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Does Remediation Work for All Students? How the Effects of Postsecondary Remedial and Developmental Courses Vary by Level of Academic Preparation

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Abstract

Each year, thousands of American students enter postsecondary institutions unprepared for college-level work and are subsequently placed in remedial or developmental courses. Several recent studies have examined the impact of these courses on student outcomes, but such studies focus exclusively on students who need just one or two classes; the impact of remediation on students with more severe levels of underpreparedness is unknown. This study addresses this hole by examining the impact of remedial and developmental courses on students at multiple points on the preparedness distribution. Using longitudinal data from Tennessee, we estimate the effects of placement into varying levels of mathematics, reading, and writing courses for students attending public four- and two-year colleges and universities. This is possible due to the state's multi-tiered system in which students could be assigned into one of four levels of mathematics and one of three levels of reading and writing courses. Therefore, unlike previous studies, we examine the effects of remediation on a wider range of students than previously analyzed. Using regression discontinuity (RD) techniques, we provide causal estimates of the effects of placement on a number of student outcomes, including persistence, degree completion, the number of total and college-level credits completed, and college GPA. The results suggest that remedial and developmental courses do differ in their impact by the level of student preparation. Similar to other research, we find negative effects for those students on the margins of needing any remediation. However, at the other end of the academic ability spectrum, the negative effects of remediation were much smaller and occasionally positive. These results suggest that remedial and developmental courses help or hinder students differently depending on their level of academic preparedness.

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1. Introduction

Increasing numbers of students are entering postsecondary institutions unprepared for college-level work (Greene & Forster, 2003). In an effort to bring these students up to the level of skill needed for college-level courses while acknowledging their differing levels of academic preparation, postsecondary institutions often offer a range of remedial and developmental courses in reading, writing, and mathematics designed to bridge this gap. Research from the National Center for Education Statistics estimates that more than one third of all first-year students in colleges today are taking some form of remedial coursework (Snyder, Tan, & Hoffman, 2004); however, this figure can be as high as 6 out of 10 students at some postsecondary institutions (Bettinger & Long, 2009).

Remediation comes at a great expense to colleges and universities, with efforts estimated to cost over a billion dollars a year at public colleges alone (Breneman & Haarlow, 1998). However, the social costs of *not* offering remediation are of great concern, given the growing demand for skilled labor in the United States (Bettinger & Long, 2007; Bailey, Jeong, & Cho, 2008). Increasing the level of educational attainment among workers has become a core focus of the federal government, with a portion of the \$3.95 billion from the 2009 federal stimulus package being directed toward remedial programs at community colleges in order to help provide retraining for adults seeking to improve their occupational skills (Killough, 2009). Additionally, the federal *Student Aid and Fiscal Responsibility Act of 2009* proposes to allocate \$12 billion to U.S. community colleges with an emphasis on increasing the number of adults with two-year degrees by 5 million over the next 10 years (Moltz, 2010). Making remediation efforts successful is core to the country reaching this goal.

Two common hypotheses have surfaced as to the potential effects of college remediation. First, attending remedial courses may provide students with the skills they need to be successful academically, thereby helping them to persist through to graduation. The second hypothesis instead suggests that remediation slows student progress, given that remedial courses rarely count toward graduation requirements. In addition, taking remedial courses may lead to lower self-esteem, higher frustration, and ultimately higher drop-out rates (Bettinger & Long, 2007; Jacob & Lefgren, 2004). Many studies in this area simply compare remedial and developmental students to their peers, and they find that students who take more remedial classes in college have a lower probability of obtaining a degree. For example, one study found that while 57 percent of students who enroll in a four-year college complete a bachelor's degree within eight years, only 29 percent of students who take one or two remedial courses while in college graduate within eight years (Strong American Schools, 2008). This difference in outcomes may even be understated due to differences in the definition of remediation across states and the stigma that institutions may

feel for offering non-college-level work (Phipps, 1998). Nevertheless, these data do not identify the *causal* effect of remedial coursework on student outcomes, and so they do not help sort out the competing hypotheses about remediation. Students who are less well prepared academically for college-level work are naturally more likely to be placed into remedial courses, making these students different from their non-remediated peers in important ways. Therefore, simply comparing the academic outcomes of these students to those of their more academically-prepared peers will lead to biased estimates of the impact of remediation due to selection (Bettinger & Long, 2009; Calcagno & Long, 2008). In other words, short of randomly assigning students on the margins of needing remediation to either remedial or college-level courses, it can be difficult to ascertain whether observed differences in student outcomes are *caused* by students' enrollment in remedial classes, or are instead explained by their lower levels of academic preparation—the very thing that required them to be remediated in the first place.

Is taking remedial courses a necessary step in preparing students for future academic success, or could these same skills be taught in college-level courses without slowing students down in their progress toward a degree (Armstrong, 1999; Jenkins, Jaggars, & Roksa, 2009)? Given the importance of remediation, several recent studies have tried to establish the causal effects of remediation using quasi-experimental designs. Each study focuses on students at the margin of passing out of remediation. For example, Bettinger and Long (2009) applied instrumental variables estimation to examine the effects of remediation in Ohio. By exploiting institutional variation in placement policies and using distance from a student's home to the nearest four-year college as an instrument for college choice (and thereby placement), the authors compare academically similar students who had different experiences with remedial courses. The authors found that placement into remediation increased the probability of college persistence in comparison to academically-similar peers not required to take remedial courses. Other studies have addressed this question using a regression discontinuity (RD) design, which compares students who are placed just above and below the cutoff for remedial courses (Calcagno & Long, 2008; Lesik, 2007; Martorell & McFarlin, 2008). In RD designs, students scoring below the specified cutoff score are assigned to a remedial-level course, while students scoring above this cutoff score are assigned to a college-level course. Assuming that students who score just above and below the placement cutoff have near similar ability, especially due to the noise inherent in such tests, one can obtain a causal estimate of the effects of remedial placement on subsequent outcomes for those students at the margins of passing (Shadish, Cook, & Campbell, 2002; Imbens & Lemieux, 2008). Using this strategy, combined with discrete-time survival analyses in her study of a large state university in the Northeast, Lesik (2007) concluded that students who did not enroll in remedial courses were 4.3 times more likely to drop out of the university during their first three years when compared to similar students who were placed in remediation. In this study, taking remedial courses was

found to have a positive effect on student persistence for students at the margins of needing remediation. In most other cases, however, the results have been less positive. In a study with over 100,000 community college students in Florida, Calcagno and Long (2008) found that assignment to developmental courses appeared to increase persistence to the second year and the total number of credits completed, but that it did not lead to increases in degree completion. Furthermore, a study of Texas students concluded that remedial courses had little effect on the number of credits attempted, receipt of a college degree, or future labor market earnings among students at the test score cutoff for needing remediation (Martorell & McFarlin, 2008). The mixed results from these studies suggest that the causal effects of remedial courses on student outcomes are mixed at best for students at the margin of passing out of remediation. The previous research literature is also limited to focusing on students just on the margin of needing the courses, so little is known about the effects on students with much lower levels of preparation.

In this study, we expand the previous research to examine the impact of remedial and developmental courses on the academic outcomes of students with varying ability levels who began at public colleges and universities in Tennessee in fall 2000. Using longitudinal data from the Tennessee Board of Regents (TBR) and the Tennessee Higher Education Commission (THEC), we isolate the effects of placement into developmental and remedial mathematics, reading, and writing courses for students attending two and four-year colleges in Tennessee. We are able to examine the effects of multiple levels of remediation, from students who need only one course to those who need several courses, due to the state's multi-tiered system in which students could be assigned into one of four levels of math and one of three levels of reading or writing (i.e., remedial, developmental, or college-level courses). We estimate the causal effects of being assigned to a certain level of remediation on the number of credits accumulated over time, persistence, degree completion, and grades in the first college-level courses. To answer these questions, we use a regression discontinuity (RD) design similar to previous studies. Due to imperfect compliance with the statewide cutoff policy on the placement exams used to assign students to remediation, the discontinuity in assignment to remedial classes is "fuzzy." Consequently, we use instrumental-variables (IV) estimation with assignment to remediation based on the cutoff as an instrument for enrollment in remedial or developmental courses.

The results suggest that remedial and developmental courses do differ in their impact by the level of student preparation. The largest negative effects were found for students on the margin of needing remediation: in comparison to their peers placed in college-level courses, students assigned to remedial courses were less likely to complete a college degree in six years and completed fewer college credits within three years. This result is similar to what has been found in other research. However, at the other end of the

academic ability spectrum, the negative effects of remediation were much smaller and sometimes positive. Students placed in lower level math courses did only marginally worse than their peers who were assigned to the next level developmental math course. In the writing courses, we found positive effects for those placed in lower level courses. For example, students in the lowest levels of remedial writing persisted through college and attained a degree at higher rates than their peers in the next highest level course. These results suggest that remedial and developmental courses help or hinder students differently depending on their level of academic preparedness, and while our study, along with several others, question the effectiveness of developmental courses for students just at the margin of needing the courses, more rather than less remediation can be beneficial for students with weaker preparation. These results suggest that it is worthwhile to investigate further why such courses do and do not work in improving student outcomes.

2. Background and Context on Remediation in Tennessee

The ways in which students are assigned to remedial courses is particularly important for understanding the pathways to, and through, college remediation. The vast majority of both two- and four-year colleges require incoming students to take some kind of placement exam in both mathematics and English, most commonly either the Computerized Adaptive Placement Assessment and Support Systems (COMPASS) exam, the Assessment of Skills for Successful Entry and Transfer (ASSET) exam, or a local exam developed by the institution (Bettinger & Long, 2009). Standardized test scores (SAT/ACT) and high-school grades can also be used in combination with the results of one or more of these exams to determine placement into remedial courses. Alternatively, institutions may elect to rely solely on one of the above placement exams for assigning students to remedial and college-level courses. This places increased importance on a student's performance on the placement exam, as their scores will determine the number and order of courses that a student must take. Many are often surprised to learn of the administration of these high-stakes placement exams upon arriving at college, and are even further surprised to learn that they did not pass directly into college-level courses (Bettinger & Long, 2009; Dillon, 2010). In these instances, the placement exam acts as a key gatekeeper between incoming students and their enrollment in college-level courses, sparking concern over the weight given to a singular placement exam.¹

Unlike the literature, which tends to use the terms *remedial* and *developmental* interchangeably, in Tennessee, public two- and four-year colleges make a distinction between the two terms, with developmental courses being just below college level and remedial courses being for students who are very underprepared. For example, in Tennessee in mathematics, students who lack basic computational arithmetic skills (addition, subtraction, multiplication, division) would be placed into *Remedial Arithmetic* (the lowest level course), while students who only lack the ability to do algebraic computations would be placed in *Developmental Algebra I* or *II*. These courses are in contrast to college-level mathematics courses, which are not considered remedial or developmental. Tennessee also offers remedial and developmental courses in reading and writing. These courses are intended to help prepare students for their college composition and/or expository writing

¹ Concern over the high stakes nature of exiting remediation placement exams has prompted some districts/states to begin testing students for remediation placement while still enrolled in high school. These efforts, commonly called Early Placement Testing or Early Assessment Programs, are intended to identify students in need of remediation at a point when they can still obtain the necessary skills for college-level work without enrolling in actual college remedial courses (Howell, Kurlaender, & Grodsky, 2009; Dillon, 2010).

courses and are heavily focused on reading comprehension and essay writing. The specific courses used to satisfy remedial and developmental reading and writing credits vary by institution, but these courses are commonly known as introductory composition or English courses. Similar to mathematics, Tennessee has multiple levels of reading and writing courses with three possible options each: *Remedial Writing* is the lowest level writing course and *Developmental Writing* is just below college level. The same hierarchy is used for reading courses in Tennessee.

Depending on the level of the course, courses are typically offered for credit and count toward a student's overall GPA, but rarely are they counted toward graduation requirements. Students may be placed in remedial or developmental courses in multiple subjects, depending on their scores on each subject's COMPASS placement exam. For example, students may be assigned to both developmental mathematics and developmental writing in the same semester. Research suggests that students enrolled in remedial or developmental reading are more likely to be enrolled in other remedial or developmental courses. In 2004, 51 percent of students nationally who took any remedial or developmental reading course enrolled in four or more courses below college level, compared with only 31 percent of students who took any remedial or developmental mathematics course (U.S. Department of Education, National Center for Education Statistics, 2004). In Tennessee, among all students recommended for at least one remedial or developmental course in any subject, 17 percent were also recommended for a second course in another subject, and 5 percent were recommended for all three.

