Improving the Transition to College: Estimating the Impact of High School Transition Courses on Short-Term College Outcomes

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Abstract

Many recent high school graduates remain inadequately prepared for college and are required to enroll in remedial or developmental education courses in mathematics or English upon enrollment in college. High rates of college remediation are associated with lower progression and college completion rates. To address this problem, some states, districts, and individual high schools have introduced "transition courses" to prepare students for college-level math and English coursework. Transition courses are typically offered to high school seniors who have been assessed as being underprepared for college math or English.

This study uses a regression discontinuity design to estimate the effect of participation in a mathematics transition course on college-level math outcomes in West Virginia for the 2011–12 and 2012–13 high school senior cohorts. Our findings suggest that, among students who scored very close to the cutoff score on an assessment used to decide what students took the course, the math transition course had no statistically significant effect on improving college readiness (as measured by exemption from remedial education upon college entry due to a passing score on a placement test) and in fact had a negative impact on students' likelihood of passing a college gatekeeper math course. Possible explanations for these outcomes include that (1) the transition course may have displaced traditional senior-year courses that were in practice more rigorous than the transition course or that provided positive impacts from inclusion of higher performing peers, and that (2) the transition course curricula may not have been well aligned to the skills required for success on the COMPASS placement test. Most students who took the transition course did not pass the COMPASS, which was taken at the conclusion of the course. The specific math course studied is no longer offered; math transition courses in West Virginia now use a different curriculum.

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1. Introduction

Many students enroll in college only to find they are required to enroll in remedial or developmental education[1] courses before taking college-level courses. About 66 percent of high school graduates enroll in college the following fall after graduation (National Center for Education Statistics, 2016). According to the literature, anywhere from 28 percent to 40 percent of first-time undergraduate students enroll in at least one remedial course in college, and community college students, in particular, enroll in remedial courses at rates above 50 percent (National Conference of State Legislatures, n.d.). Studies have found that students who are referred to college remediation are much less likely to earn degrees and that students who are referred to math remediation are particularly at risk (Bailey, Jeong, & Cho, 2010). Because of the negative impacts associated with remediation, policymakers and educational practitioners have developed a number of interventions aimed at improving students' chances of entering college ready with the skills to take and pass college-level courses without first taking transition courses. Transition courses, which are typically one year in duration and are offered during students' senior year of high school in either math or English, are one such intervention. Transition courses have been introduced into high school curricula in select states and locations across the United States; this study evaluates the effectiveness of math transition courses in West Virginia.

To our knowledge, this is one of the first reports to evaluate the impact of a statewide transition course on early college outcomes. A study conducted in 2012 found that transition courses are offered in 29 states (Barnett, Fay, Bork, & Trimble, 2013); in 2014, another study examined the implementation of transition curricula in four states: California, New York City, Tennessee, and West Virginia (Barnett, Fay, & Pheatt, 2016). No impact studies on transition courses have been completed thus far. Given the lack of empirical research to date on transition courses and the lack of consensus about what interventions are most effective at improving student outcomes, rigorous studies on the impacts of these courses should be conducted and widely disseminated.

[1] We use the terms *developmental* and *remedial* interchangeably throughout this paper.

Taking advantage of a statewide implementation of transition courses in West Virginia, we carried out such as study and report on it here. We aim to answer the following research question: Does participation in a math transition course increase the likelihood that students are deemed college ready and able to pass a college gatekeeper[2] course? To answer this question, we first discuss transition courses and their background; then we provide evidence regarding the effectiveness of transition courses on key early college outcomes using administrative data from the state of West Virginia. Finally, we discuss our findings and their implications.

1.1 Underprepared Students: Reasons and Consequences

In exploring the reasons why a high proportion of students are identified as underprepared for college, some research has pointed to the historical misalignment between high schools and colleges (Kirst & Venezia, 2001; National Center for Public Policy and Higher Education, 2010) This circumstance arises when the standards used in K-12 and in postsecondary education are not aligned or may even be in conflict (Hoffman, Vargas, Venezia, & Miller, 2007). When this occurs, students focused on meeting the immediate requirements for high school graduation can indeed graduate from high school but remain underprepared for college.

To narrow the gap between K-12 and higher education expectations, many states and high schools have begun administering assessment tests to 11th grade students to determine how well prepared students are for college-level coursework in math and English. These tests, such as PARCC and Smarter Balanced, might be associated with the Common Core State Standards, or they may be standalone assessments such as the SAT, ACT, or other tests that include college-readiness benchmarks (Barnett et al., 2013). Ideally, students who score below the benchmark indicating college readiness should receive additional support to become college ready before graduation. However, the extra support needed to improve their knowledge and skills is often absent (Bridgeland, DiIulio, & Morison, 2006).

[2] Gatekeeper courses (such as college algebra) are the first-level or lowest-level credit bearing courses in a particular subject area that students are required to take to satisfy their program requirements.

In addition to being academically underprepared, students can also be underprepared for college in other ways. For example, they may not have been exposed to college expectations or modes of critical analysis, and they may not have the social know-how to successfully navigate important college choices and demands (Deil-Amen & Rosenbaum, 2003; Karp, Raufman, Efthimiou, & Ritze, 2015).

1.2 Background on Transition Courses

The use of transition courses has been growing more prevalent in recent years. They are now offered in more than 29 states and districts to help students to become college ready by graduation (Barnett et al., 2013). In a study of the policies and programmatic features of transition courses in four states (California, New York City, Tennessee, and West Virginia), Barnett et al. (2013) found that the pedagogical structure of transition courses varied widely, ranging from face-to-face to entirely online formats. Most of these courses were developed locally by individual high schools or districts, or sometimes in partnership with colleges. The study also found that math courses were more commonly offered than English courses and that while the majority of these courses focused on strengthening academic performance, some courses also provided information about college expectations, norms, and admissions processes. Barnett et al. (2016) analyzed the implementation of transition courses in the same four states. The results of this study found that while instructor goals were generally the same in that they all wanted the courses to help students be better prepared for college-level coursework, there was wide variation in pedagogical approaches, goals, and placement of students into the courses.

In theory, transition courses reduce the need for remediation through several mechanisms depending on course goals, design, and implementation choices. In some transition course programs, students who pass a transition course in high school may be automatically exempt from remediation in participating state colleges. Examples of this type of mechanism include the SAILS program in Tennessee, as well as the Expository Reading and Writing course in California for students who scored “conditionally ready” on the Early Assessment Program test in their junior year. Other transition course programs may more tightly align their curriculum with placement test standards to enable students to test college-ready at the conclusion of the transition course. CUNY’s At

Home in College transition courses in math and English follow this approach to some extent, as do West Virginia's transition courses. Finally, transition courses may strengthen the skills and knowledge needed for success in college (including both academic and non-cognitive skills), which could help students to enroll in and pass college courses at higher rates.

