moderately strong support for Hypothesis 1A. Remedial English students who attain college-level English competency exhibit relative odds of terminal credentials (i.e., associate degrees and certificates) and odds of transfer with a credential that are comparable to students who achieve college-level English skill without remediation. However, they generally exhibit slightly lower odds of upward transfer without a credential (versus neither completing a credential nor transferring) than their college-prepared counterparts. These differences are quite small, though, particularly when compared with the sizeable differences observed between students who achieve college-level English competency and those who do not.

Nevertheless, to examine further the differences in the likelihood of upward transfer without a credential, I present in Table 2 the predicted probability of each outcome as a function of English skill at college entry and conditional on the attainment of college-level English and math competency. Although statistically significant in Table 1, a review of the absolute differences in Table 2 indicates that only those students who face the severest deficiencies in English (remedial reading) exhibit what might be considered a noteworthy disadvantage in terms of transfer without a credential.

The results presented in Table 1 provide strong support for Hypothesis 1B. With very few exceptions, students who attain college-level math skill, despite an initial deficiency in math, experience academic outcomes that are comparable, or even slightly superior, to those of students who attain college-level math skill without remedial assistance. Only one systematic exception to this generalization is observed. At all levels of initial math skill deficiency, remedial math students who attain college-level math competency exhibit significantly lower odds of completing a terminal vocational associate's degree (versus neither completing a credential nor transferring) than do students who attain college-level math skill without remediation.

Again, as with English skill at college entry, I calculated the predicted probability of each outcome as a function of math skill at college entry and conditional on the attainment of college-level math and English competency (Table 3). The findings presented in Table 3 demonstrate that the absolute differences in the likelihood of completing a vocational degree without

TABLE 1

NET EFFECTS OF TWO TWO-WAY INTERACTIONS OF INITIAL SKILL DEFICIENCY AND SUCCESSFUL REMEDIATION, ESTIMATED VIA TWO-LEVEL HIERARCHICAL MULTINOMIAL LOGISTIC REGRESSION

($N_{students}$ = 68,884; $N_{colleges}$ = 104; Control Variables Not Shown; Comparison Category = No Credential And No Transfer)

		Academic Outcome				
Skill Attained	*Skill at College Entry*	*Certificate Only*	*Vocational Associate's Degree*	*Academic Associate's Degree*	*Transfer without Credential*	*Transfer with Credential*
Attained college English skill	College-level English	----------	----------	----------	----------	----------
		----------	----------	----------	----------	----------
	Remedial writing	0.068	0.016	0.137**	-0.085*	-0.024
		(0.100)	(0.072)	(0.051)	(0.035)	(0.039)
	Remedial reading	0.076	0.061	0.044	-0.263**	-0.132
		(0.205)	(0.142)	(0.108)	(0.085)	(0.088)
Did not attain college English skill	College-level English	0.433**	-1.077***	-1.505***	-1.096***	-2.227***
		(0.145)	(0.238)	(0.168)	(0.061)	(0.146)
	Remedial writing	0.498***	-0.454***	-1.329***	-1.335***	-2.912***
		(0.095)	(0.086)	(0.078)	(0.044)	(0.104)
	Remedial reading	0.452***	-0.982***	-1.540***	-1.510***	-3.513***
		(0.137)	(0.178)	(0.164)	(0.089)	(0.310)

Table 1, cont.