Descriptive analysis comparing students enrolled in developmental courses to all other students enrolled in college-level courses at public colleges in Tennessee report that students in developmental courses had higher failure rates and lower rates of persistence from one year to the next (Gray-Barnett, 2001). In the early 2000s, the Drop-Failure-Withdrawal (DFW) rates averaged 45 percent in developmental mathematics courses, compared to 26 percent in college-level mathematics. Developmental Algebra I had a DFW rate of more than 50 percent, indicating that students taking developmental mathematics courses in Tennessee were less likely to ever complete these courses and move on to the next, compared to students in the next highest course. These high rates of failure in developmental mathematics courses caused many to wonder if assignment to developmental courses led to larger disparities in student performance and persistence over time. However, these comparisons were among all the students enrolled in remedial or developmental relative to those in college-level courses, and so the patterns found are confounded with differences in academic achievement across these different groups.

It is the way in which students were assigned to courses in Tennessee that provides the opportunity to establish the causal effects of remedial and developmental classes in this research. Tennessee is one of several states that administer a multi-tiered statewide

placement system to assign students. In the early 1990s, Tennessee experienced a large increase in the number of remedial and developmental courses being offered in its colleges due to the implementation of a policy that required that all courses below college level had to be completed before a student could begin any degree program (Van Allen & Belew, 1992). For the period of time in this study, the cutoff scores on the COMPASS placement exams that determine whether a student is assigned to remedial, developmental, or college-level courses were set at the state level by the Tennessee Board of Regents.

In Figures 1a, 1b, and 1c (Appendix A),² we illustrate the placement process for mathematics, reading, and writing, respectively, for the 2000 cohort of entering students, the time frame relevant for this study. Tennessee used a combination of ACT sub-scores and scores on a COMPASS exam to assign students to remedial and developmental classes.³ Students with an ACT sub-score less than 26 in mathematics and/or less than 24 in English or students who were 21 years of age or older were required to complete the COMPASS assessment in the respective subject. The COMPASS test is an untimed, adaptive, computerized test that measures skills in reading, writing, and mathematics. In mathematics, students with the lowest ACT scores were assigned to take the COMPASS Arithmetic exam and students with slightly higher ACT scores took the Algebra exam. In reading and writing, there was only one exam per subject. The tests were administered prior to the start of the academic year and students received a score from 0 to 100. Colleges then used these scores to assign students to remedial or developmental courses, according to the statewide policy in Tennessee. For example, students scoring 50 or above on the Algebra II test were assigned to college-level mathematics, while those scoring 49 or below should have been assigned to Developmental Algebra II. In terms of reading, a score from 53 to 67 on the COMPASS exam placed students into Developmental Reading, and below a 53 placed students into Remedial Reading. A score of 28 to 67 on the COMPASS writing exam placed students into Developmental Writing, and a score below 28 into Remedial Writing. Because the policy is set at the state-level, two-year colleges administer the same COMPASS exams and adhere to the same remediation placement cutoffs as four-year colleges. However, as discussed below, some institutions follow the placement policy more closely than others.

Tables 1a and 1b (Appendix B)⁴ provide background information on the number of students taking the COMPASS placement tests. Among students in the sample who took a COMPASS mathematics placement test, 89 percent were placed into some level of remedial

² All subsequent figures can be found in Appendix A.

³ Tennessee is considered an “ACT state.” Over 85 percent of students in Tennessee take the ACT over the SAT. In cases where a student has only a reported SAT score, the score is converted into an ACT score using the SAT percentile equivalent scores on the verbal and mathematics sections in a given year.

⁴ All subsequent tables can be found in Appendix B.

or developmental mathematics. This number does not include those students who did not take a COMPASS mathematics exam and were admitted into college-level mathematics courses for other reasons (most commonly due to an ACT score above a 26). Among all the students in the sample who took a COMPASS reading placement test, 43 percent were recommended for Remedial or Developmental Reading, and among those taking a COMPASS writing exam, 64 percent were recommended for Remedial or Developmental Writing. For both the upper and lower levels of mathematics placement, relatively equal numbers of students were placed into the corresponding higher and lower level courses. However, for the middle range of students, the vast majority were placed into Developmental Algebra II over Developmental Algebra I. For this particular cutoff, we can clearly see some degree of endogenous sorting around the cutoff, which leads us to treat the analysis for this discontinuity with caution. In reading, more students were recommended for the higher level courses than the lower, but for writing, students were nearly evenly assigned to the upper and lower courses in both regions of the distribution.

3. Data and Empirical Framework

Data

The Tennessee Higher Education Commission (THEC) and the Tennessee Board of Regents (TBR) provided the student-level data necessary for this project. THEC represents the two university systems governed by the University of Tennessee Board of Trustees, and TBR governs the state universities, community colleges, technical institutes, and technology centers, so that the merging of their datasets gives us full coverage of the public higher education system in the state. Tennessee has a higher education system similar to most other mid-sized states. In the fall of 2000, there were 9 public universities, 2 special purpose institutes, 13 two-year institutions, and 27 technology centers in Tennessee that served nearly 200,000 students. THEC and TBR collect basic enrollment information and transcript data for each student, including courses taken and grades, for any term the student is actively enrolled at any Tennessee public institution. By tracking students across public institutions, they also record transitions such as transferring or returning after a period of stopping out. Information is also available on demographic characteristics, high school background, and test scores, which are from the student's college application and ACT test score report. Key to this analysis, the dataset also includes the placement exam scores for all students and their subsequent assignment into remedial, developmental, or college-level courses based on this exam. For this study, we observe students term-by-term from fall 2000 to spring 2003 (three years) and eventual degree completion after six years.⁵ While the effects of placement into remedial courses are likely to be different for students attending two-year colleges compared to students attending four-year colleges, placement into these courses is pervasive within both types of institutions. We therefore include both two-year and four-year institutions in the analysis but also investigate whether there are heterogeneous effects by institution type.

The sample is restricted to undergraduates beginning at any public two-year or four-year college in Tennessee in fall 2000 who also took a COMPASS mathematics, reading, or writing exam. Including only those students who took the COMPASS placement exam allows for a more narrow definition of the cutoff score by which students were assigned to remedial courses. As noted above, students could also be placed in college-level courses due to high ACT scores, but including such students would introduce selection bias because such students are already different academically from their peers assigned to take a COMPASS exam. Additionally, the sample only includes full-time students so that we are

⁵ We are currently requesting access to a longer span of data.

better able to judge their progress through college. The vast majority of students in the sample (89 percent) began as full-time students, making this a weak restriction.

The student-level descriptive statistics for the sample are reported in Tables 2 and 3. We present sample means for the smaller group of students within a smaller bandwidth of points on either side of the COMPASS cutoff used to assign students to their remedial courses in Tennessee. The t-tests indicate the extent to which the sample means of each variable statistically differ on either side of the cutoff. Furthermore, we divide the sample into students beginning at a four-year college in the fall of 2000 and students beginning at a two-year college in the fall of 2000 to examine differences around the cutoffs within the institutional sector.

Over 55 percent of the students are women and over 70 percent are White. As shown in Table 2, students assigned to the lower-level developmental mathematics course have, on average, lower high school GPAs and ACT test scores than those students assigned to the college-level mathematics course, and it is more probable that they will attend a community college (two-year college). These differences, however, are not statistically significant. In mathematics, we see several more statistically significant differences in means around the cutoff for students in the middle range of the ability distribution. If the placement process were truly exogenous, we would not expect to see these differences in student characteristics around the cutoffs, which leads us to conclude that the discontinuity around RD #2 in mathematics has been manipulated and that the results must be interpreted with caution. Table 3 illustrates similar descriptive statistics for students who have taken a COMPASS reading and/or writing exam. The profile of these students looks similar to students taking a mathematics exam in most respects. The average high school GPA for students taking a COMPASS reading or writing exam is lower than that of students taking a COMPASS mathematics exam, and fewer students assigned to remedial or developmental reading/writing courses were first enrolled in a four-year college compared to students assigned to remedial or developmental mathematics.

Empirical Strategy

This paper uses a regression discontinuity (RD) design to tease out the causal effects of being placed into a remedial or developmental course in Tennessee. An RD design compares outcomes for students whose COMPASS scores fall just above and below the cutoff score(s). The analysis assumes that, other than placement into a higher or lower-level course, students immediately on either side of the cutoff are equal in expectation (i.e., the same, on average, in the population in all other respects, both observed and unobserved). This allows us to compare the enrollment patterns of students assigned to remedial or developmental courses to students at the next highest-level course, and the

analysis provides an unbiased estimate of the causal impact of being placed into the lower level for students *on the margins of passing the remedial exam* (Shadish et al., 2002; DesJardins & McCall, 2007).

In the current application, however, there is one added complexity. If all students scoring above the designated cutoff score were assigned to the higher-level course, and all students who scored below were assigned to the lower-level course, then the discontinuity would be “sharp.” Rarely, however, do we see perfect compliance in assignment to remedial courses (Bailey et al., 2008). In Tennessee, assignment to remediation is “fuzzy.” In Figures 2a, 2b, and 2c, we illustrate the distribution of student test scores on the COMPASS mathematics, reading, and writing exams, respectively, by the recommended level of remediation. The graphs are centered at the appropriate cutoff. In each of the seven cutoffs, we see some students who were assigned to the lower-level course when they should not have been and vice versa. For example, in Figure 2a, those students with scores to the left of zero who were recommended for college-level mathematics should have been recommended for Developmental Algebra II. Examining the data more closely, we find that students closest to the cutoff are the most likely to be granted an exception to the assignment policy. In speaking with Tennessee officials, it appears that many of these exceptions originate from individual counselors either promoting or demoting students due to their exceptionally close proximity to the cutoff. The subject in which the assignment to remedial courses appears to be the fuzziest is in writing. There were many exceptions given to students around the cutoff score in writing, making the use of an instrumental variable for enrollment in developmental or remedial writing an essential component in the analysis.

To address the research question in light of this fuzzy discontinuity, we adopt an instrumental variables strategy using two-stage least-squares (2SLS), treating *assignment* to developmental or remedial courses as the instrument for *enrollment* in these courses. This approach provides an estimate of the local average treatment effect (LATE) for students who complied with their assignment to remediation based on the Tennessee cutoff policy. The LATE estimates pertain only to those students who actually enrolled in a developmental or remedial mathematics, reading, or writing course. Additionally, in keeping with the critical assumption of the RD design to only examine students within a more narrow bandwidth around the cutoff (i.e., in keeping with the assumption that students are alike on either side of the cutoff), the results do not pertain to those students whose scores were well below or above the threshold.

In the first stage of the analysis, we fit a model in which we regress whether a student *enrolls* in a developmental or remedial course on whether a student was assigned to this course based on his/her COMPASS test score as follows:

$$(1) \quad DEV_i = \gamma_o + \gamma_1(ASSIGN_i) + \gamma_2(SCORE_i) + \gamma_3(Z_i) + \delta_i$$

where DEV_i is a dichotomous variable that indicates take-up of the assignment, or whether student i actually enrolled in Developmental Algebra II (1 = enrolled, 0 = otherwise). Of those students recommended for Developmental Algebra II due to their COMPASS score, 87.6 percent enroll.⁶ Less than one percent of students whose COMPASS scores are higher than the remedial cutoff score (and thus, are assigned to college-level mathematics) enroll in Developmental Algebra II. The variable $ASSIGN_i$ serves as the instrument and takes a value of 1 if students scored below the defined state cutoff on the forcing variable, and 0 otherwise. $SCORE$ is a continuous variable that measures a student's score on the COMPASS mathematics, reading, or writing exam. Finally, Z is a vector that includes information on student background and college choice, including gender, race, enrollment status in the fall of 2000, and financial need, and δ_i is a residual. For the binary outcomes, we fit a linear probability model (LPM) for which we assume normally distributed errors, and for continuous outcomes we fit ordinary least squares (OLS) models.