On the other hand, there are also some factors that in theory could inhibit or even counteract the effectiveness of transition courses. By design, the transition course places students who score low on assessments with other students who score low on assessments. Prior research using regression discontinuity designs have found a negative impact associated with being placed into a lower-ability classroom: Vardardottir (2013), for example, found moderate negative impacts on spring exam results for Icelandic high school students placed with lower ability peers in a course with identical curriculum. This negative impact could mitigate any positive impacts of transition course participation. Another explanation is that the transition course is not as rigorous as other courses that students would have taken if there was not a transition course in place. Standard senior courses may still ultimately prepare students better than transition courses for college-level work.

1.3 Transition Courses in West Virginia

In 2009, West Virginia passed legislation that required a statewide rollout of a math transition course aimed at improving college readiness rates.[3] In response to this legislation, college and high school faculty convened to draft the curriculum to be used in the course. The course, Transition Mathematics for Seniors, was designed to help students who have been identified as underprepared become college-ready by the time they graduate from high school. Partial implementation of the math transition course in some high schools began in the 2010–2011 academic year, and then full implementation followed during the 2011–12 academic year. However, beginning in the 2014–15 academic year, West Virginia replaced the course with a new course. In this paper, we

[3] In October 2012, West Virginia approved English 12 CR, an English transition course, with the same goal of increasing college readiness (decreasing the need for remedial English) for entry college-level English students (West Virginia Department of Education, n.d.). Since English transition courses were adopted later than math, we do not examine their impact in this report.

estimate the impact of the original math transition course on college readiness, not the course used in the 2014–15 implementation.

Transition Mathematics for Seniors focused on reviewing content and refining skills initially covered in previous high school math courses. A placement test, the COMPASS, was administered to transition course students toward the conclusion of the course. Through the skills they gained and the information they learned in the transition course, students ideally would score high enough on the COMPASS to be exempted from remedial education upon college entry and be permitted to enroll in credit-bearing college coursework.

The transition course included specific curriculum goals, placement instructions, professional development opportunities, and teacher resources, and the curriculum featured topics that high school and college instructors had identified as most relevant to readying students for college-level work. The curriculum included five different modules: the real and complex number system, algebra, functions, geometry, and statistics and probability. [4] However, the course placed the greatest emphasis on algebra. To help teachers deliver the curriculum well, the state provided an online source for teachers called Teach21, which provided lesson plans, suggestions for classroom activities, and additional resources. Teachers also received periodic professional development opportunities from the state during the summer.

Students were placed into the course according to their WESTEST 2 score, an assessment taken in their junior year of high school to gauge college readiness. In theory, students who scored below "mastery" were placed into the course; in practice, placement was sometimes decided through a combination of prior academic performance, counselor and teacher recommendations, and scheduling requirements, especially as some high schools handled scheduling prior to receipt of the WESTEST 2 scores. In addition, although test results and academic history were typically used to place students into the course, other factors may also have influenced course enrollment. For example, counselors may have been more likely to place students they perceived as needing extra help into the transition course; students with lower motivation may also have self-

[4] For a more thorough discussion of the goals, pedagogies, curriculum, obstacles, and facilitators to the successful implementation of West Virginia transition courses see Barnett et al. (2016).

selected into the course if they perceived it to require less effort than other math course alternatives.

One important consideration is that placement into the math transition course in West Virginia may have meant that students were actually displaced from taking more rigorous math courses. As discussed earlier, not taking a more rigorous course could affect student readiness for college through at least two mechanisms: peer effects or a missed opportunity to learn advanced skills and knowledge that are relevant to student readiness. West Virginia, among a number of other states, requires four years of mathematics to graduate. A student who has enrolled in Transition Mathematics has thus taken it in lieu of another math course (a minority of students had taken a year of high school mathematics prior to the ninth grade and were therefore exempt from taking a senior year math course). The counterfactual in this study is therefore typically not “no math course taken by the student” but rather a different math course taken (which will vary in terms of content, learning objectives, and quality). Other senior year math options in West Virginia include algebra I or math I, geometry, and conceptual mathematics; more advanced students may take courses such as algebra III, trigonometry, precalculus, or calculus. We discuss the alternative mathematics courses more in section 4.

2. Data and Measures

To conduct this analysis we matched student-level data received from the West Virginia Department of Education (WVDE), the West Virginia Higher Education Policy Commission (HEPC), and the Community and Technical College System (CTCS). Combined, these administrative datasets include data on students’ background and academic characteristics, including course-level transcript data, test score data, graduation information, and administrative records of student characteristics (including gender, race/ethnicity, receipt of free or reduced lunch, and birth year and month).

College enrollments for students who attended college out of state were unobserved because college data were unavailable.[5]

Our original sample includes three consecutive high school senior cohorts: 2010–11, 2011–12, and 2012–13, for a total of 53,626 students. Because the course was not fully implemented in the 2010–11 academic year, we focus on the latter two cohorts for our analysis. Further, due to a transition in data systems at the state level, transcript information was unavailable for a substantial number of students at 32 percent of high schools in the 2012–13 academic year, affecting 29 percent of students in that cohort. Students at these schools in the 2012–13 cohort were excluded from our sample, and an additional 2 percent of students were excluded from analysis due to missing high school transcript data. Eleven percent of students were further excluded because the WVDE had no social security number on file for them, and therefore those data could not be matched with the HEPC and CTCS data. Our final analytic sample contains 26,628 students.

To estimate the impact of the course on student outcomes, we use 11th grade WESTEST 2 mathematics scores and participation in the transition course as our main independent variables. The WESTEST 2 is a scaled score, in which students' raw scores are converted to a standardized score that allows them to be compared along a continuum. This means that there may be many students with scores of 671, 676, 680, 684, and 688; however, there will be no students with scores in between those totals. A student's scaled score is then translated into one of five mastery levels: novice, partial mastery, mastery, above mastery, and distinguished. Students who scored at or above a 680 on this assessment met the mastery benchmark and were considered to be on track for college readiness; those who scored below 680 did not meet the mastery benchmark and were then required to take the mathematics transition course or another higher level mathematics course. Participation in the transition course was identified via the course number in transcript records.

[5] In our analyses, we treat students who did not have matching college data as though they did not enroll in college. This may result in some measurement bias. However, evidence suggests that the bias introduced should be minimal; only 15 percent of recent high school graduates in West Virginia who enrolled in college in fall 2008 enrolled in out-of-state institutions (National Center for Education Statistics, 2009). Moreover, we expect that high achieving students, who are unlikely to participate in transition courses, will be the most likely to attend out-of-state institutions; in our data, we see that students with the highest test scores were less likely to enroll in in-state college, supporting this expectation (see Appendix Figure A.3).