Skill Attained	*Skill at College Entry*	*Academic Outcome*				
		Certificate Only	*Vocational Associate's Degree*	*Academic Associate's Degree*	*Transfer without Credential*	*Transfer with Credential*
Attained college math skill	College-level math	----------	----------	----------	----------	----------
		----------	----------	----------	----------	----------
	Interm algebra/geometry	-0.041	-0.288*	-0.081	-0.058	0.110*
		(0.222)	(0.130)	(0.079)	(0.048)	(0.050)
	Beginning algebra	-0.310	-0.297*	0.025	0.150**	0.356***
		(0.238)	(0.128)	(0.081)	(0.054)	(0.055)
	Pre-algebra	-0.242	-0.695**	-0.170	0.261*	0.407***
		(0.396)	(0.225)	(0.142)	(0.104)	(0.102)
	Basic arithmetic	-0.588	-0.737***	-0.358*	-0.099	0.128
		(0.422)	(0.225)	(0.156)	(0.121)	(0.116)
Did not attain college math skill	College-level math	-0.143	-0.378	-0.938***	-1.481***	-2.717***
		(0.240)	(0.215)	(0.142)	(0.063)	(0.129)
	Interm algebra/geometry	0.180	-0.192	-0.903***	-1.906***	-2.791***
		(0.175)	(0.120)	(0.086)	(0.049)	(0.081)
	Beginning algebra	0.252	-0.273**	-0.998***	-2.154***	-2.870***
		(0.157)	(0.100)	(0.069)	(0.043)	(0.061)
	Pre-algebra	0.138	-1.032***	-1.482***	-2.512***	-3.304***
		(0.168)	(0.122)	(0.088)	(0.060)	(0.091)
	Basic arithmetic	0.243	-1.287***	-1.581***	-2.685***	-3.325***
		(0.166)	(0.124)	(0.093)	(0.066)	(0.096)

*p 0.05; **p 0.01; ***p 0.001; standard errors in parentheses

TABLE 2

PREDICTED PROBABILITIES OF VARIOUS ACADEMIC OUTCOMES FOR A STUDENT WHO ATTAINED COLLEGE-LEVEL ENGLISH AND COLLEGE-LEVEL MATH COMPETENCY, BY INITIAL LEVEL OF ENGLISH DEFICIENCY

(Based on the coefficients presented in Table 1)

	Academic Outcome						
Skill at College Entry	*No Credential and No Transfer*	*Certificate Only*	*Vocational Associate's Degree*	*Academic Associate's Degree*	*Transfer without Credential*	*Transfer with Credential*	**TOTAL**
College-level English	0.177	0.004	0.007	0.043	0.372	0.398	1.000
Remedial writing	0.183	0.004	0.008	0.051	0.353	0.402	1.000
Remedial reading	0.204	0.005	0.009	0.051	0.329	0.402	1.000

Notes: These predicted probabilities were obtained by setting all of the statistical control variables to their respective means (for continuous variables) or modes (for categorical variables) except initial math deficiency (which was set to "college-level"), and then by systematically adjusting the measure of initial English deficiency.

TABLE 3

PREDICTED PROBABILITIES OF VARIOUS ACADEMIC OUTCOMES FOR A STUDENT WHO ATTAINED COLLEGE-LEVEL ENGLISH AND COLLEGE-LEVEL MATH COMPETENCY, BY INITIAL LEVEL OF MATH DEFICIENCY

(Based on the coefficients presented in Table 1)

	Academic Outcome						
Skill at College Entry	*No Credential and No Transfer*	*Certificate Only*	*Vocational Associate's Degree*	*Academic Associate's Degree*	*Transfer without Credential*	*Transfer with Credential*	**TOTAL**
College-level math	0.177	0.004	0.007	0.043	0.372	0.398	1.000
Interm algebra/geometry	0.173	0.003	0.005	0.039	0.344	0.436	1.000
Beginning algebra	0.144	0.002	0.004	0.036	0.351	0.462	1.000
Pre-algebra	0.136	0.002	0.003	0.028	0.371	0.460	1.000
Basic arithmetic	0.177	0.002	0.003	0.030	0.336	0.452	1.000

Notes: These predicted probabilities were obtained by setting all of the statistical control variables to their respective means (for continuous variables) or modes (for categorical variables), and then by systematically adjusting the measure of initial math deficiency.

subsequent transfer are quite small. Thus, the finding that mathematics remediation is essentially equally efficacious across levels of initial deficiency is effectively sustained.

Breadth of Skill Deficiency

In Table 4, I present the net effects of the four-way interaction of math skill at college entry, English skill at college entry, attainment of college-level math skill, and attainment of college-level English skill. Hypotheses 2A and 2B predicted that students who attain college-level competency in math and English experience similar academic outcomes regardless of the number of subject areas in which remediation is necessary (i.e., math, English, or math *and* English). The results of primary interest for Hypotheses 2A and 2B are those associated with the groups who attained college-level competency in both math and English (shaded). Note, however, that the number of independent variables involved in executing this four-way interaction ultimately required the collapse of two categories of the dependent variable (vocational associate's degree and academic associate's degree) into a single category (associate's degree) to avoid an analytical problem with small cell sizes.