$ASSIGN_i$ in equation (1) is the instrument used to account for the fuzziness of the RD design. $ASSIGN_i$ is a good choice for an instrument, as it is strongly correlated with enrollment in developmental courses, but is exogenously determined by state policy (Calcagno & Long, 2008; Bloom, 2009). The probability of being assigned to developmental courses obtained from the fitted model in equation (1) is then used in the second stage statistical model to estimate the causal effect of remediation on outcome, Y_i , as follows:

$$(2) \quad Y_i = \beta_0 + \beta_1(\hat{DEV}_i) + \beta_2(SCORE_i) + \beta_3(Z_i) + \varepsilon_i$$

where ε_i is a residual. In this second-stage model, we use generic outcome Y_i to refer to one of the eight outcomes described above. The coefficient of interest in equation (2) is β_1 and it represents the causal effect of enrollment in remediation on the outcomes of interest. For continuous outcomes we specify a second-stage OLS regression model, and for the two dichotomous outcomes we fit a linear probability model using a standard maximum likelihood estimation.

⁶ The vast majority of these (over 85 percent) enroll in the fall semester. However, it may be that those who delayed enrollment in their developmental mathematics course to a later semester differ in unobserved ways from those who enroll in their first semester. To check this, we conducted sensitivity analyses by comparing the results only for students who enrolled in Developmental Algebra II in their first semester to the results for students who enrolled in a subsequent semester. None of these results differed from those for the entire sample.

In order to ensure sufficient statistical power for the analyses, we pooled the data across all colleges in the sample, rather than examining the effects within individual institutions. However, we include institutional fixed effects to account for differences between institutions, and for the nonrandom clustering of students within these institutions. It is quite likely, however, that there are different effects of being assigned to remedial courses for students attending two-year colleges compared to students attending four-year colleges (Bettinger & Long, 2007). To allow for this possible variation, we limit the sample to include only two-year colleges and only four-year colleges, which are shown in the second and third sections of all results tables.

The RD design assumes that students cannot manipulate their scores in order to make themselves fall just above or below the cutoff, and as such, the cutoff score is truly exogenous to the outcome (Shadish et al., 2002). If students could increase their probability of passing out of remediation, perhaps by retesting, then the critical assumption of the RD design would be violated. After speaking with officials in Tennessee, we learned that institutions rarely permitted students to retake their COMPASS placement exam, and that when this did occur, it was isolated to only a few institutions. In these cases, administrators were granting exceptions to students given extenuating circumstances, or based on other information provided by the student, such as prior mathematics or English courses taken in high school. These cases occurred at only a few institutions, and are not cause for concern as the IV strategy accounts for this selection.

Determining the Optimal Bandwidth Within Which to Conduct the RD Analyses

A critical component of an RD design is the selection of the bandwidth around the cutoff score within which the analysis will be conducted. In an RD specification, it is assumed that the observations to the right and left of the cutoff are equal in expectation. By selecting a smaller bandwidth near the cutoff, we gain more confidence in the functional form specified by the model. A common problem in analyzing data from an RD design is model misspecification, as the effects will be unbiased only if the functional form of the relationship between the outcome variable and the forcing variable is modeled correctly (Schochet, 2008).

We examine the sensitivity of the findings to bandwidth size empirically, using a cross-validation procedure developed by Imbens and Lempoux (2008) to estimate the optimal bandwidth, h . To estimate the optimal bandwidth for each point around the cutoff, we estimate a linear regression function to predict the probability of achieving the outcome, for example degree completion, at each point within a selected bandwidth. The residuals from each point on the left and right of the cutoff are then calculated. This process is

repeated for a series of possible bandwidths around the cutoff. Summing the squared residuals across all scores for each choice of bandwidth, we then choose the bandwidth that minimizes the sum of square residuals. Formally, this optimal bandwidth is calculated from equation (3):

$$(3) \quad h_{CV}^{\delta,opt} = \arg \min_h CV_Y^\delta(h)$$

The preferred bandwidth that we obtain using this procedure ranges depending on the discontinuity being exploited. It ranges from +/- 7 points in both writing discontinuities to +/- 5 points in the lower levels of mathematics. It is within this bandwidth that the results are most credible, and as such, we report only the results for the subsample of cases within the optimal bandwidth on either side of the cutoff.

Statistical Power Analysis

A drawback of the RD design is that much larger sample sizes are required in order to achieve outcome estimates with the same level of statistical power as one would get from a randomized control trial (Shochet, 2008). Under an RD design, the sample must be approximately 2.75 times larger than in a randomized experiment to achieve the same level of statistical power (Goldberger, 1972 as cited in Shochet, 2008; Bloom, 2009).⁷ After accounting for the use of an RD design, we estimate the statistical power of the study to be approximately 0.71 to detect effect sizes of 0.25 standard deviations for the first RD in mathematics. At the second discontinuity in mathematics, given the limited sample, we are only able to detect a very large effect size of 0.52. Given the other limitations and concerns with this particular cutoff (between upper and lower developmental math), it is unlikely that we will see effects. For RD #3 in mathematics, the power is 0.82 for the same criteria described above. The power for the upper RD in reading and writing is around 0.80 and is only slightly smaller for the lower RD in both subjects (0.74 and 0.79, respectively).

Measures

The outcomes are divided into short-, medium-, and long-term outcomes. In the short term, we explore the early persistence of students from the first to the second semester of college. Early persistence captures the probability of enrollment after the first semester. Of particular interest in studies on college remediation efforts are whether assignment to

⁷ One way to increase statistical power, is to include covariates that predict variation in the outcome (Light, Singer, & Willett, 1990; Murnane & Willett, 2011). So while an RD design will need a substantially larger sample than a randomized experiment to achieve similar statistical power, the sample size can be somewhat reduced depending on the predictive power of the covariates included in the model.

remedial courses slows students down in their early progress toward a degree so much so that they become discouraged and stop out of college. Additionally, we explore the number of credits a student has accumulated by the end of the first year.

In the intermediate, we explore the effects of remediation on whether or not a student was still enrolled in the third year of college, the total number of credits completed by the third year, and the total number of college credits completed by the third year. While the number of cumulative credits in the third year may be a good indication of student progress toward a degree, it is the number of college credits completed over time that will be most instrumental to degree attainment. Examining the data, we see that the number of total credits accumulated after three years differs little between students assigned to the higher-level mathematics, reading, or writing courses compared to students assigned to the lower-level courses. However, a larger gap exists in the number of *college* credits completed over time for students assigned to the higher compared to the lower level courses. We include both the number of total credits and the number of college credits as outcomes to further explore this gap.

We also examine students' grades in their first college-level composition or mathematics course to determine whether or not it appears that remedial or developmental courses are resulting in students being more prepared for college-level work.⁸ Particularly in mathematics and writing courses, it becomes important for students to build a solid base of skills before progressing to the next course, as more advanced courses are designed to build upon material learned in earlier courses. Passing college-level courses is an especially important milestone on the way to degree completion, and the first college-level course is often a gatekeeper to further courses in one's degree program. By including students' grades in the first college-level course as an outcome, we explore whether placement into developmental and remedial courses actually leads to improved skills that are required for college-level courses down the road.

Finally, we examine the effects on placement into remedial and developmental courses on student degree attainment after six years. Student credit accumulation and course grades are continuous variables, while persistence and degree completion are captured by a dichotomous variable equal to 1, if, for example, a student persists to the second semester or receives a college degree.

⁸ This grade is measured on a 4.0 scale, although is not an average of grades across courses, but a single grade. A 4.0 is equivalent to a student receiving an A in his/her first college-level course, a 3.67 is equivalent to receiving an A-, a 3.33 is equivalent to receiving a B+, etc.

4. Results

This paper examines the effects of being placed into remedial, developmental, or college-level courses relative to similar students placed in courses just above that level. Our results suggest that there are differences in these outcomes for students at different levels of the preparation distribution. For higher ability students (RD #1), being assigned to the lower-level mathematics course, for example, suggests negative effects on long-term college persistence and degree completion. For students in the middle of the mathematics distribution, assignment into the lower level course appears to make no statistically significant difference in students' persistence rates or eventual degree completion. For students at the lowest end of the mathematics distribution, there are small effects found at the margins for both short- and long-term enrollment outcomes. The largest negative effects were found for students on the margins of needing any developmental education; however, at the other end of the academic ability spectrum, the effects were much smaller. Students placed into lower level mathematics courses did only marginally worse than their peers who were assigned in the higher developmental course. In the writing courses, we found positive effects for those placed in lower level courses. Meanwhile, students at the top part of the ability distribution experienced negative effects from being placed in the developmental course rather than in the college-level course.

Mathematics: College-Level vs. Developmental Education (RD #1)

Table 4 begins the analysis by displaying the short-, medium-, and long-term results for students assigned to Developmental Algebra II compared to similar peers assigned to college-level mathematics. These results suggest that students recommended for Developmental Algebra II take the same amount of total credits in their first year as their peers in the college-level courses, an average of 26.6 credits in the first year. Column 1 of Table 4 shows that the differences in the total number of credits taken by students assigned to developmental mathematics compared to students assigned to college-level mathematics are very small in magnitude and are not statistically significant. Looking at the total number of credits in both remedial and college-level courses that students completed in year three, it appears that after three years, statistically significant differences in course-taking behavior begin to emerge. Graphically, these differences can be seen in Figure 3a. At the highest level of mathematics remediation, there were no statistically significant differences in the total number of credits taken by students by their third year, but there were considerable differences in the number of college-level credits taken by the end of the third year.

Students on the margins of needing mathematics remediation took nearly 6.5 fewer college-level credits by the end of their third year than their peers placed into college-level mathematics. This gap in credits was even more pronounced at the community colleges, in which students assigned to remedial mathematics took over 8.0 fewer college-level courses by the end of their third year.

Although students who placed into Developmental Algebra II appear to take fewer college-level credits by their third year, we see no real effects of placement into developmental mathematics courses on the likelihood of students stopping out during their first or second year. None of the short-term or medium-term measures of persistence (columns 2 and 3 of Table 4) are statistically significant. The last two columns of Table 4 report results for student degree completion within six years. Exploring this longer-term outcome allows us to determine if the absence of effects on stop-out behavior found in years one and two carries through into later years. Comparing students assigned to the developmental courses to those assigned to college-level courses, placement into the lower-level course in mathematics appears to have a negative effect on degree completion within six years. As shown in column 6 of Table 4, students assigned to the developmental course are less likely to complete a degree within six years than their peers assigned to college-level courses, particularly at the community colleges.

Mathematics: Upper Developmental vs. Lower Developmental Education (RD #2)

For the middle range of mathematics developmental courses, we find few statistically significant differences in student behavior for being placed into the lower developmental course (Algebra I) compared to the upper developmental course (Algebra II). As seen in Table 5 and Figure 3b, by the end of the first year, students assigned to the lower-level developmental algebra course had completed an average of 1.3 fewer total credits than their peers in the upper-developmental algebra course, but this finding was only for students enrolled in community colleges. While this trend did not carry through over time, however, we did see negative effects on the number of *college* credits completed after three years, and the magnitude of these effects is similar to the effects found in RD #1 in mathematics. Students assigned to Developmental Algebra I have taken 6.8 fewer college credits on average after three years compared to their peers assigned to Developmental Algebra II, or the equivalent of three college courses. This finding, however, does not appear to translate into a smaller likelihood of receiving a college degree, as we find no statistically significant differences in degree completion (columns 6 and 7) for students in the middle range of mathematics remediation. These results, however, should be interpreted with caution, given the aforementioned concerns with the placement process for RD #2 in mathematics.

Mathematics: Developmental vs. Remedial Education (RD #3)

Similar to the upper levels of mathematics remediation (RD #1 and RD #2), we found negative effects on the number of college credits completed after three years for students assigned to the lowest-levels of mathematics remediation (Remedial Algebra) compared to students assigned to the next highest course (Developmental Algebra I). Interestingly, however, these effects are much smaller in magnitude than for those students needing less intensive mathematics remediation. As shown in Table 6 and Figure 3c, placement into the lowest-levels of mathematics remediation results in students taking only three fewer college-level credits by the end of the third year when compared to their peers assigned to take Developmental Algebra I. At the upper end of the mathematics distribution we saw students taking 6.5 fewer college-level courses than their peers assigned to college-level mathematics. As a fraction of the total number of credits completed, this is a notable difference. So, while students assigned to the lowest levels of mathematics remediation still take fewer college-level credits after three years compared to their peers in the next highest course (RD #3), this difference does not appear to be as dramatic as for students who just barely missed the cutoff for placement into college-level mathematics (RD #1). Furthermore, we see no statistically significant differences in six-year degree completion rates at this level.