The course objective was to help underprepared students become college ready prior to college enrollment and thus avoid any need for remediation. We therefore focus on two outcomes: college readiness upon college entry and passing a gatekeeper math course in college within the first year following high school graduation.

The first outcome measure, college readiness in math, is a binary variable derived from scores on the COMPASS, ACT, SAT, and ACCUPLACER assessments as recorded in the state college system. Students who tested above the college-level benchmark on one or more of these assessments were automatically exempt from remedial coursework. In math, students were exempt from remedial education if they scored equal to or above a 19 on the ACT, a 460 on the SAT, a 59 on the pre-algebra portion or a 36 on the algebra portion of the COMPASS, or an 85 in arithmetic or an 84 in elementary algebra on the ACCUPLACER. Our second primary outcome is a binary indicator measuring whether a student has passed a college-level gatekeeper math course (a course at the first-level or lowest-level of college-level courses that is credit bearing, such as college algebra) within one year following high school graduation. Because these outcomes are based on college administrative data, students who did not enroll in college in West Virginia are coded with zeroes; that is, in our analyses, they are considered not ready for college-level math at entry, do not attempt or pass a gatekeeper math course, and earn zero college-level and developmental credits.

We also examine a group of secondary outcomes to explore other effects transition courses may have, but these are not used to determine the effectiveness of the intervention.[6] The secondary outcomes include a binary indicator for enrollment in college, a binary indicator for attempting a college-level gatekeeper math course within one year (implying completion of developmental requirements), developmental education credit accumulation within one year, and college-level credit accumulation within one year.

[6] When using multiple inferences, it is important to limit the number of hypotheses that are tested in a single model in order to lower the risk of committing a Type I error (Shaffer, 1995). As the number of hypotheses that are being tested increases, the risk of rejecting a true null hypothesis increases (a "false positive"). For this reason, we limit our analyses to two primary outcomes, which we selected before running the model.

2.1 Descriptive Statistics

To demonstrate how the students who took transition courses compared with those who did not, we present sample means for observable student characteristics for the 2011–12 and 2012–13 high school cohorts (see Table 1). On average, students who took transition courses were different from their peers who did not take the courses on many major characteristics. Transition course participants were significantly more likely to be female, less likely to be Asian, and more likely to be receiving free or reduced lunch. They had significantly lower average GPAs in 9th through 11th grade and significantly lower scores on mathematics, reading, and social studies assessments in both 10th and 11th grades. These results suggest that the transition course participants were less advantaged and less academically successful on average than their peers. We know students differed on many observable characteristics, and it is also highly likely that they differed on unobservable characteristics (such as motivation or innate mathematics ability) . To account for these observable and unobservable characteristics and provide an estimate of the impact of the course while accounting for both observable and unobservable characteristics, we employ a causal design, which is discussed in the next section.

Table 1
Sample Descriptive Statistics for 2011–12 and 2012–13 Analytic Cohorts

Covariates	All Students		Transition Course Non-Participants		Transition Course Participants	
	Mean	SD	Mean	SD	Mean	SD
Female **	0.50	0.50	0.48	0.50	0.55	0.50
Black **	0.05	0.22	0.05	0.22	0.06	0.24
Hispanic	0.01	0.09	0.01	0.10	0.01	0.08
Asian	0.01	0.08	0.01	0.08	0.00	0.07
Received free or reduced lunch **	0.39	0.49	0.37	0.48	0.44	0.50
Estimated GPA in grades 9–11 **	2.91	0.72	2.97	0.74	2.71	0.61
WESTEST 2 grade 11 mathematics score**	663	59	666	64	654	41
WESTEST 2 grade 10 mathematics score**	652	51	657	51	638	48
WESTEST 2 grade 11 reading score**	483	68	485	72	477	54
WESTEST 2 grade 10 reading score**	407	34	410	34	400	31
WESTEST 2 grade 11 social studies score **	485	58	488	61	475	50
WESTEST 2 grade 10 social studies score**	406	34	409	34	398	30
N	24,688		18,479		6,209	

Note. The *p*-value reflects whether the relationship between transition course participants and non-participants is statistically distinguishable from zero.

* *p* < .05. ** *p* < .01.

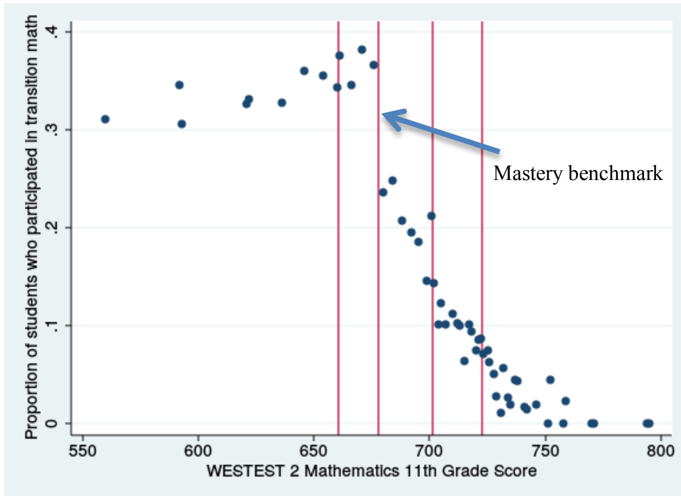
3. Methods

3.1 Examining Discontinuities at the Cutoff

To examine the impact of the West Virginia math transition courses on early college outcomes we use regression discontinuity (RD), a quasi-experimental analytic approach. RD depends on the existence of a predetermined threshold for a continuous variable (such as a test score), which determines student participation in the intervention being studied. If student characteristics are evenly distributed across a predetermined threshold, then any differences in outcomes across that threshold can be attributed to the treatment—in this case, the transition course (Imbens & Lemieux, 2008). In the case of the present study, student characteristics were evenly distributed across a predetermined threshold after controlling for a linear trend in the test scores. To estimate the impact of transition course participation, we take the difference between two regression functions, one that is above and one that is below the mastery cutoff on the WESTEST 2 assessment. The effect of the treatment on the outcome, therefore, is the difference between these two regression functions at the cutoff.

Figure 1 demonstrates the proportion of students who participated in the transition course at each test score, where the four vertical lines distinguish the five mastery levels (novice, partial mastery, mastery, above mastery, and distinguished). The second vertical line from the left represents the cut score of 680, which is between "below mastery" and "mastery." There is a visible difference, or discontinuity, between transition course participation rates above and below this threshold. Based on our knowledge of policies in West Virginia, we assume that the difference in participation in the transition course above and below the mastery cutoff is due to the guidance of students below the cut score into the transition course. We further assume, also based on knowledge of policies in West Virginia, that this is the only mechanism through which scoring just below or above the mastery cutoff would impact students on measures of college success. This assumption would be violated, for example, if the same cutoff score were also used to determine eligibility for a scholarship that guaranteed free tuition to within-state colleges, since that would be a separate mechanism that could impact college outcomes; however, that is not the case in West Virginia.

