The *Matthew Effect* in Postsecondary Remediation: Testing the Moderating Effects of Depth and Breadth of Under-Preparation on the Efficacy of Remediation

by

Peter Riley Bahr*
Department of Sociology
Wayne State University

7,862 words
5 tables
1 figure

Key Words:
Remediation, Remedial Education, Developmental Education, Basic Skills, Mathematics, English, Community College, Transfer, Attainment, Achievement, Degree, Certificate

*Please direct all correspondence to the author at the Department of Sociology, Wayne State University, Detroit, Michigan, 48202. Email: peter.bahr@wayne.edu. Phone: 313-577-3285. Fax: 313-577-2735.

The *Matthew Effect* in Postsecondary Remediation: Testing the Moderating Effects of Depth and Breadth of Under-Preparation on the Efficacy of Remediation

ABSTRACT

Postsecondary remediation is a highly contentious issue among stakeholders in the educational community, and one that has received unduly little comprehensive, methodologically sound attention with respect to evaluating the effectiveness of such programs. This study addresses two relatively unexplored aspects of the efficacy of remediation, namely the moderating effects of depth and breadth of under-preparation. With two exceptions, I find that students who achieve college-level competency in English and math exhibit similar levels of attainment regardless of depth or breadth of initial deficiency. Thus, the findings support the efficacy of remediation even for those students who face the greatest deficiencies.

The *Matthew Effect* in Postsecondary Remediation: Testing the Moderating Effects of Depth and Breadth of Under-Preparation on the Efficacy of Remediation

BACKGROUND

One would do well to avoid the topic of postsecondary remediation in casual conversation. Postsecondary remediation – commonly referred to as *developmental* or *basic skills* education – has been for some time, and remains today, a topic of considerable controversy, at the heart of which lie vital educational policy questions concerning access, equity, and social mobility for a sizeable segment of the population (Attewell, Lavin, Domina & Levey, 2006; Bahr, 2008; McMillan, Parke & Lanning, 1997; Mills, 1998; Shaw, 1997).

The arguments for, and against, the continuation of postsecondary remedial programs have been detailed extensively and repeatedly in the literature (Bahr, 2008). 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) and, moreover, to the dependence of the economy and the democracy on a populace that exhibits at least a minimum of reading, writing, and math skills (McCabe, 2003; Kozeracki, 2002). 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 policy pertaining to postsecondary remediation (Bastedo & Gumport, 2003; Breneman & Haarlow, 1998; Jenkins & Boswell, 2002). For example, Parker (2007) notes that twenty-two states and systems of higher education have reduced substantially, or even eliminated, remedial coursework, and similar changes are being considered elsewhere (Mazzeo, 2002). 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, policy makers, and, most importantly, students all share a vested interest.

Out of this controversy, one vital question has arisen, namely, does remediation work? Interestingly, there is surprising little solid empirical evidence to answer this question. Although numerous small-scale (or otherwise limited) evaluations have been published over the last several decades, nearly all of these studies have been plagued with methodological problems of various sorts, producing findings of questionable value (Bahr, 2008; 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 (Grubb & Gardner, 2001; Koski & Levin, 1998; Phipps, 1998; Roueche & Roueche, 1999). Consequently, until very recently there has been little certainty about the effectiveness of remediation with respect to resolving students' deficiencies.

However, three recent studies have sought to address this weakness in the literature (Attewell et al., 2006; Bahr, 2008; Bettinger & Long, 2004). All three of these studies drew upon large-scale statewide or national data and employed methodologically sophisticated analyses, and the findings generally agree that skill-deficient students who remediate successfully experience academic outcomes that are comparable to those of their college-prepared counterparts. Collectively, these studies provide a strong foundation of evidentiary support for the efficacy of postsecondary remediation with respect to students' attainment, and, furthermore, they constitute a hearty endorsement of remediation in its present form.