Reading: College-Level vs. Developmental Education (RD #1)

Much like in mathematics, we see few differences in the early college outcomes of students on the margins of needing reading remediation. The one exception to this occurs at the two-year colleges, where students are taking an average of 1.0 credit more in their first year, as shown in column 1 of Table 7 and in Figure 4a. This difference, however, does not appear to persist over time, as students placed into Developmental Reading consistently took fewer college-level credits than their peers placed into college-level reading courses. Students placed into Developmental Reading at the upper end of the distribution are taking over 7.0 fewer college-credits by the end of their third year. This number is even higher in the community colleges, where students are reporting 9.5 fewer college-level credits by the end of the third year. This is the equivalent of approximately three college-level courses. For students at the margins of needing remediation in reading, placement into developmental reading courses has a negative effect on degree completion within six years (statistically significant at the 15 percent level). Given the large difference in the number of college-level credits that students report after three years, it may not be surprising that students on the margins of needing remediation are less likely to complete a degree within six years than their peers assigned to college-level reading courses. This difference in degree attainment is only statistically significant when looking across all colleges, however, and cannot be detected in a smaller subsample of two and four-year institutions.

Reading: Developmental vs. Remedial Education (RD #2)

For the lowest end of the reading distribution (Table 8 and Figure 4b), we only see an effect of being placed into Remedial Reading on the number of college-level credits a student completed by the end of the third year, and on eventual degree completion at the two-year colleges. Much like in mathematics, the magnitude of these effects in reading is smaller at the lower end of the academic spectrum than at the higher end. Whereas students placed into Developmental Reading at the upper end of the distribution are taking over 7.0 fewer college-credits by the end of their third year, students at the lower end are taking 4.6 fewer credits. For the lower levels of reading, we see no statistically significant difference in six-year degree completion rates at these levels, with the exception being in reading at the two-year colleges.

Writing: College-Level vs. Developmental Education (RD #1)

Only when comparing students assigned to developmental writing to students assigned to college composition do we see statistically significant differences in persistence in the first year. Students on the margins of needing writing remediation (i.e., those recommended for Developmental Writing) were less likely to enroll in their second year compared to their peers assigned to college composition (Table 9). The difference, however, disappears by the third year, as we no longer see a difference in enrollment patterns for these same students. Students placed into the upper levels of developmental writing also reported taking an average of 1.0 to 1.5 fewer total credits in their first year, as compared to their peers in college composition courses, and these results are consistent across institutional type. This trend persists over time, and we see negative effects on the number of college-credits students have taken by the end of the third year, with students on the margins of needing Remedial Writing taking an average of 5.2 fewer college-level credits over time as compared to their peers placed into college composition.

Writing: Developmental vs. Remedial Education (RD #2)

Students assigned to the lowest-level of writing (Remedial Writing) are actually taking 4.0 *more* total credits by the end of their third year when compared to students assigned to Developmental Writing, but we see no differences in the number of college-level credits completed after one or three years (Table 10 and Figure 5b). This result is similar to those found in other work, in which small effects of being placed into remedial courses in early years disappear in subsequent years (e.g., Calcagno & Long, 2008). At the lowest-levels of writing, however, it appears that students assigned to Remedial Writing are more likely to be enrolled in college in their third consecutive year than their peers assigned to Developmental Writing (Table 10). These students also attained a degree (associates or

bachelors) at higher rates as compared to their peers in the next highest level of Developmental Writing. The trends we saw previously in mathematics and reading seem to reverse here: Placement into the lowest level of Remedial Writing appears to have positive effects on student persistence, college-level credit accumulation, and degree completion.

Grade in First College-Level Course

Although not causal, we also investigate the effects of being assigned to remedial courses on students grades in their first college-level course. The majority of students assigned to college-level courses complete this course in their first semester (85 percent), with over 95 percent completing it by the end of their first year. For students assigned to take Developmental Algebra II, for example, slightly over half subsequently take their first college-level mathematics course in the second semester of their first year. The primary reason for offering remedial courses is to help prepare students to complete college-level work in subsequent courses. Remediation programs rest on the assumption that taking developmental mathematics prepares one to be successful in college-level mathematics down the road. In Table 11, we see no statistically significant differences in students' grade in their first college-level mathematics or reading courses. It appears that students assigned to Remedial or Developmental Writing, however, ultimately do perform better in their first college-level composition course than students assigned to the next highest level course. Students in the most need of remedial writing completed their first college-level composition course with a GPA that is 0.54 points higher than their peers who enrolled directly in college-level composition courses. It is worth noting, however, that the average grade in the first college-level composition course is around a 2.16, or the equivalent of a C, which means that the average effect of enrolling in developmental composition is equivalent to raising one's grade from a C to a C+. This is not a large jump, but it is a statistically significant effect. Again, these results are not causal, so we cannot conclude that the remedial or developmental courses were the cause of the better performance in the first college-level course. It could be the case that students with the characteristics to persevere through remedial programs have the traits that would also make them successful in later courses. Still, it is interesting to see the higher level of achievement for students once deemed unprepared for college.

5. Conclusion and Implications

The effects of college remediation on credit accumulation, persistence, and graduation are of great interest to college administrators, policymakers, and taxpayers. In this study, we add to the existing literature by exploring remediation in a new context and for students with differing levels of prior academic ability. We find that effects on student credit accumulation do differ for students on the margins of needing remedial courses. Over time, students taking developmental and remedial mathematics courses accumulate fewer total college-level credits than their peers who take the next highest level of mathematics courses. By the end of the third year, students at the upper ends of the mathematics preparation distribution have taken about six college credits less than their peers, and students at the lower end have taken three fewer college-level credits. In the early years, however, we do not detect any observable differences in college persistence, although the effects appear to differ based on the type of institution a student attends (two versus four-year institutions). In the writing courses, we found positive effects for those placed in lower level, remedial courses relative to those placed in developmental courses. For example, students in the lowest levels of remedial writing persisted through college and attained a degree at higher rates than their peers in the next highest level course. It may be that the skills obtained through remedial writing courses are so fundamental to success in other courses that the acquisition of these skills resulted in improved academic performance and persistence in the long term. Students who took remedial writing courses also received higher grades in their first college-level writing course, indicating that some remedial courses are indeed helpful in preparing students for college-level work.

Our analysis suggests that the effects of remediation are far more nuanced than previously thought. Recent rigorous research has given us mixed, mostly negative estimates of the effects of developmental courses, but until now, the analysis has been limited to students needing only one or two classes. As we have shown, it appears that the effects of providing below-college-level courses varies along the student ability distribution: While developmental courses for students at the margin of needing any remediation have mostly negative effects, the impact of such courses for students with lower levels of preparation can be positive or have much smaller effects. In essence, remedial and developmental courses help or hinder students differently depending on their levels of academic preparedness. Therefore, states and schools need not treat remediation as a singular policy but instead should consider it as an intervention that might vary in its impact according to student needs.

The results present an interesting puzzle about why remedial and developmental courses have such different effects by student ability. Understanding the reasons for the differences could spur some insight into how to make *all* developmental and remedial courses effective. It may also be the case that remediation is not needed for as many students as currently placed. Our research methodology is based on the fact that placement exams are noisy measures of students' true ability, and our results, along with those from the literature, suggest more careful consideration of how to measure which students truly need below-college-level help.

Colleges and universities should also focus their efforts on helping students assigned to remedial courses to make continued progress toward their degrees. While taking remedial courses may not have large effects on short-term persistence, it does affect the number of college-level credits a student has completed by the end of the third year. Credit accumulation may be the reasons why students in need of remediation obtain degrees at rates lower than their peers. For this reason, it is important to consider ways in which students can complete their remedial requirements, yet not be deterred from taking additional courses. It is also important to understand why some students pass their first college-level courses after taking remedial composition courses while others do not. Answers to these questions could help to better identify strategies to improve remediation programs.

These findings are particularly relevant for Tennessee today, as the state recently redesigned their remedial courses with the hope of improving effectiveness. During the 2009–10 academic year, the state began piloting three redesigns of their instructional approaches with the goal of allowing students to spend less time in remedial courses. In these pilot programs, students complete their remedial coursework in modules outside of their regular courses. These modules require much less time and money on the part of the student and are designed to pinpoint instruction to only those mathematics skills the student needs. Given that our findings suggest that the old developmental courses did not have large positive effects on outcomes for students on the margins of remedial placement, except at the lowest level of writing, these more focused reform efforts may be a welcome solution.

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Appendix A: Figures

Figure 1a: Remedial Mathematics Placement Policy in Tennessee, Fall 2000

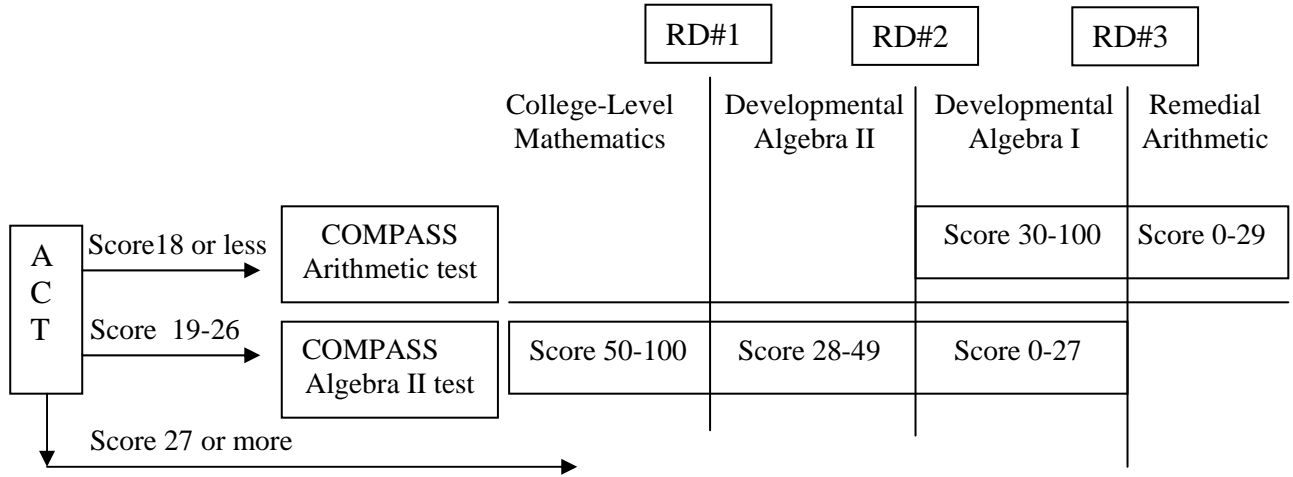


Figure 1b: Remedial Reading Placement Policy in Tennessee, Fall 2000

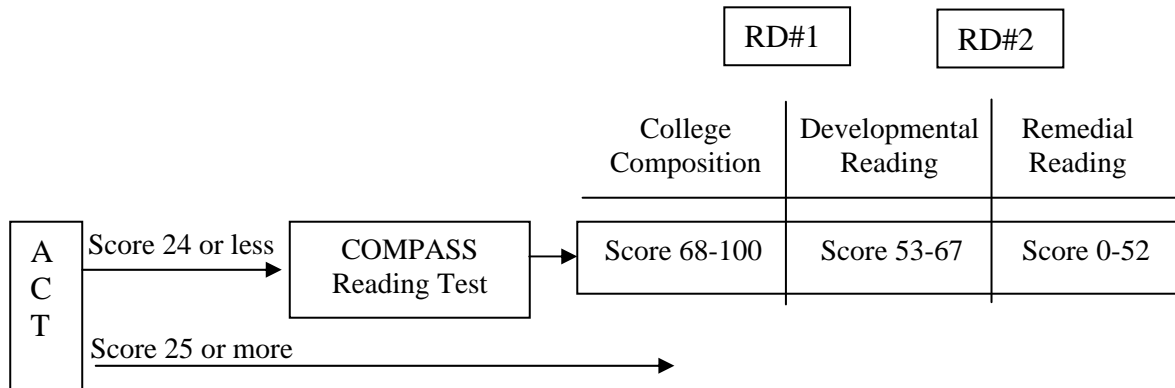


Figure 1c: Remedial Writing Placement Policy in Tennessee, Fall 2000

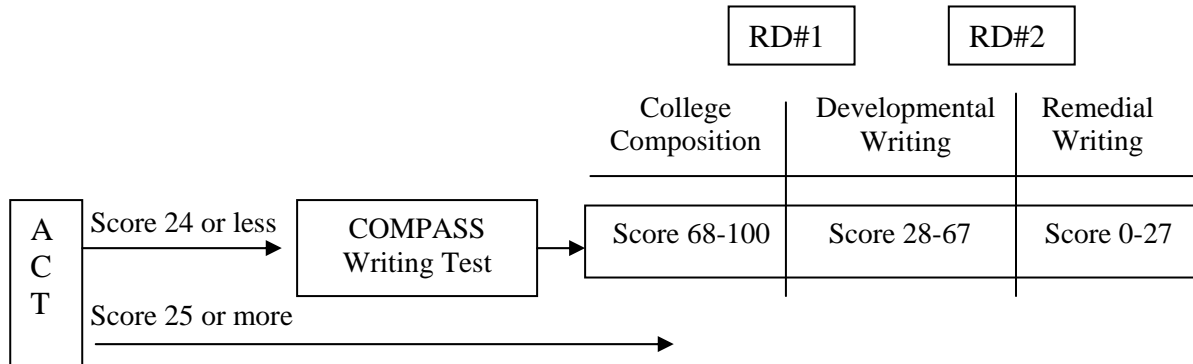


Figure 2a: Raw Distribution of Scores on the COMPASS Mathematics Exams by Recommended Level of Remediation