Figure 1
Relationship Between WESTEST 2 Test Scores and Enrollment in Transition Math for Seniors (2011–12 and 2012–13)



To estimate the impact of the course on students, we compare the outcomes of students who scored just below the college-ready threshold with students who scored just above the threshold. We select a bandwidth that includes only students who scored within a narrow, selected range on the WESTEST 2. There are a number of ways to calculate the optimal bandwidth, but there is no clear consensus on which way is best. We employ a graphical inspection of the functional form to determine our optimal bandwidth. Figure 2 illustrates the functional form for the relationship between test scores and college enrollment. The vertical line represents the cutoff score of 680 on the WESTEST 2 (note that the test scores are centered at 680). We see that students on either side of the cutoff follow a linear trajectory. An important assumption that must be met to use RD with our selected model specification is that students just above and below the cutoff have equal expectations for outcomes after controlling for the linear trend. A relationship between test score and outcomes that is nonlinear would violate this assumption. The tails of the distribution in Figure 2 (plotting test score against college enrollment, one of our secondary outcomes) appear nonlinear and so our assumption of equal expectations is violated. We therefore limit our range to 20 points above and below the cutoff (660–700) to optimize the linear relationship. By limiting our sample to just above and below the cut score, we limit the generalizability of our findings but increase their validity since we can more safely assume these students are equal in expectations. In the interest of transparency, we do report estimates resulting from the use of other bandwidths as well as those using the full sample, though we caution against interpreting those estimates causally.

Figure 2
College Enrollment as a Function of WESTEST 2 Score

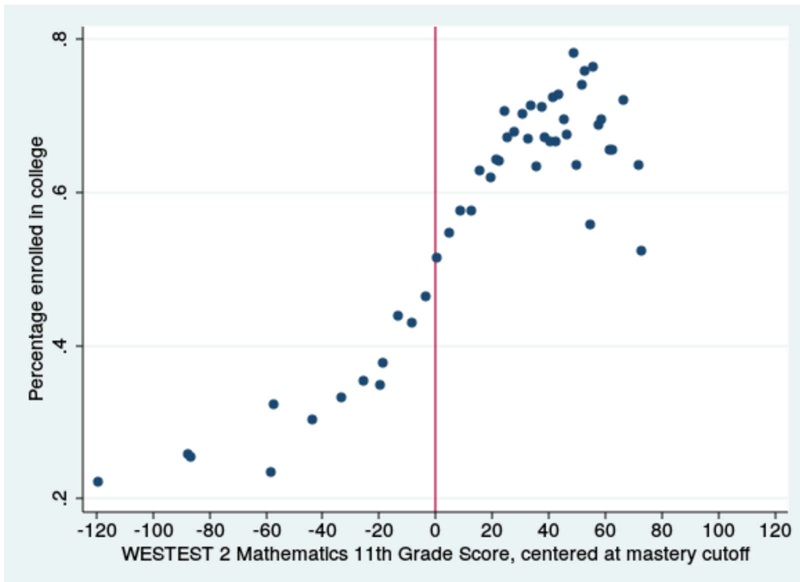
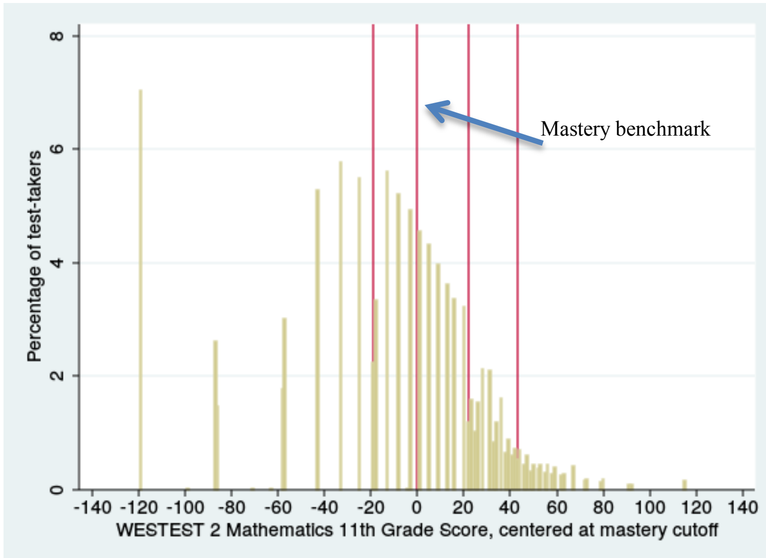


Figure 3 depicts the distribution of student test scores with vertical lines representing boundaries between each mastery level. As mentioned earlier, the variable we use is a scaled test score and so not every score is observed. To appropriately estimate a linear trend for test score we therefore prefer bandwidths that include multiple test score data points both below and above the cutoff score.

Figure 3
Distribution of WESTEST 2 Math Scores (2011–12 and 2012–13)



3.2 Intent to Treat Analysis

The regression model for the effect of falling below the cutoff on an outcome Y_i is as follows:

$$(1)\ Y_i = \mu_1(BELOW_i) + \mu_2(WESTEST_i - 680) + \mu_3[(BELOW_i)(WESTEST_i - 680)] + \boldsymbol{\pi}'\boldsymbol{X}_i + \varepsilon_i$$