Nevertheless, despite the strengths of these studies, a number of questions remain. In

particular, recent evidence has drawn attention to the significance of *depth* and *breadth* of under-preparation in predicting successful remediation in core skill areas. Depth of under-preparation refers to the degree of deficiency in a given subject area, while breadth of under-preparation refers to the number of basic skill areas in which a student requires remedial assistance (Bahr, 2007). Both have been found to be negatively correlated with the likelihood of successful remediation (Adelman, 1996; McCabe, 2000; Weissman, Silk & Bulakowski, 1997).

The phrase *Matthew Effect*, coined by Merton (1968), has been extended to describe this finding among remedial students (Bahr, 2007), just as it has been used to describe similar stratification processes in other aspects of the U.S. educational system (e.g., Kerckhoff & Glennie, 1999; Stanovich, 1986). The *Matthew Effect* refers 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" (*New American Standard Bible*, Matthew 25:29). As it relates to remediation, the phrase highlights the fact that, 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.

One of the remaining unanswered questions regarding 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 *least-skilled* students. The one prior study that sought to address this issue found that remedial math students who achieve college-level math skill exhibit similar levels of attainment regardless of initial level of deficiency (Bahr, 2008). This is an encouraging finding with respect to the efficacy of remediation across various levels of under-preparation in math. However, it remains to be determined if the same holds for English, the second most common area of remedial need after math (Adelman, 2004b).

In fact, there are sound reasons to anticipate that students who face severe English deficiencies (i.e., deficiencies in *reading*, as opposed to lesser deficiencies in *writing*) may not gain the same benefit from remediating successfully in English as do students who face less severe English deficiencies. As Adelman (1996, p. A56) explains,

> Deficiencies in reading skills are indicators of comprehensive literacy problems, and they significantly lower the odds of a student's [sic] 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.

Elsewhere, Adelman (1998, p. 11) elaborates on this point, arguing that "[i]f you can't read, you can't read the math problem either (let alone the chemistry textbook, the historical documents or the business law cases)." In other words, severe English deficiencies constitute a unique impediment in the skill acquisition process, 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 under-preparation 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 under-preparation?

A second unanswered question regarding the efficacy of postsecondary remediation concerns the extent to which multiple deficiencies interact in predicting attainment. The three 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 seldom follow this pattern. Instead, those students who have the poorest math skills

tend also to have poor English skills, and vice-versa (Adelman, 1996; Bahr, 2007). It follows that efforts to evaluate fully the efficacy of remediation should account for differences between students who need only remediate in a single subject and students who have multiple skill deficiencies. Thus, the question posed here is, to what extent does *breadth* of under-preparation at college entry moderate the effect of successful remediation on academic attainment? Said another way, is postsecondary remediation equally efficacious across varying breadths of under-preparation?

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 concerning the relationship between depth and breadth of under-preparation, successful remediation, and academic attainment. Consequently, I seek to address the following two questions:

1. To what extent does *depth* of under-preparation at college entry moderate the effect of successful remediation on academic attainment?
2. To what extent does *breadth* of under-preparation at college entry moderate the effect of successful remediation on academic attainment?

In this study, I focus specifically on under-preparation in math and English, as these are the core subjects in which remediation most often is required (Adelman, 2004b).

Operating under the assumption that remediation is equally efficacious across various depths and breadths of under-preparation, 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 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 under-preparation in *math* (Hypothesis 1B) has been explored in one prior study (Bahr, 2008), here I seek to reexamine this hypothesis using an outcome variable that is 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 the California Community Colleges. The Chancellor's Office collects data each term from the 112 community colleges and affiliated adult education centers in California. I focus specifically on community colleges because such institutions are the principal venue in which remediation is performed (Adelman, 2004b; Day & McCabe, 1997; Parsad, Lewis & Greene, 2003).

The data collected by the Chancellor's Office constitute a census of California's community college students and include transcripts, demographics, financial aid, credential awards, and a variety of other information. 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 in order to identify students who transferred to four-year institutions, including public, private, in-state, and out-of-state (Bahr, Hom & Perry, 2005).