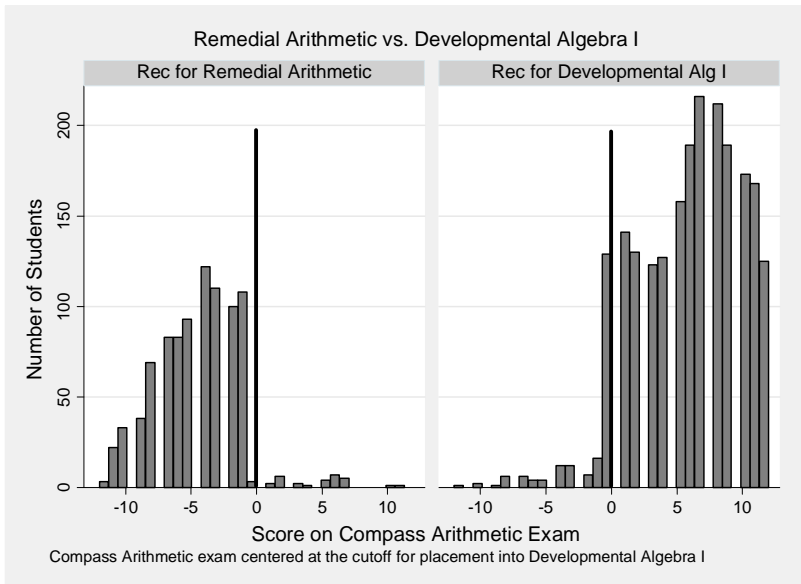
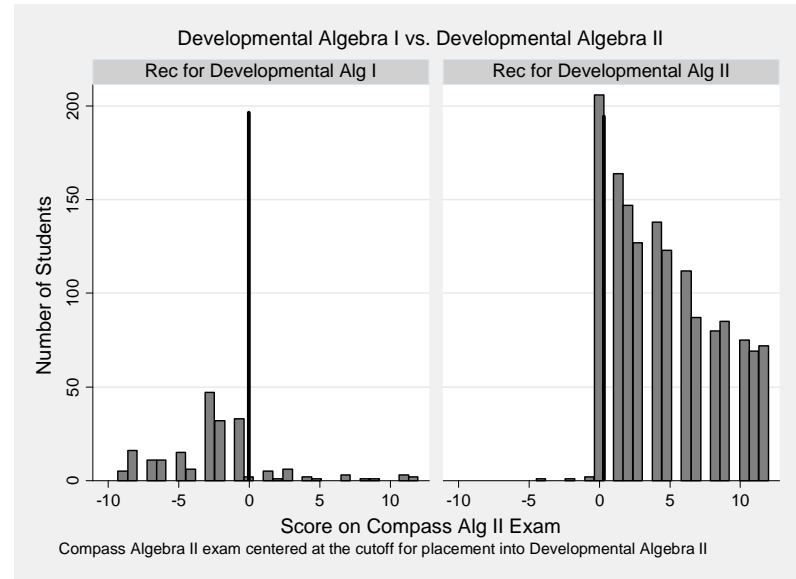
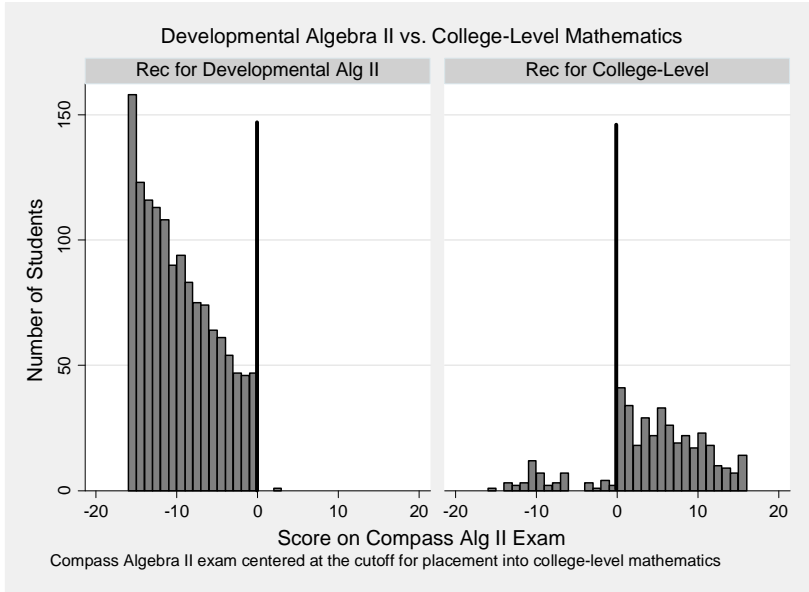


Figure 2b: Raw Distribution of Scores on the COMPASS Reading Exams by Recommended Level of Remediation

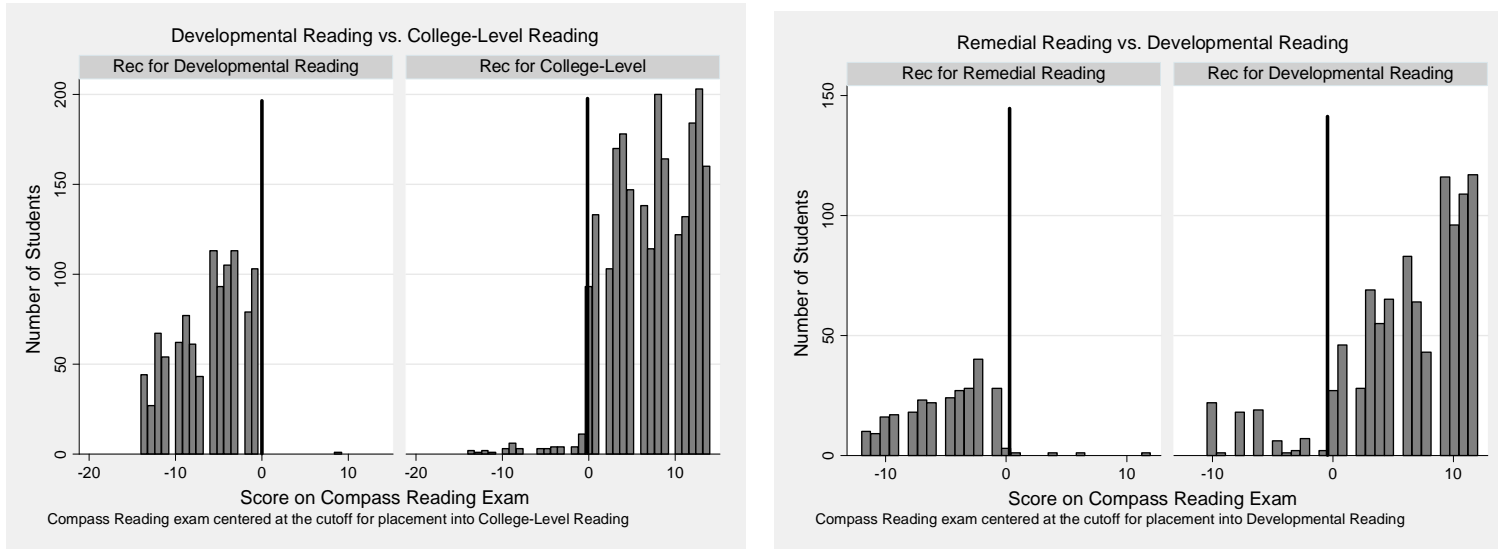


Figure 2c: Raw Distribution of Scores on the COMPASS Writing Exams by Recommended Level of Remediation

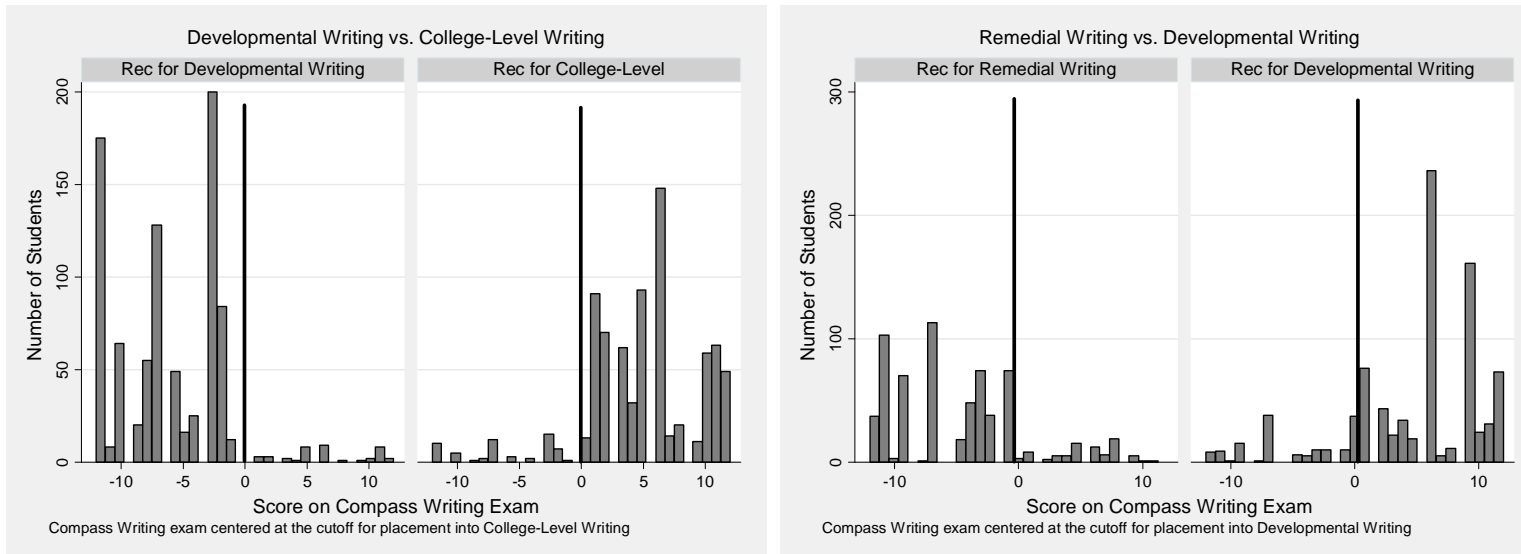
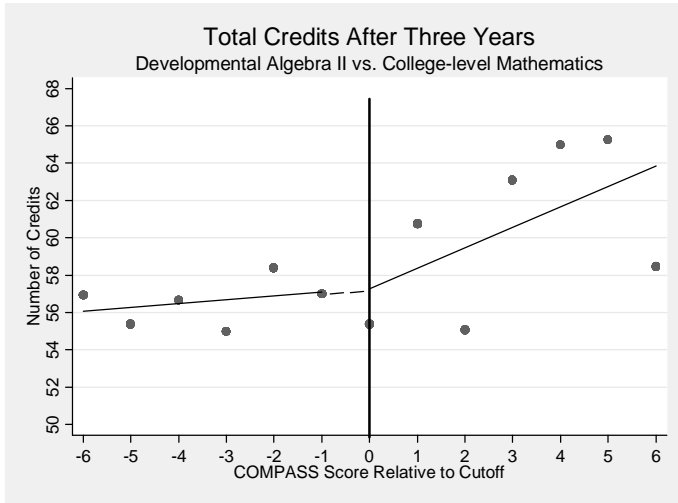