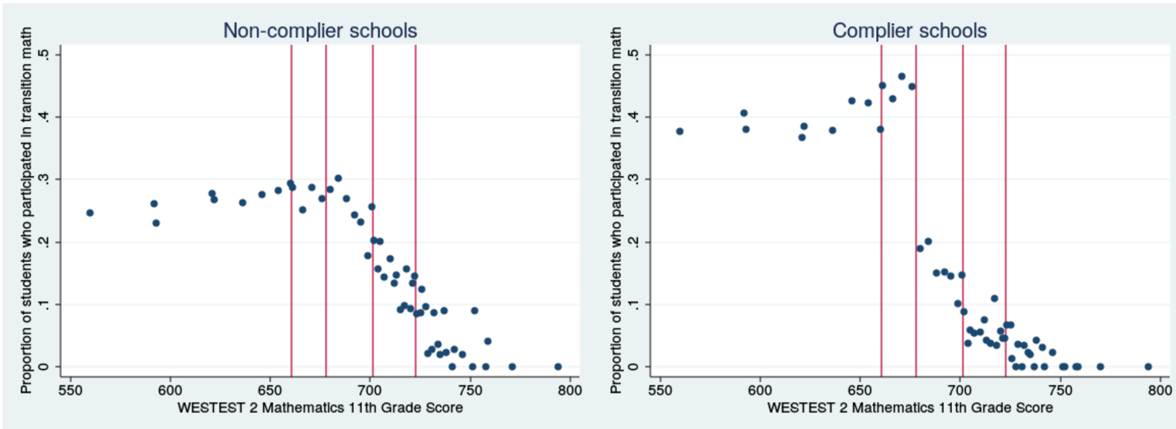
where $BELOW_i$ is a binary indicator of whether the student scored below the cutoff score of 680 on the WESTEST 2; $(WESTEST_{i,} - 680)$ is a function of the scores on the WESTEST 2 that creates a score centered at 0; $[(BELOW_i)(WESTEST_i - 680)]$ is an interaction effect between falling below the cutoff score and test score, allowing the slope of the relationship between test score and the outcome to differ above and below the cutoff score; and $\boldsymbol{X_i}$ is a vector of covariates that includes a binary indicator for being female, binary indicators for being black or African American, Asian or Pacific Islander, and Latino or Hispanic, an indicator of receipt of free or reduced lunch which serves as a proxy for socioeconomic status, GPA in 9th–11th grades, WESTEST 2 scores for mathematics in 10th grade as well as reading and social studies in 10th and 11th grades, and high school fixed effects. Missing GPA and test scores are coded as 0, and a binary indicator for missing each variable is also included in the vector.

This equation yields a consistent estimator μ_1—often referred to as the intent to treat (ITT) effect. The ITT estimate allows us to estimate the degree to which the policy will realistically impact the population as a whole given observed levels of noncompliance (Heckman, LaLonde, & Smith, 1999). Ideally, there is perfect compliance, and the instrument (the test score) which places students above or below the cutoff score perfectly predicts whether or not a student participates in the course. However, in most cases and in the case of West Virginia, compliance is imperfect. Figure 1 shows that many of the students who fell below the cutoff did not participate in the transition course while many students who scored above the cutoff did. In our sample, only 35 percent of students who scored below the cut score on the WESTEST 2 in math participated in the transition course. Additionally, a small but not insubstantial percentage of students (14 percent) who exceeded the test threshold were also enrolled in the course. When there is imperfect compliance, researchers will separately estimate the effect of course participation for just the course participants. This approach is usually referred to as measuring the impact of the treatment on the treated (TOT). If compliance were perfect, the ITT and TOT estimates would be the same.

In West Virginia, imperfect compliance may result from two sources: first, some schools may not implement the selection procedure with fidelity to the intended policy, and second, even schools that generally adhere to the policy may apply discretion with regard to scheduling particular students. Based on conversations with administrators at both the state and school levels in West Virginia, we understand that some schools did not consider students' test scores in assigning students to transition courses, often because they handled scheduling prior to when scores became available. For this reason, we separate our sample into "complier" schools and "non-complier" schools and perform our primary analysis on complier schools only.[7] Figure 4 demonstrates that a substantial discontinuity exists for the complier schools but not for the non-complier schools in terms of participation in the transition course around the cutoff.

[7] To identify complier schools, we calculated the difference in transition course participation rates between mastery level 2 and mastery level 3 students (2 = below mastery; 3 = at mastery). Schools in the 50th percentile or greater on this difference were identified as complier schools.

Figure 4
Relationship Between WESTEST 2 Test Score and Enrollment in Transition Math for Seniors, for Non-complier and Complier Schools (2011–2012 and 2012–13 Cohorts)



There are additional concerns in undertaking this analysis. One concern is that students who fall below the cutoff score (and are therefore induced to participate in the transition course) are substantively different from students who score above it, even after controlling for observable characteristics and a linear trend in test score. Differences in student motivation or other unobserved student characteristics could be responsible for any change in outcome rather than the treatment. To address this concern, we conduct falsification checks wherein we estimate our model using our covariates as outcome variables, expecting to find no significant "impacts" on variables for which a causal effect from transition course participation would be theoretically implausible or even impossible (see Table 2).

Another concern is whether there was strategic behavior or manipulation of test scores that could have resulted in students being placed into (or out of) the transition course.[8] However, students can only take the test once during their junior year, so retaking the test is not an option. Thus, as long as the probability of treatment changes discontinuously at the threshold, we can determine the treatment effect by comparing the average outcomes of students in a narrow range on either side of the threshold.

[8] For further discussion on the concerns around manipulation of the running variable, see Imbens and Lemieux (2008) and McCrary (2008).

3.3 Treatment on the Treated Analysis

Given the issue of noncompliance, we estimate the effect of actual participation in the transition course on college outcomes by using an instrumental variables (IV) approach to determine the treatment on the treated (Gennetian, Morris, Bos, & Bloom, 2005; Heckman et al., 1999). An IV approach combined with the RD design takes advantage of the exogenous determination of assignment (falling below the predetermined cutoff) as an instrument for enrollment in the transition course. The IV exclusion restrictions are arguably satisfied by design; assignment is correlated with enrollment in the transition course but may not be directly correlated with future achievement or the error term in the outcome equation after controlling for a linear trend in the test score. However, a key assumption in the validity of these estimates is that changes in college outcomes are *only* impacted via students who actually participate in the transition course rather than through any other mechanism. In particular, if assignment to the transition course (that is, scoring below the mastery benchmark) impacted college outcomes even for students who did not ultimately enroll in the transition course, the original ITT approach detailed above would be valid, but it would be inappropriate to scale up those results to estimate a TOT. This assumption is violated if students who are told they should participate in a transition course or told they scored "below mastery" feel discouraged from enrolling in college and pursuing a college-level math sequence. We cannot directly test this assumption; we therefore report the results from this approach and interpret these results with some caution.

Here the first stage equation predicts participation in the transition math course through exogenous assignment:

(2) $$TRANSMATH_i = \alpha_0 + \alpha_1(BELOW_i) + \alpha_2(WESTEST_i - 680_i) + \alpha_3(BELOW_i)(WESTEST_i - 680) + \boldsymbol{\varphi}'\boldsymbol{X}_i + \delta_i$$

where $TRANSMATH$ is a binary variable for whether the student participated in the transition math course (1 = yes; 0 = no); $WESTEST_i$ represents a student's score on the standardized math test that was taken during the junior year of high school which is used as the forcing variable in the ITT or "fuzzy" RD design; $BELOW_i$ is a binary instrument that describes whether the student's WESTEST 2 score fell below the cut score of 680; $\boldsymbol{X_i}$ is a vector of student characteristics and school fixed effects as above; and δ_i is the error term.