The findings presented in Table 4 provide unequivocal support for these hypotheses. Students who exhibit only a single deficiency (in math or English) at college entry and attain college-level competency in math and English, and students who exhibit dual deficiencies (in math and English) at college entry and remediate both deficiencies, experience rates of credential completion and upward transfer that are comparable, or slightly superior, to those of students who attain college-level competency in math and English skill without remediation. The few statistically significant differences between these groups all are small in magnitude and favor the students who faced initial skill deficiencies. Commensurate with this finding, the absolute differences in the predicted probability of each outcome either are negligible or indicate an advantage for skill-deficient students (Table 5).

Discussion

In this study, I extended ongoing research on the efficacy of postsecondary remediation in community colleges (e.g., Attewell et al., 2006; Bahr, 2008a; Bettinger & Long, 2004, 2008). In particular, I focused on two questions. First, do students who face severe skill deficiencies in a given subject gain the same benefit from remediating successfully as students who face moderate skill deficiencies, and, collectively, do these students fare as well as students who attain college-level English and math competency without remedial assistance? Second, do students who have multiple skill deficiencies benefit as much from successful remediation as students who face only a single deficiency, and, together, do these students gain the same benefit as

TABLE 4

NET EFFECTS OF THE FOUR-WAY INTERACTION OF INITIAL SKILL DEFICIENCYAND SUCCESSFUL REMEDIATION, ESTIMATED VIA TWO-LEVEL HIERARCHICAL MULTINOMIAL LOGISTIC REGRESSION

($N_{students}$ = 68,884; $N_{colleges}$ = 104; control variables not shown; comparison category = no credential and no transfer)

			Academic Outcome			
Skill Attained	*Math Skill at College Entry*	*English Skill at College Entry*	*Certificate Only*	*Associate's Degree*	*Transfer without Credential*	*Transfer with Credential*
College math and college English	College math	College English	----------	----------	----------	----------
	College math	Remedial English	0.167	0.102	0.002	0.037
			(0.384)	(0.111)	(0.076)	(0.080)
	Remedial math	College English	-0.023	-0.030	0.114*	0.287***
			(0.305)	(0.081)	(0.055)	(0.057)
	Remedial math	Remedial English	-0.159	-0.105	-0.035	0.191**
			(0.292)	(0.080)	(0.057)	(0.059)
College math but not college English	College math	College English	0.514	-1.409***	-1.640***	-2.843***
			(0.514)	(0.324)	(0.128)	(0.275)
	College math	Remedial English	0.616	-1.372***	-1.921***	-3.644***
			(0.359)	(0.198)	(0.107)	(0.269)
	Remedial math	College English	0.313	-1.839***	-1.999***	-1.923***
			(0.574)	(0.410)	(0.214)	(0.249)
	Remedial math	Remedial English	0.262	-1.424***	-2.399***	-3.076***
			(0.325)	(0.145)	(0.124)	(0.169)

Skill Attained	Math Skill at College Entry	English Skill at College Entry	Academic Outcome: Certificate Only	Associate's Degree	Transfer without Credential	Transfer with Credential
College English but not college math	College math	College English	-0.056	-1.080***	-1.669***	-2.872***
			(0.410)	(0.172)	(0.087)	(0.160)
	College math	Remedial English	0.710	-0.712**	-1.779***	-3.021***
			(0.421)	(0.219)	(0.150)	(0.271)
	Remedial math	College English	0.298	-0.993***	-2.297***	-3.072***
			(0.243)	(0.073)	(0.052)	(0.068)
	Remedial math	Remedial English	0.365	-0.957***	-2.533***	-3.093***
			(0.239)	(0.072)	(0.055)	(0.066)
Neither college math nor college English	College math	College English	0.162	-2.606***	-2.378***	-4.307***
			(0.514)	(0.589)	(0.125)	(0.455)
	College math	Remedial English	-0.013	-1.432***	-2.687***	-4.739***
			(0.453)	(0.254)	(0.123)	(0.454)
	Remedial math	College English	0.726**	-2.297***	-3.060***	-5.241***
			(0.266)	(0.174)	(0.079)	(0.266)
	Remedial math	Remedial English	0.774***	-2.094***	-3.515***	-5.943***
			(0.236)	(0.080)	(0.056)	(0.139)