Analytical Cohort

I selected for this analysis the Fall 1995 cohort of first-time college freshmen who enrolled in any of California's 107 semester-based community colleges (N = 202,484). Valid course enrollment records were available for 93.9% of these students (N = 190,177). I observed students' records across all of the 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 = 79,516). I further reduced this cohort by dropping all students whose first English course was English-as-a-Second-Language (ESL; N = 8,449), all students whose total math enrollments were composed exclusively of vocational math (N = 943), and all students who were missing data on sex, age, or the ID variable used to track students' records across colleges (N = 938), resulting in an analytical cohort composed of 69,373 students.[1] Finally, in 2003, I refreshed the data with updated information about students' credential awards and transfer through the Spring of 2003.

[1] I exclude ESL students from the category of remedial English because these students face substantively different challenges in skill acquisition compared with students who require remedial reading or writing assistance. As Kurzet (1997, p. 60) explains, "the assumption that the ESL students are illiterate or marginally literate adult education students…fails to recognize that the prior education of ESL students ranges from primary schooling through university and professional school." While there is some debate about the inclusion of ESL in the category of remedial coursework (Ignash, 1997; Martinez, Snider & Day, 2003), the distinction that I make here is consistent with the bulk of the literature (Boylan & Saxon, 1999b).

Outcome Variable

Although a variety of dependent variables have been employed in tests of the efficacy of remediation (Bahr, 2008), one of the most robust is students' long-term attainment (Grubb & Gardner, 2001). Thus, the outcome of interest here is students' long-term attainment in the community college system. In this context, two expressions of 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). Of these, the associate's degree is considered a higher-level credential than is the certificate, although not all degree and certificate programs overlap.

When the three credentials are combined with the possibility of transfer, six mutually exclusive attainment outcomes may be derived, based upon the highest credential earned and whether transfer occurred: *no credential and no transfer*, *certificate*, *vocational associate's degree*, *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 two or more associate degrees of varying types (i.e., vocational or academic), blurring the distinction between the third and fourth categories. Consequently, I focus here on the *first* associate's degree completed by a student, and I give preference to the academic degree when both a first vocational degree and a first academic degree are 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. Initial competency in math and English would be operationalized optimally using placement exams administered at first enrollment in college. Alas, matriculation processes at the 107 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-skill, successfully completed math and English courses, 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. In total, I collapsed 2,750 math courses into five categories: arithmetic, pre-algebra, beginning algebra, intermediate algebra/geometry, and college-level. Arithmetic is the lowest level of math skill, followed in order by pre-algebra, beginning algebra, and intermediate algebra and geometry (the latter two are parallel courses). 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 categorized as college-level.

I categorized English courses in a similar manner. In total, I collapsed 4,031 English courses into three categories: remedial reading, remedial writing, and college-level English. Remedial reading is the lowest level of English competency, followed by 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, only the condition of whether a student attained college-level competency is of interest in this study. In that regard, I define attainment of college-level competency as a passing grade (A, B, C, D, or Credit) in a college-level course in that subject.

Multiplicative Interactions

To test the hypotheses offered here requires a set of interaction terms composed of

various combinations of English skill at college entry, math skill at college entry, and whether or not 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. This 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 ten 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 remediated, and, likewise, comparable to those of students who attain college-level skill without remediation. Testing 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 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 variables that, taken together, serve as proxies of SES include a dummy

variable that indicates receipt of a fee waiver during the first year, 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 ten 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, and delay of first math, 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 and math are operationalized as the term number of first English and math enrollment, respectively (e.g., *Fall 1995* = 1; *Spring 2001* = 17).

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 was 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. Two separate models are estimated, 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 are 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 from one college to another is not uncommon among community college students (Adelman, 1999), this model 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).

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. For example, while two-thirds (69%) of those students who evidenced no deficiencies in math also evidenced no deficiencies in English, 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 one in twenty-five (4%) 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 is a student's math skill deficiency at college entry, the more likely is the student to have an English deficiency *and* the more likely is the student to have a *more severe* English deficiency. These two observations highlight the importance of accounting for the depth and breadth of skill deficiencies in testing the efficacy of remediation.

[insert Figure 1 about here]

Efficacy of Remediation with respect to 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 math skill, as estimated simultaneously via two-level hierarchical multinomial logistic regression. Recall that 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, which are shaded in Table 1.