The outcome response is then related to the treatment via this second-stage equation:

(3) $Y_i =$

$$\beta_0 + \beta_1(\widehat{TRANSMATH_i}) + \beta_2(WESTEST_{i,} - 680) +$$

$$\beta_3(TRANSMATH_i)(WESTEST_i - 680) + \gamma' X_i + \varepsilon_i$$

where Y_i is the outcome variable; $\widehat{TRANSMATH_i}$ is the predicted value of transition course participation estimated in the first stage; $\boldsymbol{X_i}$ is a vector of student characteristics and school fixed effects as above; and ε_i is the error term.

We conduct F tests when estimating the first stage of the IV in order to test whether falling below the test score serves as a strong instrument for transition course participation (results not reported here). We find it does, both for the full sample and for the subsample of complier school attendees.

3.4 Estimating the Parameters of Interest

We take several steps to ensure the validity of the estimation of our parameters of interest. For the binary outcomes, we use ordinary least squares to estimate the coefficients in the above equations for ease of interpretation; however, we also estimate but do not report probit models in which we find that the pattern of results do not change. Our dataset also includes a moderately rich set of student-level covariates in addition to high school fixed effects, which improves our precision (Imbens & Lemieux, 2008). Standard errors are clustered at the high school level.

4. Results

We first examine the results of a falsification check. Table 2 shows the estimates for the ITT (left subcolumns) and TOT (right subcolumns) results for the preferred bandwidth as well as for the full sample and for a wide and a narrow bandwidth on our covariates. As described in the methodology section, we should expect no impact on these baseline characteristics; finding an "impact" might indicate bias in our methodological design. For the most part, we do not find these false impacts with the limited bandwidths. However, run on the full sample (which we caution against doing in the methods section), the RD suggests that there is likely to be bias, and therefore impacts on outcomes using the full sample should not be interpreted as causal. The full sample RD-IV estimates are statistically significant for all covariates and outcomes. This is not unexpected because the data at the tails of our test score distribution weigh heavily on the estimate (see Figure 3), skewing the averages for the groups below and above the cutoff after accounting for the otherwise linear relationship between test score and the outcomes. As discussed in the methods section, we focus on a preferred bandwidth of +/- 20 points because it provides enough test score data points to estimate a linear trend of test scores on each outcome, and because it appears to exclude the non-linear tail upon visual inspection of test scores versus each outcome. For example, Figures 5 and 6 demonstrate there is a nonlinear pattern at either end of the tails for our two primary outcomes, but we do observe a linear trend near the cutoff score (both below and above the cutoff score) within a +/- 20-point bandwidth (see Appendix Tables A.1–A.4 for the distributions of our secondary outcomes). These visual results lend support to our claim that student characteristics are likely to be evenly distributed across the predetermined threshold after controlling for a linear trend in test scores.

Table 2
Regression Discontinuity Estimates of Impact on Covariates

	Preferred Bandwidth (+/−20)		Full Sample		Bandwidth (+/−30)		Bandwidth (+/−10)	
	ITT	TOT	ITT	TOT	ITT	TOT	ITT	TOT
Female	0.03	0.12	0.03*	0.11*	0.03	0.11	0.03	0.12
	[0.02]	[0.08]	[0.01]	[0.05]	[0.02]	[0.08]	[0.03]	[0.13]
White	0.01	0.04	0.01	0.02	0.01	0.06	0.00	0.02
	[0.01]	[0.05]	[0.01]	[0.03]	[0.01]	[0.04]	[0.02]	[0.07]
Free/reduced lunch	0.01	0.04	0.02	0.07	0.01	0.05	0.02	0.10
	[0.03]	[0.11]	[0.01]	[0.04]	[0.02]	[0.09]	[0.05]	[0.22]
10th grade WESTEST math score	−0.44	−1.73	−10.23**	−38.40**	−1.31	−5.28	−7.78*	−34.80*
	[2.27]	[8.64]	[1.10]	[5.08]	[1.70]	[6.56]	[2.92]	[15.53]
Estimated GPA	−0.02	−0.08	−0.19**	−0.71**	−0.01	−0.04	−0.06	−0.25
	[0.03]	[0.10]	[0.02]	[0.10]	[0.02]	[0.09]	[0.04]	[0.17]

* $p < .05$. ** $p < .01$

Figure 5
Percentage of Students Determined College-Ready for Math as a Function of WESTEST 2 Scores

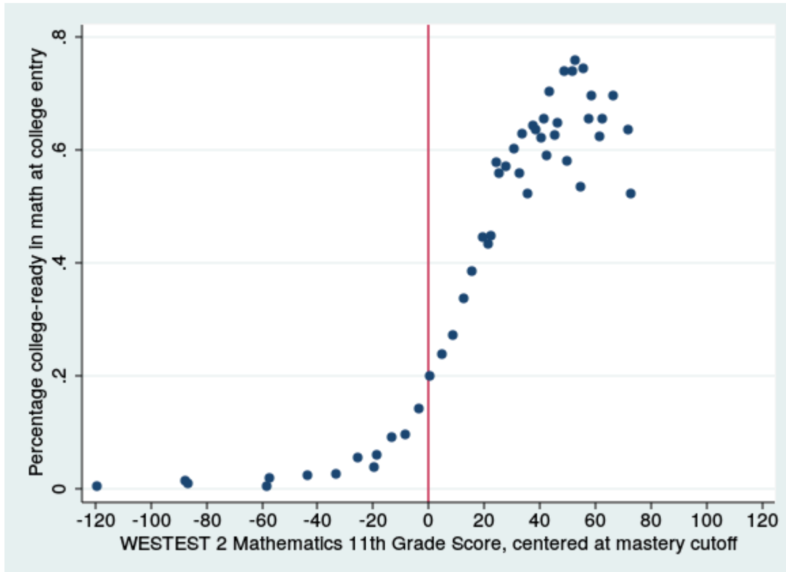
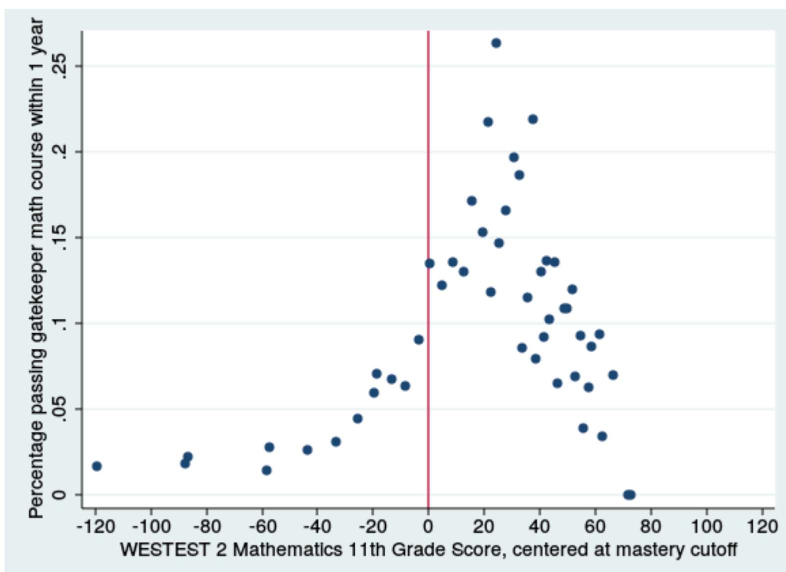