Figure 3a: Mathematics – College-Level vs. Developmental Course in (RD #1)

No statistically significant effect



Statistically significant effect

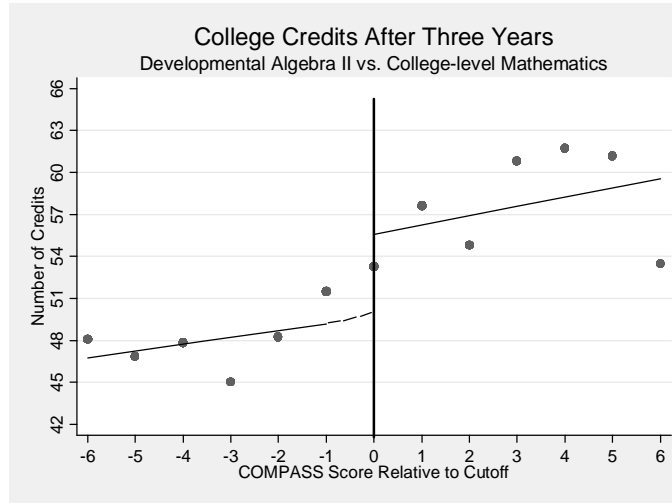
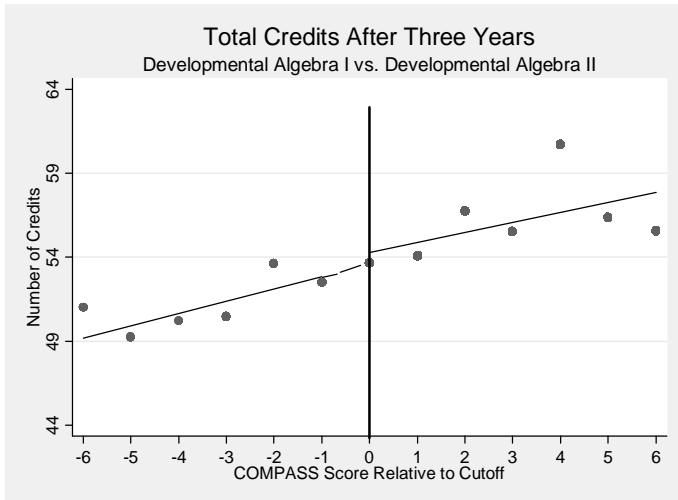


Figure 3b: Mathematics – Upper Developmental vs. Lower Developmental Course (RD #2)

No statistically significant effect



Statistically significant effect

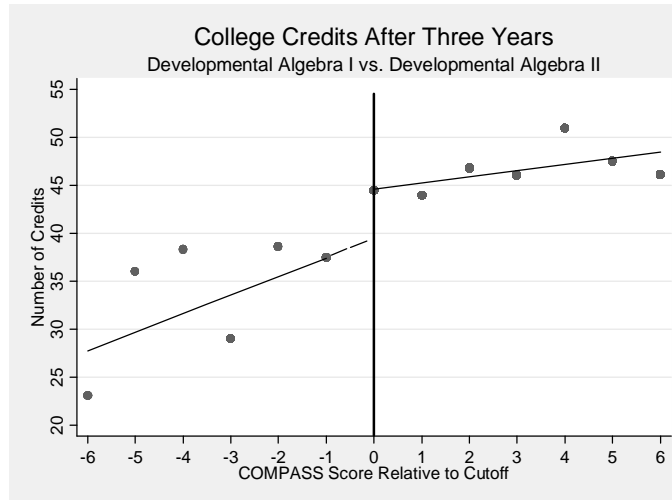
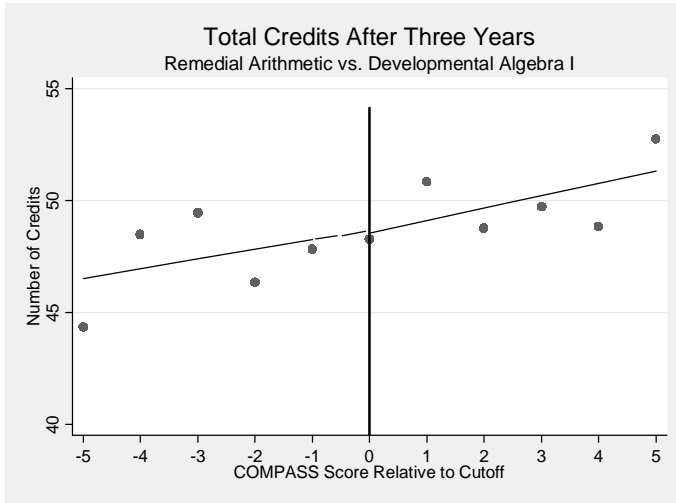


Figure 3c: Mathematics – Developmental vs. Remedial Course (RD #3)

No statistically significant effect



Statistically significant effect

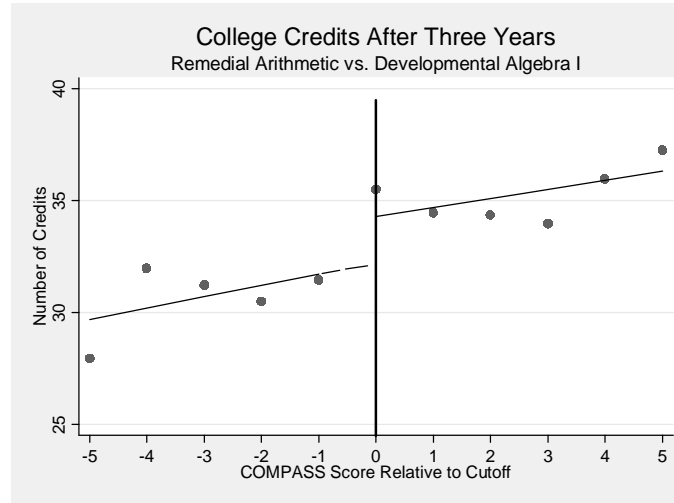
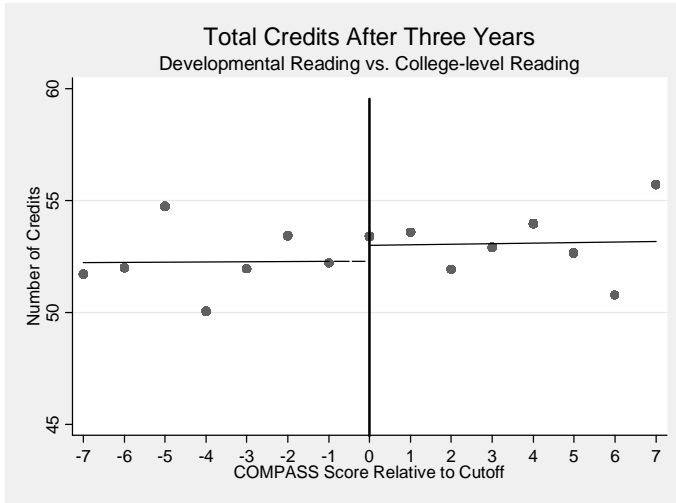


Figure 4a: Reading – College-Level vs. Developmental Course (RD #1)

No statistically significant effect



Statistically significant effect

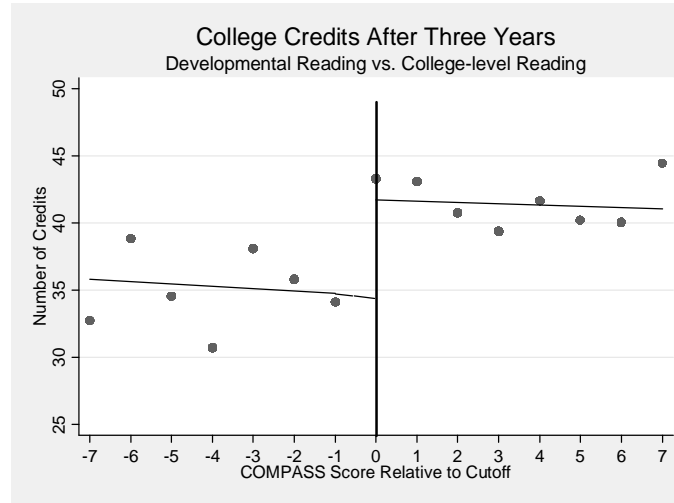
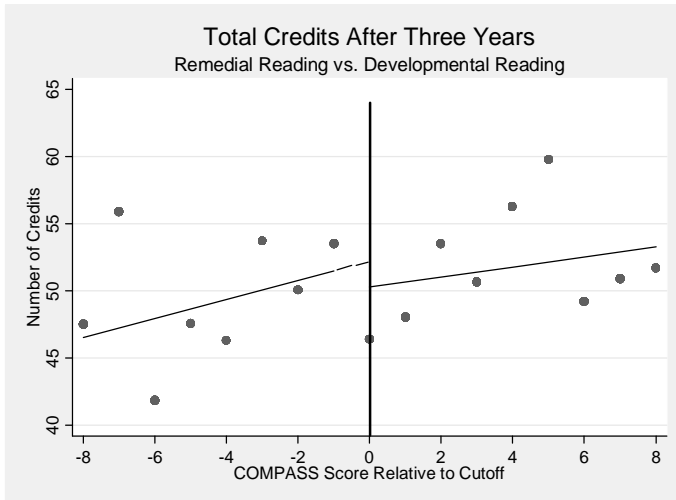


Figure 4b: Reading – Developmental vs. Remedial Course (RD #2)

No statistically significant effect



Statistically significant effect

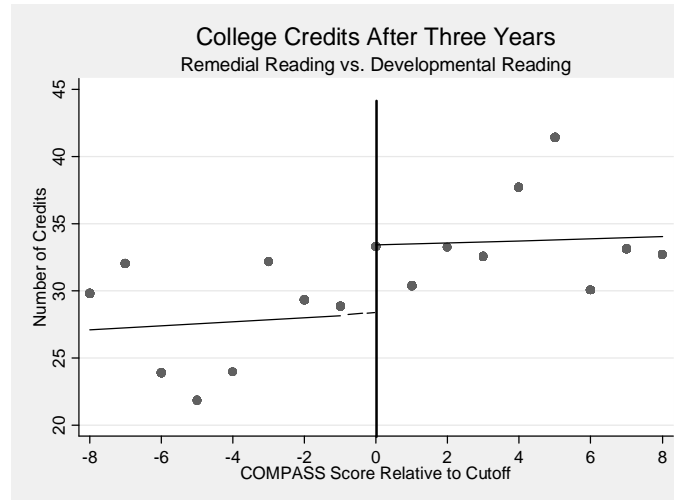
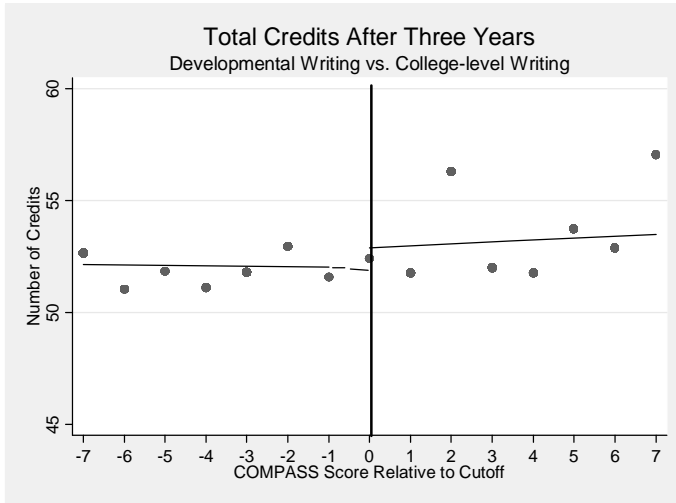


Figure 5a: Writing – College-Level vs. Developmental Course (RD #1)