Notes: *p≤0.05; **p≤0.01; ***p≤0.001; standard errors provided in parentheses

TABLE 5

PREDICTED PROBABILITIES OF VARIOUS ACADEMIC OUTCOMES FOR A STUDENT WHO ATTAINED COLLEGE-LEVEL ENGLISH AND MATH COMPETENCY, BY INITIAL COMPETENCY IN MATH AND ENGLISH

(Based on the coefficients presented in Table 4)

		Academic Outcome					
Math Skill at College Entry	*English Skill at College Entry*	*No Credential and No Transfer*	*Certificate Only*	*Associate's Degree*	*Transfer without Credential*	*Transfer with Credential*	***TOTAL***
College math	College English	0.167	0.003	0.065	0.370	0.395	1.000
College math	Remedial English	0.164	0.004	0.070	0.362	0.400	1.000
Remedial math	College English	0.142	0.003	0.054	0.353	0.448	1.000
Remedial math	Remedial English	0.157	0.003	0.055	0.336	0.449	1.000

Note: These predicted probabilities were obtained by setting all of the statistical control variables to their respective means (for continuous variables) or modes (for categorical variables), and then by systematically adjusting the measures of initial math and English competency.

students who attain college-level competency in English and math without remediation? This study is distinct from prior work in that, in testing the efficacy of remediation, it distinguishes both between varying degrees of deficiency and between varying combinations of deficiencies.

To answer these questions, I tested the moderating effects of the depth and breadth of initial skill deficiencies on the effects of successful remediation in English and math on a six-category measure of credential completion and upward transfer. I employed data that address a population of first-time college freshmen who attended any of California's 104 semester-based community colleges and who enrolled in at least one substantive, nonvocational math course and at least one substantive, non-ESL English course. My analysis included as statistical controls a wide array of potentially confounding variables, including sex, age, race/ethnicity, three proxies of SES, academic goal, performance in first math and English, four measures of enrollment patterns, and the college-level concentrations of remedial English and remedial math students.

My findings indicate that, with just two systematic exceptions, skill-deficient students who attain college-level English and math skill experience the various academic outcomes at rates that are very similar to those of college-prepared students who attain college-level competency in English and math. Thus, the results of this study demonstrate that postsecondary remediation is highly efficacious with respect to ameliorating both moderate and severe skill deficiencies, and both single and dual skill deficiencies, for those skill-deficient students who proceed successfully through the remedial sequence. These findings agree with a prior study (Bahr, 2008a) that used a similar cohort drawn from these same data, but which focused exclusively on math, ignoring both remediation in English and the potential moderating interaction between skill deficiencies in English and math.

These findings are important for several reasons. As discussed earlier, postsecondary remediation is a highly contentious issue (Kozeracki, 2002; Mazzeo, 2002; Oudenhoven, 2002), but solid evidence regarding the efficacy of remediation has been, until recently, notably lacking (Bahr, 2008a; Grubb, 2001; Koski & Levin, 1998; Perin & Charron, 2006; Phipps, 1998; Roueche & Roueche, 1999). Given that the fate of remedial programs may hang in the balance of the ongoing debates concerning the place of such programs in postsecondary education, it is imperative that their effectiveness be tested empirically.

Moreover, although a disproportionate number of the students who enter college with severe and/or multiple deficiencies do not remediate successfully—the Matthew Effect in action (Bahr, 2007), this study demonstrates that those who *do* remediate successfully go on to acquire two-year credentials and to transfer to four-year institutions at rates that are comparable

to those of college-prepared students who attain similar math and English competency. In other words, even students who are sorely underprepared for college coursework, even in multiple skills areas, may succeed and achieve well beyond what one would predict based on their initial course placements. This finding speaks strongly to the importance of remedial programs for preserving the accessibility of postsecondary education, maintaining equity of opportunity, and upholding the promise of social mobility in the United States (Bahr, forthcoming; Davis & Palmer, n.d.).