Figure 6
Percentage of Students Passing Gatekeeper Math Within One Year as a Function of WESTEST 2 Scores



We turn next to our main analysis. Table 3 summarizes our RD estimates at each bandwidth for both our primary and secondary outcomes. Again, we focus our attention on the preferred bandwidth of +/- 20 points. There is no statistically significant effect of the transition course on whether or not students are successfully prepared for college-level math coursework at college entry, though the estimate is negative. That is, the transition course had no significant impact on whether students scored high enough on any one of the standardized college entrance or placement tests (i.e., the ACT, SAT, ACCUPLACER, or COMPASS) to become exempt from taking remediation. However, for our second primary outcome, we find that students who scored just below the cutoff score (anywhere between 660 and 679) were 5 percentage points less likely to pass a gatekeeper course within one year following high school graduation compared with students who scored just above the threshold (680–700) after controlling for a linear trend on test scores and other student characteristics. This effect is statistically significant. Our secondary effects are also significant and negative. Students just below the threshold were less likely to enroll in college, earned fewer college level credits, and were less likely to attempt a gatekeeper course in the first year, compared with their peers who scored just above the cutoff.

The TOT results scale up the ITT results to account for compliance in transition course participation, using falling below the cutoff score as an instrument for transition course participation to estimate the impact of treatment on the treated. The TOT estimates mirror the results of the ITT estimates but suggest larger estimated impacts for actual course participants, with the assumption that impacts flow only through students induced to participate in the transition course rather than those who, while assigned to participate, ended up not doing so. There is no statistically significant impact of participating in the transition course on being college-ready. We find that students who fell just below the cut score (within 20 points below) and who took the course were 19 percentage points less likely to pass a math gatekeeper course within the first year of completing high school compared to similar students just above the cut score (within 20 points above) who did not take the course. As for our secondary impacts, we find that students who took the transition course were less likely to enroll in college, earned fewer college-level credits, and were less likely to attempt college gatekeeper math.

Table 3
Regression Discontinuity Estimates of Impact on Primary and Secondary Outcomes (2011–12 and 2012–13 Cohorts)

	Preferred Bandwidth (+/−20)		Full Sample		Bandwidth (+/−30)		Bandwidth (+/−10)	
	ITT	TOT	ITT	TOT	ITT	TOT	ITT	TOT
College-ready in math at entry	−0.04	−0.14	−0.13**	−0.50**	−0.03*	−0.13	−0.01	−0.04
	[0.02]	[0.07]	[0.01]	[0.08]	[0.02]	[0.07]	[0.03]	[0.14]
Passed gatekeeper math within 1 year	−0.05**	−0.19**	−0.06**	−0.25**	−0.04**	−0.16**	−0.03	−0.14
	[0.01]	[0.05]	[0.01]	[0.04]	[0.01]	[0.05]	[0.03]	[0.12]
Enrolled in college	−0.06**	−0.22**	−0.08**	−0.31**	−0.05**	−0.18**	−0.04	−0.17
	[0.02]	[0.06]	[0.01]	[0.05]	[0.02]	[0.07]	[0.04]	[0.18]
College-level credits earned within 1 year	−2.02**	−7.76**	−2.11**	−8.16**	−1.67**	−6.61**	−2.48**	−11.22*
	[0.58]	[2.19]	[0.35]	[1.43]	[0.49]	[1.95]	[0.90]	* [4.06]
Developmental credits earned within 1 year	−0.10	−0.39	0.20**	0.76**	−0.02	−0.09	−0.15	−0.69
	[0.09]	[0.36]	[0.06]	[0.28]	[0.09]	[0.34]	[0.15]	[0.68]
Attempted gatekeeper math within 1 year	−0.04*	−0.16*	−0.07**	−0.28**	−0.04**	−0.16**	−0.01	−0.03
	[0.02]	[0.07]	[0.01]	[0.04]	[0.01]	[0.06]	[0.03]	[0.12]

* $p < .05$. ** $p < .01$

We perform several additional checks. First, in a separate analysis not reported here, we test the model on a limited sample consisting only of students who attended college on our primary outcomes. We do this to ensure that a negative impact on enrollment in college was not driving the other negative findings, since all other outcomes are coded 0 when students do not enroll in college. However, the pattern of results remains consistent.

Second, we perform two sensitivity checks. As mentioned above, a substantial number of students in the 2012–13 cohort did not have transcript data and are excluded from our primary analysis. However, we conduct two subgroup analyses, the details of which are not reported here, to test whether students in the 2011–12 cohort who attended schools with missing transcript data differed from those who did not. We find that students at schools missing transcript data performed slightly worse, suggesting that the estimates reported above could have a slight positive bias, if anything. Second, we analyze whether the impacts were different for students in the 2012–13 cohort versus the 2011–12 cohort (for students in schools with transcript data in both years). We find slightly less negative impacts for the 2012–13 cohort year, suggesting that, if anything, the transition course was improving over time.

Finally, we perform a falsification check using an alternate sample. In the 2010–11 senior cohort, transition courses in mathematics were partially rolled out. Schools that were not implementing the transition course that year make an ideal control group to test whether something else might be happening at the cutoff score besides the transition course. If we were to run our RD analysis on students at schools that were not offering transition courses and find the same negative effect as above, it would suggest that the negative findings are not wholly attributable to the transition course. However, as shown in Table 4, we find no statistically significant "impacts" of falling below the cutoff score, and estimates are less negative than in the true specification above. This lends further credibility to our estimation strategy.