[insert Table 1 about here]

The findings presented in Table 1 provide moderately strong support for Hypothesis 1A. Remedial English students who attain college-level English competency exhibit odds of terminal outcomes (i.e., associate degrees and certificates) that are comparable to those of students who achieve college-level English skill without remediation. However, they generally exhibit slightly

lower odds of upward transfer (versus neither completing a credential nor transferring). 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, 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 (Table 1), a review of the absolute differences (Table 2) indicates that only those students who face the most severe English deficiencies (remedial reading) exhibit what might be considered a noteworthy disadvantage, and then only in terms of transfer without a credential.

[insert Table 2 about here]

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 slightly superior, to those of students who attain college-level math skill without the need for remedial assistance. Only one systematic exception to this generalization is observed. Namely, at all levels of initial math skill deficiency, remedial math students who attain college-level math competency exhibit significantly lower odds of completing a vocational associate's degree (versus neither completing a credential nor transferring) than do students who attain college-level math skill without remedial assistance. Again, as with English skill at college entry, I calculated the predicated 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 (please see Table 3). The findings presented in Table 3 demonstrate that the absolute differences in the likelihood of completing a vocational degree

without subsequent transfer are inconsequentially small. Thus, the finding that mathematics remediation is essentially equally efficacious across levels of initial deficiency is sustained.

[insert Table 3 about here]

Efficacy of Remediation with respect to 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. Recall that Hypotheses 2A and 2B predict 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, which, again, are 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 a problem with small cell sizes.

[insert Table 4 about here]

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 are negligible (please see Table 5).

[insert Table 5 about here]

DISCUSSION

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

To answer these questions, I tested the moderating effects of depth and breadth of initial skill deficiency 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 107 community colleges in California 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 very similar rates to those of college-prepared students who attain college-level competency in English and math. Thus, globally speaking, 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.

This is a significant finding for several reasons. As discussed earlier, postsecondary remediation is a highly contentious issue (Kozeracki, 2002; Mazzeo, 2002; Oudenhoven, 2002). Yet, remarkably few large-scale, comprehensive, methodologically sound research studies have taken as their focus the efficacy of remedial programs (Bahr, 2008; Grubb & Gardner, 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 established empirically.

Moreover, although a disproportionate number of the students who enter college with severe and/or multiple deficiencies do not remediate successfully (i.e., the *Matthew Effect* in remediation; 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 comparable rates to those of college-prepared students who attain similar math and English competency. In other words, even those students who are sorely under-prepared for college coursework may succeed and achieve well beyond what one would predict based upon 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 U.S.

The two systematic exceptions, however, are worthy of 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 descriptive work that identifies reading deficiencies as uniquely disadvantageous (e.g., Adelman, 1998). 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. Although the reading deficiency itself may be overcome, difficulty in early coursework may depress students' grade point averages and, in the end, hurt students' chances of transferring. However, it is encouraging to find here 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.

Concerning the second exception, the finding that successful remedial math students are slightly less likely than their college-prepared counterparts to complete a vocational associate's degree without subsequent transfer has not be observed in prior research, presumably due to the fact that prior studies have not distinguished between vocational and academic associate degrees (e.g., Bahr, 2008). Although the absolute differences in vocational degree attainment across initial levels of math skill deficiency are exceedingly small, the consistency of this relationship (evident at all four levels of math deficiency) is intriguing.

Why this relationship exists, though, is unclear. One possible interpretation is that only the most determined students ultimately manage to overcome their math deficiencies. Such students may be unlikely to "settle" for completing only a vocational associate's degree, electing

instead to "go all the way" by transferring to a four-year institution. In fact, prior research indicates that only one-quarter of remedial math students achieve college-level math competency (Bahr, 2007; Bahr, 2008), and the findings presented here indicate that remedial math students who attain college-level math skill are somewhat more likely to transfer *with* a two-year credential than are their college-prepared counterparts. Thus, there is indirect support for this interpretation. However, this study cannot speak conclusively regarding why successful remediation math students are less likely to complete a terminal vocational degree, and further research on this issue may prove fruitful.