No statistically significant effect



Statistically significant effect

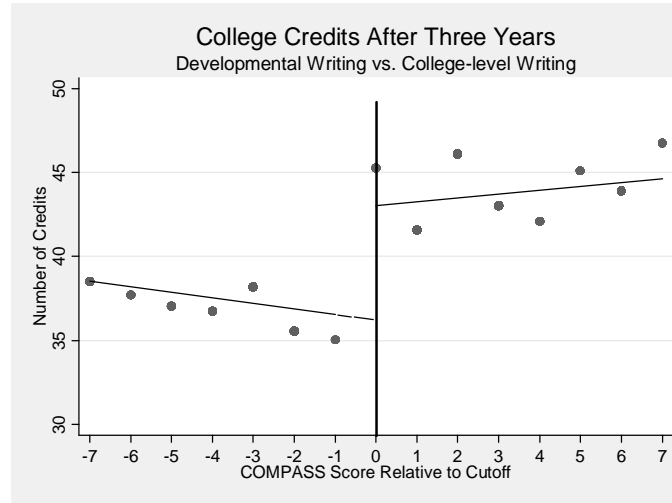
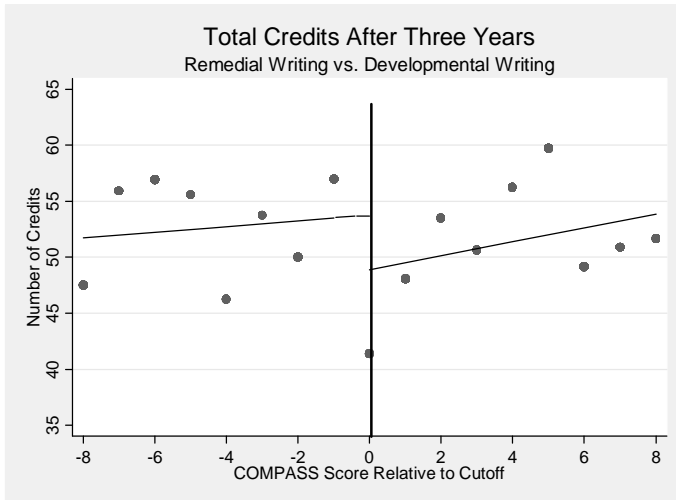
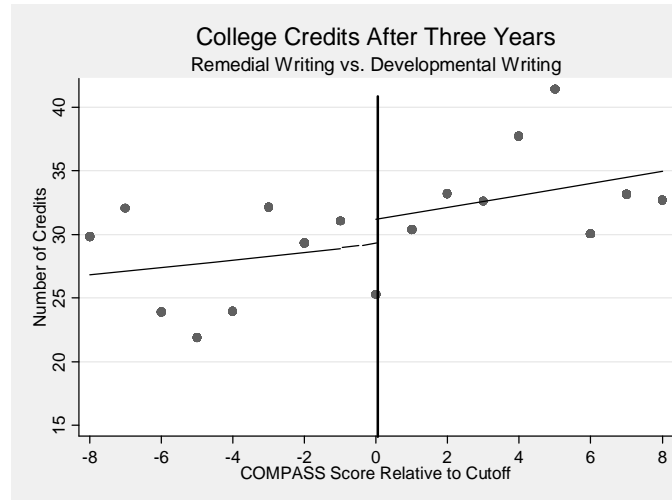


Figure 5b: Writing – Developmental vs. Remedial Course (RD #2)

Statistically significant effect



No statistically significant effect



Appendix B: Tables

Table 1a: Course Assignment Distribution for Those Students Taking a COMPASS Placement Exam – Math

RD#1: College-Level vs. Developmental Education <i>Optimal Bandwidth: +/- 6 points</i>			RD #2: Upper Developmental vs. Lower Developmental Education <i>Optimal Bandwidth: +/- 6 points</i>			RD #3: Developmental vs. Remedial Education <i>Optimal Bandwidth: +/- 5 points</i>		
Took the Test	Recomm. College Level	Recomm. Develop. Algebra 2	Took the Test	Recomm. Develop. Algebra 2	Recomm. Develop. Algebra 1	Took the Test	Recomm. Develop. Algebra 1	Recomm. Remedial Arithmetic
Full sample								
704	42.33%	57.67%	2,175	86.90%	13.10%	2,532	56.79%	43.21%
Four-Year Institutions								
316	43.99%	56.01%	812	92.36%	7.64%	672	59.67%	40.33%
Two-Year Institutions								
399	40.98%	59.02%	1,363	83.64%	16.36%	1,860	55.75%	44.25%

Table 1b: Course Assignment Distribution for Those Students Taking a COMPASS Placement Exam – Reading and Writing

READING						WRITING					
RD#1: College-Level vs. Developmental Education <i>Optimal Bandwidth: +/- 6 points</i>			RD #2: Developmental vs. Remedial Education <i>Optimal Bandwidth: +/- 7 points</i>			RD#1: College-Level vs. Developmental Education <i>Optimal Bandwidth: +/- 7 points</i>			RD #2: Developmental vs. Remedial Education <i>Optimal Bandwidth: +/- 7 points</i>		
Took the Test	Recomm. College Level	Recomm. Develop. Reading	Took the Test	Recomm. Develop. Reading	Recomm. Remedial Reading	Took the Test	Recomm. College Level	Recomm. Develop. Writing	Took the Test	Recomm. Develop. Writing	Recomm. Remedial Writing
Full sample											
2,318	63.37%	36.63%	1,055	73.55%	26.45%	1,879	50.29%	49.71%	1,540	53.90%	46.10%
Four-Year Institutions											
687	65.36%	34.64%	254	73.62%	26.38%	497	55.13%	44.87%	406	58.37%	41.63%
Two-Year Institutions											
1,631	62.54%	37.46%	801	73.53%	26.47%	1,382	48.55%	51.45%	1,134	52.29%	47.71%

Table 2: Summary Statistics of the Sample around the Mathematics Placement Cutoffs

	RD#1: College-Level vs. Developmental Education <i>Optimal Bandwidth: +/- 6 points</i>			RD #2: Upper Developmental vs. Lower Developmental Education <i>Optimal Bandwidth: +/- 6 points</i>			RD #3: Developmental vs. Remedial Education <i>Optimal Bandwidth: +/- 5 points</i>		
	Recomm. College Level	Recomm. Develop. Algebra 2	t-test	Recomm. Develop. Algebra 2	Recomm. Develop. Algebra 1	t-test	Recomm. Develop. Algebra 1	Recomm. Remedial Arithmetic	t-test
	Female	0.596	0.618	0.521	0.590	0.546	1.074	0.608	0.593
White	0.713	0.753	1.014	0.767	0.745	0.628	0.632	0.573	2.204
Black	0.239	0.209	0.818	0.201	0.223	0.675	0.346	0.393	1.786
Hispanic	0.000	0.015	1.835	0.012	0.024	1.344	0.009	0.012	0.605
Other Race	0.046	0.025	1.614	0.019	0.006	1.194	0.011	0.019	1.259
Age in 2000	18.07 (0.55)	18.09 (0.57)	0.278	18.10 (0.57)	18.32 (0.65)	2.533	18.24 (0.67)	18.27 (0.68)	0.779
Took ACT	0.967	0.984	1.314	0.989	0.975	0.500	0.980	0.980	0.023
ACT Composite Score	19.17 (2.41) [206]	18.92 (2.47) [315]	1.150	18.43 (2.46) [1476]	17.80 (2.69) [156]	2.014	16.15 (2.61) [842]	15.92 (2.53) [540]	1.387
ACT Math Score	17.32 (1.56) [206]	17.21 (1.47) [315]	0.830	16.62 (1.42) [1476]	16.13 (1.62) [156]	2.035	15.17 (1.58) [842]	14.94 (1.56) [540]	1.918
High School GPA	2.97 (0.50) [206]	2.93 (0.56) [315]	0.830	2.85 (0.56) [1476]	2.79 (0.66) [156]	1.162	2.65 (0.60) [842]	2.61 (0.59) [540]	1.167
Need-based Aid received	0.281	0.306	0.607	0.292	0.366	1.936	0.314	0.306	0.301
Merit-based Aid received	0.145	0.131	0.469	0.146	0.099	2.099	0.122	0.108	0.760
Began at a Four- Year College	0.563	0.481	1.861	0.448	0.279	3.108	0.348	0.333	0.546
Observations	213	320		1492	161		859	551	

NOTE: Standard errors are shown in parentheses. When fewer than the total number of observations is used, the number of observations is shown in brackets. The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS mathematics exam (either the COMPASS Arithmetic or COMPASS Algebra II, as detailed in Figure 1a).

Table 3: Summary Statistics of the Sample around the Reading and Writing Placement Cutoffs

	READING						WRITING					
	RD#1: College-Level vs. Developmental Education			RD #2: Developmental vs. Remedial Education			RD#1: College-Level vs. Developmental Education			RD #2: Developmental vs. Remedial Education		
	<i>Optimal Bandwidth: +/- 7 points</i>			<i>Optimal Bandwidth: +/- 8 points</i>			<i>Optimal Bandwidth: +/- 7 points</i>			<i>Optimal Bandwidth: +/- 8 points</i>		
	Recomm. College Level	Recomm. Develop. Reading	t-test	Recomm. Develop. Reading	Recomm. Remedial Reading	t-test	Recomm. College Level	Recomm. Develop. Writing	t-test	Recomm. Develop. Writing	Recomm. Remedial Writing	t-test
Female	0.573	0.597	0.951	0.630	0.560	1.702	0.548	0.525	0.763	0.528	0.520	0.254
White	0.627	0.537	3.553	0.578	0.439	3.308	0.710	0.718	0.295	0.598	0.465	4.167
Black	0.342	0.430	3.560	0.373	0.489	2.814	0.255	0.250	0.220	0.353	0.489	4.285
Hispanic	0.009	0.008	0.173	0.016	0.000	1.841	0.007	0.011	0.701	0.009	0.016	1.056
Other Race	0.021	0.023	0.253	0.031	0.070	2.277	0.026	0.020	0.686	0.038	0.028	0.819
Age in 2000	18.18 (0.61)	18.16 (0.65)	0.764	18.21 (0.70)	18.31 (0.67)	1.588	18.15 (0.64)	18.18 (0.65)	0.732	18.27 (0.67)	18.26 (0.68)	0.224
Took ACT	0.980	0.978	0.315	0.970	0.974	0.305	0.978	0.979	0.110	0.980	0.976	0.402
ACT Composite Score	16.11 (1.79) [972]	15.86 (1.83) [593]	1.856	15.17 (2.14) [460]	14.85 (2.06) [193]	1.876	17.18 (0.64) [551]	16.94 (1.98) [529]	1.867	16.07 (2.15) [540]	15.61 (2.19) [411]	2.380
ACT English Score	15.31 (3.02) [972]	14.63 (2.95) [593]	2.378	13.39 (3.33) [460]	12.91 (3.34) [193]	1.945	15.86 (2.33) [551]	15.62 (2.47) [529]	1.351	14.22 (2.63) [540]	13.78 (2.84) [411]	1.927
High School GPA	2.71 (0.59) [972]	2.67 (0.57) [593]	1.088	2.65 (0.59) [460]	2.48 (0.55) [193]	2.418	2.79 (0.58) [551]	2.74 (0.61) [529]	1.317	2.64 (0.60) [540]	2.55 (0.57) [411]	1.246
Need-based Aid received	0.319	0.295	1.026	0.329	0.353	0.610	0.296	0.266	1.101	0.339	0.325	0.457
Merit-based Aid received	0.114	0.115	0.090	0.118	0.121	0.111	0.111	0.127	0.812	0.096	0.116	1.018
Began at a Four-Year College	0.374	0.330	1.795	0.327	0.282	1.124	0.388	0.298	2.185	0.350	0.313	1.202
Observations	991	606		474	198		563	540		551	421	

NOTE: Standard errors are shown in parentheses. When fewer than the total number of observations is used, the number of observations is shown in brackets. The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS reading or writing exam.

Table 4: College-Level vs. Developmental Education in Mathematics (RD #1)**Optimal Bandwidth: +/- 6 points**

	EARLY OUTCOMES		MEDIUM-TERM OUTCOMES			COMPLETION AFTER 6 YRS	
	Total Credits Completed after 1 year	1 st to 2 nd Semester Persistence	Still Enrolled in Year 3	Total Credits Completed after 3 years	College Credits Completed after 3 years	Completed any Degree or Certificate	Completed a Bachelor's Degree
FULL SAMPLE							
Assigned to the Lower-level course	-0.3111 (0.5733)	-0.0230 (0.1774)	-0.0628 (0.1355)	-1.4753 (2.6086)	-6.4105** (2.6360)	-0.2333* (0.1297)	-0.0136 (0.1530)
Outcome Mean	26.59	0.877	0.582	61.02	54.23	0.352	0.222
Observations	490	485	490	490	490	490	490
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-0.6799 (0.6916)	-0.1488 (0.2683)	0.0758 (0.1827)	-0.9504 (3.3765)	-4.8965 (3.4042)	-0.1176 (0.1687)	-0.0728 (0.1813)
Outcome Mean	27.40	0.912	0.669	66.32	61.73	0.371	0.331
Observations	263	263	263	263	263	263	263
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	0.3674 (0.9728)	0.1853 (0.2604)	-0.2331 (0.2107)	-2.1376 (4.1381)	-8.3325** (4.1780)	-0.4397** (0.2080)	-0.5754 (0.4086)
Outcome Mean	25.75	0.839	0.490	55.43	46.34	0.333	0.107
Observations	227	227	227	227	227	227	227

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS math exam.