The two systematic exceptions, however, merit further discussion. The finding that successful remedial reading students are slightly less likely than their college-prepared counterparts to transfer without a credential is consistent with some prior work that identifies reading deficiencies as uniquely disadvantageous (e.g., Adelman, 1998; Murray, 2008). Although not tested here, one might surmise that severe English deficiencies lead to poorer outcomes in other coursework in which performance depends upon students' absorption and assimilation of textual material (Goldstein & Perin, 2008). Although the reading deficiency itself may be overcome, difficulty in early coursework may depress students' grade point averages and, in the end, hurt their chances of transferring. However, it is encouraging to find that the probability of transferring with a credential is quite similar across levels of initial English competency. Accordingly, it may be that students who complete a credential also complete enough credits to dilute any poor performance evident early in their academic records.

The second exception is the finding that successful remedial math students are slightly less likely than their college-prepared counterparts to complete a terminal vocational associate's degree. This result has not been observed in prior research, presumably because prior studies have not distinguished between vocational and academic associate degrees (e.g., Bahr, 2008a). Although the absolute differences in vocational degree attainment across initial levels of math skill deficiency are extremely small, the consistency of this relationship (evident at all four levels of math deficiency) is intriguing. Interestingly, however, the same observation does not hold for terminal academic associate degrees, which seems counterintuitive on its face and suggests something unique about the relationship between successful remediation in math and the terminal vocational degree outcome.

One plausible interpretation that may account both for the differences observed in the terminal vocational degree outcome and the absence of differences in the terminal academic degree outcome involves a possible selection effect. Perhaps students who face initial deficiencies in math elect disproportionately to pursue a vocational math track instead of the remedial math track, which would exclude them from the remedial cohort addressed here. Those math-deficient students who, in contrast, pursue the

remedial math track rather than the vocational math track may be especially determined to achieve an academic goal that requires college-math competency. Skill-deficient students who choose the remedial math track over the vocational math track, and who ultimately succeed in overcoming their math deficiencies, may have dismissed at the outset the idea of "settling" for a vocational associate's degree and instead elected to "go all the way" by transferring to a four-year institution. Thus, self-selection at the juncture between the vocational math track and the remedial math track may explain the relatively lower rates of terminal vocational degrees among remedial math students. Ultimately, however, the question of why successful remedial math students are less likely to complete a terminal vocational degree will require further research to answer conclusively. In particular, it may be useful to examine if and/or how math-deficient students are channeled into remedial versus vocational math tracks at the outset of college attendance.

Conclusion

Postsecondary remediation is a key battleground among stakeholders in contemporary educational policy circles and one that has received markedly little methodologically sound, empirical attention. This study builds on ongoing work in this area by addressing two relatively unexplored aspects of the efficacy of remediation—namely, the moderating effects of depth and breadth of underpreparation on the effect of successful remediation on credential completion and upward transfer. With due consideration to the two exceptions discussed earlier, I find that, regardless of the depth or breadth of deficiency evident at first enrollment, students who achieve college-level competency in English and math exhibit remarkably similar levels of attainment. Hence, the evidence presented here supports the conclusion that remediation is efficacious even for those students who face the greatest academic deficiencies as well as those who face multiple deficiencies. This is an important, but previously neglected, aspect of the larger question of the efficacy of remediation.

Capitalizing on these and related findings concerning the efficacy of postsecondary remediation, future research on this topic should seek to disentangle the relative efficacy of particular methods of remedial instruction and of particular operational structures of remedial services and coursework within the community college (e.g., McMillan, Parke, & Lanning, 1997). In other words, the next steps in this line of inquiry will involve detailed comparative analyses of the various approaches to remediation as community colleges actually execute them. Such questions may be particularly amenable to experimental or quasi-experimental research designs and are likely to produce findings of tremendous value.

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