CONCLUSION

Postsecondary remediation is a key battleground among stakeholders in contemporary educational policy circles, and one that has received unduly little comprehensive, methodologically sound, empirical attention. In this study, I sought to address two relatively unexplored aspects of the efficacy of remediation, namely the moderating effects of depth and breadth of under-preparation on the effect of successful remediation on attainment. With due consideration to the two exceptions discussed earlier, I find that students who achieve college-level competency in English and math exhibit remarkably similar levels of attainment (credential completion and upward transfer) regardless of the depth or breadth of deficiency evident at first enrollment. Thus, the evidence presented here supports strongly a conclusion that postsecondary remediation is efficacious even for those students who face the greatest academic deficiencies.

ACKNOWLEDGEMENTS

I am indebted to Tim Brown, Willard Hom, Myrna Huffman, Tom Nobert, Mary Kay Patton, and Patrick Perry of the California Community College Chancellor's Office for their assistance with the data employed in this study. I thank Elisabeth Bahr for her assistance with

the editing of this manuscript. This research was supported by a grant from the Association for Institutional Research and the National Postsecondary Education Cooperative (AIR Grant # 212). An earlier version of this paper was presented at the 2008 Forum of the Association for Institutional Research in Seattle, Washington.

REFERENCES

Adelman, C. (1996). The truth about remedial work: It's more complex than windy rhetoric and simply solutions suggest. *Chronicle of Higher Education, 43,* A56.

Adelman, C. (1998). The kiss of death?: An alternative view of college remediation. *National Crosstalk, 6,* 11.

Adelman, C. (1999). *Answers in the tool box: Academic intensity, attendance patterns, and bachelor's degree attainment*. Washington, D.C.: Office of Educational Research and Improvement. ERIC ED431363.

Adelman, C. (2004a). *Principal indicators of student academic histories in postsecondary education, 1972-2000*. Washington, D.C.: Institute of Education Sciences.

Adelman, C. (2004b). *The empirical curriculum: Changes in postsecondary course-taking, 1972-2000*. Washington, D.C.: Institute of Education Sciences.

Attewell, P., Lavin, D., Domina, T., and Levey, T. (2006). New evidence on college remediation. *Journal of Higher Education, 77,* 886-924.

Bahr, P. R. (2007). Double jeopardy: Testing the effects of multiple basic skill deficiencies on successful remediation. *Research in Higher Education, 48,* 695-725.

Bahr, P. R. (2008). Does mathematics remediation work?: A comparative analysis of academic attainment among community college students. *Research in Higher Education, 49,* 420-450.

Bahr, P. R., Hom, W., and Perry, P. (2005). College transfer performance: A methodology for equitable measurement and comparison. *Journal of Applied Research in the Community College, 13*, 73-87.

Bastedo, M. N., and Gumport, P. J. (2003). Access to what?: Mission differentiation and academic stratification in U.S. public higher education. *Higher Education, 46*, 341-359.

Bettinger, E., and Long, B. T. (2004). Shape up or ship out: The effects of remediation on students at four-year colleges. National Bureau of Economic Research, Working Paper No. W10369.

Boylan, H. R., and Saxon, D. P. (1999a). *Outcomes of remediation*. Boone, North Carolina: National Center for Developmental Education.

Boylan, H. R., and Saxon, D. P. (1999b). *Remedial courses: Estimates of student participation and the volume of remediation in U.S. community colleges*. Boone, North Carolina: National Center for Developmental Education.

Breneman, D. W., and Haarlow, W. N. (1998). *Remediation in higher education*. Washington, D.C.: Thomas B. Fordham Foundation.

Brothen, T., and Wambach, C. A. (2004). Refocusing developmental education. *Journal of Developmental Education, 28*, 16-33.

Calcagno, J. C., Crosta, P., Bailey, T., and Jenkins, D. (2007). Stepping stones to a degree: The impact of enrollment pathways and milestones on community college student outcomes. *Research in Higher Education, 48*, 775-801.

Chancellor's Office of the California Community Colleges. (2004). *Taxonomy of programs, 6th edition*. Sacramento, California: California Community Colleges, Chancellor's Office.