Table 5: Upper Developmental vs. Lower Developmental Education in Mathematics (RD #2)
Optimal Bandwidth: +/- 6 points

	EARLY OUTCOMES		MEDIUM-TERM OUTCOMES			COMPLETION AFTER 6 YRS	
	Total Credits Completed after 1 year	1 st to 2 nd Semester Persistence	Still Enrolled in Year 3	Total Credits Completed after 3 years	College Credits Completed after 3 years	Completed any Degree or Certificate	Completed a Bachelor's Degree
FULL SAMPLE							
Assigned to the Lower-level course	-0.8843 (0.6101)	-0.0910 (0.1476)	-0.0360 (0.1290)	-0.8826 (2.6054)	-6.8230*** (2.5605)	-0.1166 (0.1358)	-0.1750 (0.1840)
Outcome Mean	26.59	0.877	0.582	61.02	54.23	0.352	0.222
Observations	1562	1562	1562	1562	1562	1562	1562
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	0.5717 (1.2286)	0.0397 (0.4063)	-0.2006 (0.2973)	0.1696 (5.8834)	-5.2957 (5.9278)	-0.2235 (0.2750)	-0.2333 (0.3112)
Outcome Mean	27.39	0.913	0.669	66.32	61.73	0.371	0.331
Observations	697	697	697	697	697	697	697
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-1.3529* (0.7338)	-0.0687 (0.1728)	-0.0297 (0.1453)	-2.1642 (2.8820)	-8.1737*** (2.7701)	-0.0984 (0.1579)	-0.2096 (0.2395)
Outcome Mean	25.74	0.839	0.490	55.43	46.34	0.333	0.107
Observations	865	865	865	865	865	865	865

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS math exam.

Table 6: Developmental vs. Remedial Education in Mathematics (RD #3)**Optimal Bandwidth: +/- 5 points**

	EARLY OUTCOMES		MEDIUM-TERM OUTCOMES			COMPLETION AFTER 6 YRS	
	Total Credits Completed after 1 year	1 st to 2 nd Semester Persistence	Still Enrolled in Year 3	Total Credits Completed after 3 years	College Credits Completed after 3 years	Completed any Degree or Certificate	Completed a Bachelor's Degree
FULL SAMPLE							
Assigned to the Lower-level course	0.0596 (0.4165)	0.0389 (0.1017)	-0.0017 (0.0873)	0.0524 (1.7409)	-3.0366* (1.5681)	-0.1227 (0.1009)	-0.1393 (0.1230)
Outcome Mean	25.10	0.802	0.478	53.33	36.44	0.201	0.115
Observations	1279	1279	1279	1279	1279	1279	1279
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-0.4030 (0.6202)	-0.1431 (0.2103)	-0.1787 (0.1531)	-3.2922 (3.0729)	-5.7550** (2.9051)	-0.2475 (0.1597)	-0.1718 (0.1636)
Outcome Mean	27.46	0.896	0.617	65.42	51.33	0.308	0.267
Observations	469	469	469	469	469	469	469
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	0.3597 (0.5473)	0.1334 (0.1179)	0.1033 (0.1083)	2.2181 (2.0909)	-1.2294 (1.8187)	-0.0140 (0.1335)	-0.0497 (0.2070)
Outcome Mean	23.88	0.753	0.406	47.08	28.73	0.146	0.036
Observations	810	810	810	810	810	810	810

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS math exam.

Table 7: College-Level vs. Developmental Education in Reading (RD #1)

Optimal Bandwidth: +/- 7 points

	EARLY OUTCOMES		MEDIUM-TERM OUTCOMES			COMPLETION AFTER 6 YRS	
	Total Credits Completed after 1 year	1 st to 2 nd Semester Persistence	Still Enrolled in Year 3	Total Credits Completed after 3 years	College Credits Completed after 3 years	Completed any Degree or Certificate	Completed a Bachelor's Degree
FULL SAMPLE							
Assigned to the Lower-level course	0.3930 (0.3993)	0.1062 (0.0994)	-0.0712 (0.0853)	-0.1537 (1.6805)	-7.3924*** (1.5918)	-0.1344+ (0.0898)	-0.1637 (0.1114)
Outcome Mean	25.28	0.807	0.533	55.91	41.91	0.249	0.155
Observations	1497	1497	1497	1497	1497	1497	1497
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-0.6790 (0.5913)	-0.1752 (0.2151)	0.0825 (0.1594)	1.7533 (3.0358)	-4.1206 (3.0274)	-0.1424 (0.1506)	-0.1688 (0.1612)
Outcome Mean	27.72	0.912	0.682	68.44	56.37	0.358	0.318
Observations	559	559	559	559	559	559	559
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	0.9108* (0.5245)	0.1821 (0.1108)	-0.1813* (0.1029)	-1.5519 (2.0221)	-9.5066*** (1.8544)	-0.1526 (0.1157)	-0.2564 (0.1738)
Outcome Mean	23.83	0.744	0.445	48.45	32.38	0.184	0.059
Observations	938	938	938	938	938	938	938

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS reading exam.

Table 8: Developmental vs. Remedial Education in Reading (RD #2)**Optimal Bandwidth: +/- 8 points**

	EARLY OUTCOMES		MEDIUM-TERM OUTCOMES			COMPLETION AFTER 6 YRS	
	Total Credits Completed after 1 year	1 st to 2 nd Semester Persistence	Still Enrolled in Year 3	Total Credits Completed after 3 years	College Credits Completed after 3 years	Completed any Degree or Certificate	Completed a Bachelor's Degree
FULL SAMPLE							
Assigned to the Lower-level course	-0.3524 (0.6844)	-0.0609 (0.1740)	0.1743 (0.1489)	0.8216 (2.9040)	-4.6431* (2.6439)	-0.2411 (0.1835)	-0.0986 (0.2478)
Outcome Mean	25.52	0.830	0.491	54.75	34.72	0.194	0.096
Observations	623	623	623	623	623	623	623
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-0.5724 (0.8805)	0.5099 (0.4107)	0.3657 (0.2585)	0.7172 (4.8797)	-3.5387 (4.8739)	0.0221 (0.2531)	0.0500 (0.2610)
Outcome Mean	27.92	0.927	0.660	68.16	51.16	0.315	0.262
Observations	206	206	206	206	206	206	206
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-0.3788 (0.9339)	0.0233 (0.2095)	0.1162 (0.1876)	0.9898 (3.5771)	-5.0290 (3.0799)	-0.4713* (0.2668)	-0.8278 (0.7304)
Outcome Mean	24.34	0.782	0.408	48.13	26.60	0.134	0.014
Observations	417	417	417	417	417	417	417

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS reading exam.

Table 9: College-Level vs. Developmental Education in Writing (RD #1)**Optimal Bandwidth: +/- 7 points**

	EARLY OUTCOMES		MEDIUM-TERM OUTCOMES			COMPLETION AFTER 6 YRS	
	Total Credits Completed after 1 year	1 st to 2 nd Semester Persistence	Still Enrolled in Year 3	Total Credits Completed after 3 years	College Credits Completed after 3 years	Completed any Degree or Certificate	Completed a Bachelor's Degree
FULL SAMPLE							
Assigned to the Lower-level course	-1.3566*** (0.4723)	-0.2349** (0.1177)	0.0173 (0.0996)	-0.6468 (2.0478)	-5.2471*** (1.9341)	0.0989 (0.1081)	0.0923 (0.1308)
Outcome Mean	25.38	0.816	0.527	56.38	44.69	0.292	0.165
Observations	1018	1018	1018	1018	1018	1018	1018
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-1.1288* (0.5988)	-0.2360 (0.2210)	0.1617 (0.1619)	1.7309 (3.2018)	-2.0349 (3.1653)	0.1982 (0.1626)	0.1891 (0.1648)
Outcome Mean	27.83	0.907	0.634	67.31	58.44	0.383	0.347
Observations	366	366	366	366	366	366	366
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-1.5859** (0.6737)	-0.2457* (0.1439)	-0.0473 (0.1294)	-2.2474 (2.6645)	-7.3279*** (2.4366)	0.0035 (0.1488)	-0.0532 (0.2094)
Outcome Mean	24.02	0.766	0.467	50.28	37.04	0.242	0.064
Observations	652	652	652	652	652	652	652

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS writing exam.

Table 10: Developmental vs. Remedial Education in Writing (RD #2)
Optimal Bandwidth: +/- 8 points

	EARLY OUTCOMES		MEDIUM-TERM OUTCOMES			COMPLETION AFTER 6 YRS	
	Total Credits Completed after 1 year	1 st to 2 nd Semester Persistence	Still Enrolled in Year 3	Total Credits Completed after 3 years	College Credits Completed after 3 years	Completed any Degree or Certificate	Completed a Bachelor's Degree
FULL SAMPLE							
Assigned to the Lower-level course	0.4092 (0.6548)	0.0664 (0.1524)	0.2197+ (0.1378)	3.9792+ (2.7198)	-0.4107 (2.5282)	0.3057* (0.1623)	0.3402* (0.2038)
Outcome Mean	24.80	0.785	0.500	53.22	36.12	0.187	0.111
Observations	898	898	898	898	898	898	898
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	-1.0377 (0.7709)	-0.2335 (0.2544)	0.0713 (0.1970)	-0.6326 (4.0214)	-3.2463 (3.9283)	0.2226 (0.2011)	0.2761 (0.2045)
Outcome Mean	27.18	0.887	0.670	66.74	52.92	0.291	0.269
Observations	309	309	309	309	309	309	309
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	1.2481 (0.9836)	0.2150 (0.2002)	0.3446* (0.1927)	6.9964* (3.6959)	1.7769 (3.3119)	0.3913 (0.2530)	0.3305 (0.4254)
Outcome Mean	23.55	0.732	0.407	46.13	27.31	0.132	0.029
Observations	589	589	589	589	589	589	589

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS writing exam.

Table 11: Grade in First College-level Course

	MATHEMATICS			READING		WRITING	
	College-Level vs. Developmental Education (RD #1)	Upper Developmental vs. Lower Developmental (RD #2)	Developmental vs. Remedial Education (RD #3)	College-Level vs. Developmental Education (RD #1)	Developmental vs. Remedial Education (RD #2)	College-Level vs. Developmental Education (RD #1)	Developmental vs. Remedial Education (RD #2)
FULL SAMPLE							
Assigned to the Lower-level course	0.1710 (0.1565)	-0.0068 (0.2027)	-0.0352 (0.1634)	-0.0096 (0.0886)	0.0888 (0.1721)	0.0342 (0.0998)	0.5389*** (0.1598)
Outcome Mean	1.99	1.99	1.71	2.23	2.26	2.31	2.16
Observations	335	803	375	1056	374	782	522
FOUR-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	0.2169 (0.2025)	0.3306 (0.4126)	0.1068 (0.2462)	-0.1058 (0.1382)	0.2558 (0.2492)	0.2791* (0.1464)	0.1954 (0.1803)
Outcome Mean	1.97	1.97	1.59	2.47	2.52	2.50	2.46
Observations	185	372	183	460	160	315	231
TWO-YEAR INSTITUTIONS ONLY							
Assigned to the Lower-level course	0.1451 (0.2422)	-0.1503 (0.2353)	-0.0617 (0.2128)	0.0473 (0.1171)	0.0099 (0.2327)	-0.1438 (0.1356)	0.8960*** (0.2765)
Outcome Mean	2.01	2.01	1.81	2.04	2.07	2.19	1.93
Observations	150	431	192	596	214	467	291

NOTE: The sample is limited to students who began at a Tennessee public college or university in the fall of 2000 with complete information on gender, race, age, high school grade point average, college financial aid, and the postsecondary institution attended. The sample is also limited to students under the age of 21 who began full time and whose assignment to remediation was based on their scores on a COMPASS math, reading, or writing exam.