Day, P. R., Jr., and McCabe, R. H. (1997). *Remedial education: A social and economic*

imperative. Washington, D.C.: American Association of Community Colleges.

Grimes, S. K., and David, K. C. (1999). Underprepared community college students: Implications of attitudinal and experiential differences. *Community College Review, 27*, 73-92.

Grubb, W. N., and Gardner, D. (2001). *From black box to Pandora's Box: Evaluating remedial/developmental education*. New York, New York: Community College Research Center, Teachers College, Columbia University.

Ignash, J. M. (1997). Who should provide postsecondary remedial/developmental education? *New Directions for Community Colleges, 100*, 5-20.

Jenkins, D., and Boswell, K. (2002). *State policies on community college remedial education: Findings from a national survey*. Denver, Colorado: Education Commission of the States, Community College Policy Center. Publication No. CC-02-01.

Kerckhoff, A. C., and Glennie, E. (1999). The Matthew Effect in American education. *Research in Sociology of Education and Socialization, 12*, 35-66.

Koski, W. S., and Levin, H. M. (1998). *Replacing remediation with acceleration in higher education: Preliminary report on literature review and initial interviews*. Stanford, California: National Center for Postsecondary Improvement.

Kozeracki, C. A. (2002). ERIC review: Issues in developmental education. *Community College Review, 29*, 83-101.

Kurzet, R. (1997). Quality versus quantity in the delivery of developmental programs for ESL students. *New Directions for Community Colleges, 100*, 53-62.

Levin, H. M., and Calcagno, J. C. (2008). Remediation in the community college: An evaluator's perspective. *Community College Review, 35*, 181-207.

Martinez, S., Snider, L. A., and Day, E. (2003). *Remedial in Higher Education: A Review of the Literature*. Topeka, Kansas: Kansas State Department of Education.

Mazzeo, C. (2002). Stakes for students: Agenda-setting and remedial education. *Review of Higher Education, 26*, 19-39.

McCabe, R. H. (2000). *No one to waste: A report to public decision-makers and community college leaders*. Washington, D.C.: Community College Press.

McCabe, R. H. (2003). *Yes we can!: A community college guide for developing America's underprepared*. Phoenix, Arizona: League for Innovation in the Community College.

McCusker, M. (1999). ERIC review: Effective elements of developmental reading and writing programs. *Community College Review, 27*, 93-105.

McMillan, V. K., Parke, S. J., and Lanning, C. A. (1997). Remedial/developmental education approaches for the current community college environment. *New Directions for Community Colleges, 100*, 21-32.

Merton, R. K. (1968). The Matthew Effect in science. *Science, 159*, 56-63.

Mills, M. (1998). From coordinating board to campus: Implementation of a policy mandate on remedial education. *Journal of Higher Education, 69*, 672-697.

Oudenhoven, B. (2002). Remediation at the community college: Pressing issues, uncertain solutions. *New Directions for Community Colleges, 117*, 35-44.

Parker, T. L. (2007). Ending college remediation: Consequences for access and opportunity. ASHE/Lumina Policy Briefs and Critical Essays, No. 2.

Parsad, B., Lewis, L., and Greene, B. (2003). *Remedial education at degree-granting postsecondary institutions in Fall 2000 (NCES 2004-010)*. Washington, D.C.: National Center for Education Statistics.

Perin, D., and Charron, K. (2006). Lights just click on every day. In T. Bailey & V. S. Morest (Eds.), *Defending the community college equity agenda* (pp. 155-194). Baltimore, Maryland: John Hopkins University Press.

Phipps, R. (1998). *College remediation: What it is. what it costs. what's at stake.* Washington, D.C.: Institute for Higher Education Policy.

Raudenbush, S. W., and Bryk, A. S. (2002). *Hierarchical linear models: Applications and data analysis methods*. Thousand Oaks, California: Sage.

Roueche, J. E., and Roueche, S. D. (1999). *High stakes, high performance: Making remedial education work*. Washington, D.C.: American Association of Community Colleges.

Saxon, D. P., and Boylan, H. R. (2001). The cost of remedial education in higher education. *Journal of Developmental Education, 25*, 2-8.

Shaw, K. M. (1997). Remedial education as ideological battleground: Emerging remedial education policies in the community college. *Educational Evaluation and Policy Analysis, 19*, 284-296.

Stanovich, K. E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly, 21*, 360-407.

Tomlinson, L. M. (1989). *Postsecondary developmental programs: A traditional agenda with new imperatives*. Washington, D.C.: The George Washington University.

Weissman, J., Silk, E., and Bulakowski, C. (1997). Assessing developmental education policies. *Research in Higher Education, 38*, 187-200.

TABLE 1: Net effects of two two-way interactions of initial skill deficiency and successful remediation, estimated via two-level hierarchical multinomial logistic regression ($N_{students}$ = 69,373; $N_{colleges}$ = 107; 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	0.050	-0.003	0.120*	-0.118***	-0.069
		(0.096)	(0.071)	(0.050)	(0.034)	(0.038)
	Remedial Reading	-0.050	-0.022	0.000	-0.331***	-0.211**
		(0.201)	(0.140)	(0.105)	(0.082)	(0.086)
Did Not Attain College English Skill	College-Level English	0.551***	-1.329***	-1.286***	-0.945***	-2.088***
		(0.155)	(0.307)	(0.181)	(0.066)	(0.164)
	Remedial Writing	0.524***	-0.366***	-1.230***	-1.259***	-2.889***
		(0.094)	(0.086)	(0.080)	(0.045)	(0.111)
	Remedial Reading	0.475***	-0.917***	-1.475***	-1.447***	-3.561***
		(0.135)	(0.180)	(0.169)	(0.090)	(0.341)
Attained College Math Skill	College-Level Math	----------	----------	----------	----------	----------
		----------	----------	----------	----------	----------
	Interm Algebra / Geometry	-0.067	-0.324**	-0.063	-0.077	0.097*
		(0.207)	(0.127)	(0.075)	(0.045)	(0.048)
	Beginning Algebra	-0.240	-0.287*	0.033	0.131**	0.331***
		(0.216)	(0.123)	(0.077)	(0.050)	(0.052)
	Pre-Algebra	-0.291	-0.741***	-0.116	0.180	0.335***
		(0.372)	(0.217)	(0.131)	(0.097)	(0.095)
	Basic Arithmetic	-0.472	-0.784***	-0.313*	-0.146	0.076
		(0.376)	(0.219)	(0.146)	(0.114)	(0.109)
Did Not Attain College Math Skill	College-Level Math	-0.097	-0.186	-0.874***	-1.462***	-2.729***
		(0.254)	(0.245)	(0.163)	(0.069)	(0.154)
	Interm Algebra / Geometry	0.211	-0.037	-0.858***	-1.862***	-2.823***
		(0.169)	(0.120)	(0.088)	(0.049)	(0.088)
	Beginning Algebra	0.270	-0.192*	-0.958***	-2.123***	-2.870***
		(0.149)	(0.098)	(0.068)	(0.042)	(0.062)
	Pre-Algebra	0.144	-0.965***	-1.487***	-2.454***	-3.316***
		(0.160)	(0.121)	(0.089)	(0.060)	(0.094)
	Basic Arithmetic	0.247	-1.238***	-1.564***	-2.638***	-3.350***
		(0.158)	(0.123)	(0.092)	(0.066)	(0.099)

NOTES: *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; standard errors provided in parentheses

TABLE 2: Predicted probabilities of various academic outcomes for a student who attained college-level math and English competency, *by initial level of English deficiency* (based on the coefficients presented in Table 1)

Skill at College Entry	Academic Outcome						
	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	0.188	0.004	0.007	0.042	0.371	0.388	1.000
Remedial Writing	0.201	0.004	0.007	0.050	0.351	0.386	1.000
Remedial Reading	0.229	0.004	0.008	0.051	0.324	0.383	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 systematically adjusting the measure of initial English deficiency.

TABLE 3: Predicted probabilities of various academic outcomes for a student who attained college-level math and college-level English competency, *by initial level of math deficiency* (based on the coefficients presented in Table 1)

Skill at College Entry	Academic Outcome						
	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	0.188	0.004	0.007	0.042	0.371	0.388	1.000
Interm Algebra / Geometry	0.187	0.004	0.005	0.039	0.341	0.425	1.000
Beginning Algebra	0.157	0.003	0.004	0.036	0.352	0.449	1.000
Pre-Algebra	0.155	0.002	0.003	0.031	0.365	0.445	1.000
Basic Arithmetic	0.195	0.002	0.003	0.032	0.333	0.434	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 systematically adjusting the measure of initial math deficiency.

TABLE 4: Net effects of the four-way interaction of initial skill deficiency and successful remediation, estimated via two-level hierarchical multinomial logistic regression ($N_{students}$ = 69,373; $N_{colleges}$ = 107; control variables not shown; comparison category = *no credential and no transfer*)

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 Math and College English	College Math	College English	----------	----------	----------	----------
			----------	----------	----------	----------
	College Math	Remedial English	0.309	0.114	0.007	0.035
			(0.340)	(0.106)	(0.070)	(0.075)
	Remedial Math	College English	0.132	-0.026	0.115*	0.285***
			(0.277)	(0.078)	(0.052)	(0.054)
	Remedial Math	Remedial English	-0.151	-0.090	-0.084	0.136*
			(0.268)	(0.076)	(0.053)	(0.055)
College Math but not College English	College Math	College English	0.667	-1.455***	-1.372***	-2.700***
			(0.556)	(0.400)	(0.135)	(0.318)
	College Math	Remedial English	0.725*	-1.224***	-1.793***	-3.557***
			(0.342)	(0.196)	(0.104)	(0.277)
	Remedial Math	College English	0.379	-1.634***	-1.537***	-1.939***
			(0.639)	(0.443)	(0.210)	(0.293)
	Remedial Math	Remedial English	0.387	-1.258***	-2.389***	-3.101***
			(0.307)	(0.143)	(0.125)	(0.181)
College English but not College Math	College Math	College English	0.227	-1.011***	-1.564***	-2.835***
			(0.403)	(0.204)	(0.094)	(0.191)
	College Math	Remedial English	0.636	-0.617**	-1.907***	-3.102***
			(0.451)	(0.243)	(0.169)	(0.321)
	Remedial Math	College English	0.356	-0.902***	-2.235***	-3.052***
			(0.228)	(0.071)	(0.049)	(0.068)
	Remedial Math	Remedial English	0.416	-0.923***	-2.493***	-3.141***
			(0.224)	(0.070)	(0.053)	(0.066)
Neither College Math nor College English	College Math	College English	0.409	-2.036***	-2.176***	-3.981***
			(0.558)	(0.592)	(0.140)	(0.508)
	College Math	Remedial English	-0.167	-1.167***	-2.572***	-4.744***
			(0.555)	(0.293)	(0.138)	(0.583)
	Remedial Math	College English	0.923***	-2.139***	-2.882***	-4.858***
			(0.260)	(0.195)	(0.084)	(0.275)
	Remedial Math	Remedial English	0.869***	-1.932***	-3.352***	-5.848***
			(0.221)	(0.079)	(0.054)	(0.150)

NOTES: *$p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$; standard errors provided in parentheses

TABLE 5: Predicted probabilities of various academic outcomes for a student who attained college-level math and English competency, *by initial competency in math and English* (based on the coefficients presented in Table 4)

Math Skill at College Entry	English Skill at College Entry	Academic Outcome					
		No Credential and No Transfer	Certificate Only	Associate's Degree	Transfer without Credential	Transfer with Credential	**TOTAL**
College Math	College English	0.182	0.003	0.063	0.368	0.383	1.000
College Math	Remedial English	0.178	0.004	0.069	0.361	0.387	1.000
Remedial Math	College English	0.156	0.003	0.053	0.353	0.436	1.000
Remedial Math	Remedial English	0.179	0.003	0.057	0.331	0.430	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 systematically adjusting the measures of initial math and English competency.

FIGURE 1: Unadjusted distribution of initial competency in English, by initial competency in math ($N_{students}$ = 69,373; $N_{colleges}$ = 107)