Table 4
Falsification Check: Regression Discontinuity Estimates of Impact on Primary and Secondary Outcomes (2010–11 Cohort, Non-Implementing Schools Only)

Preferred Bandwidth (+/- 20)					
College-ready in math at entry	**Passed gatekeeper math within 1 year**	**Enrolled in college**	**College-level credits earned within 1 year**	**Developmental credits earned within 1 year**	**Attempted gatekeeper math within 1 year**
0.06 [0.03]	-0.03 [0.03]	0.02 [0.04]	-0.16 [0.98]	-0.14 [0.13]	-0.02 [0.04]

* $p < .05$. ** $p < .01$

4.1 Supplemental Analyses: Exploring Potential Mechanisms

The generally negative impact results point to a failure of mathematics transition courses in West Virginia over this time period to meet their intended goal of increasing college readiness and college course completion in math, at least for students near the assessment cutoff for needing such courses. In this section, we investigate three factors that may contribute to these negative impact results. First, we show that most high school graduates are not immediately enrolling in college, limiting the extent to which transition courses can be effective. Second, we demonstrate that the counterfactual (the alternative to enrolling in a transition course) may involve enrollment in a higher level math course with higher ability peers. Finally, we show that even among students who take the transition course in high school, the vast majority are still not meeting college readiness benchmarks on the COMPASS placement assessment.

Table 4 summarizes the outcome variables for transition course participants relative to non-participants. As Table 5 shows, only 47 percent of high school seniors in our analytic sample enrolled in a West Virginia college in the following academic year, and only 43 percent of transition course participants (not reported in Table 5, 51 percent of students within the bandwidth of 20 from the mastery benchmark enrolled in college). By definition, college non-enrollees would also not be college-ready in math upon college entry, would not attempt or pass a gatekeeper math course, and would earn zero college-level and developmental credits. Encouraging students to enroll in college was not an explicit goal of the transition course; rather, the goal was to better prepare students who *chose* to enroll. Still, we ran our model again, restricting the sample to students who enrolled in college, and our results remained consistently negative and produced approximately the same coefficients.

Table 5
Descriptive Statistics on Outcomes for 2011–12 and 2012–13 Analytic Cohort

	All Students		Transition Course Non-Participants		Transition Course Participants	
Outcome	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
College ready in math at entry	0.23	0.42	0.27	0.45	0.11	0.31
Passed gatekeeper math within 1 year	0.08	0.27	0.08	0.27	0.06	0.24
Enrolled in college	0.47	0.50	0.48	0.50	0.43	0.50
College-level credits earned within 1 year	9.5	12.9	10.4	13.4	6.7	10.7
Developmental credits earned within 1 year	0.7	2.1	0.5	1.8	1.0	2.6
Attempted gatekeeper math within 1 year	0.10	0.30	0.10	0.30	0.09	0.28

In the impact models above, the comparison group is non-participants in Transition Mathematics for Seniors; as mentioned above, many students took other math courses instead of no math course. Table 6 summarizes the most popular mathematics courses taken in the senior year, both for the full sample of seniors and for the students within the 20-point bandwidth around the mastery cutoff.

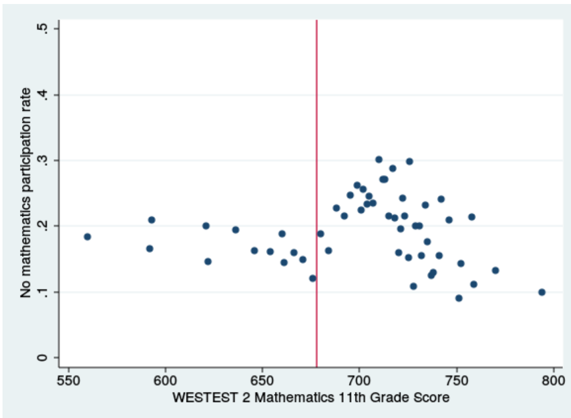
Table 6
Percentage of Seniors Enrolling in Each Math Course

Course	Preferred Bandwidth +/– 20	All Seniors
Transition mathematics	28.2%	25.1%
No math	18.8%	19.8%
Trigonometry	17.0%	13.1%
Conceptual mathematics	12.0%	13.3%
Algebra 2	11.5%	11.5%
Precalculus	7.6%	6.9%
Algebra 3	6.6%	6.1%
Statistics	4.1%	4.4%
Calculus	3.0%	7.3%
Geometry	1.9%	2.7%
Algebra 1	0.7%	1.1%

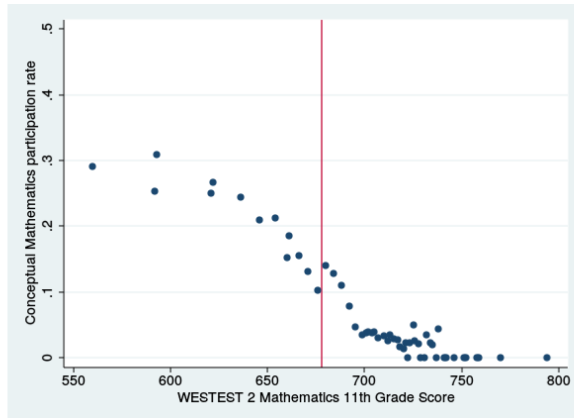
The RD design depends not on overall enrollment trends but rather on which courses students are induced to take and not take by virtue of scoring just above or just below the cutoff score. Figure 7 displays students' participation rate in selected senior year math courses in relation to junior year WESTEST 2 scores, with the vertical line representing the mastery cutoff for recommendation to take the transition math course. There is a clear but small discontinuity just above the college readiness benchmark for participation in conceptual mathematics, trigonometry, and precalculus. The discontinuity suggests that students who were not directed to transition mathematics because they placed just above the cutoff score (and require four years of mathematics) were likely to be directed to one of these alternative math courses. The test score distribution for each course illustrates that the conceptual mathematics course tended to enroll students with lower test scores relative to transition mathematics for seniors, but trigonometry and precalculus enrolled students with higher test scores. There appear to be more students directed into these higher-level courses than lower-level courses or to no mathematics at all. On average, therefore, we find that the counterfactual is enrolling in a higher level math course with higher ability peers, providing support for the claims of peer effects or enrolling in more rigorous courses as factors contributing to the negative impacts found above.

Figure 7
Participation in Selected Mathematics Courses at Complier Schools by Test Score

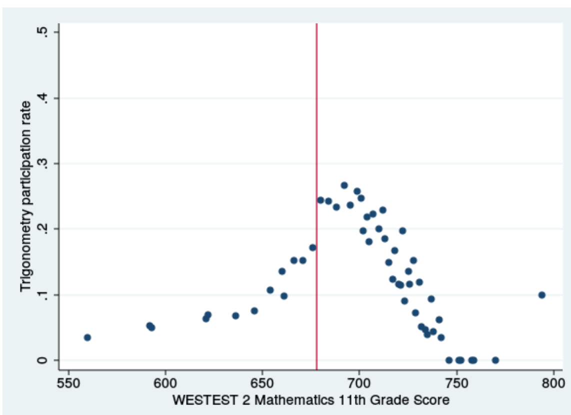
No Mathematics



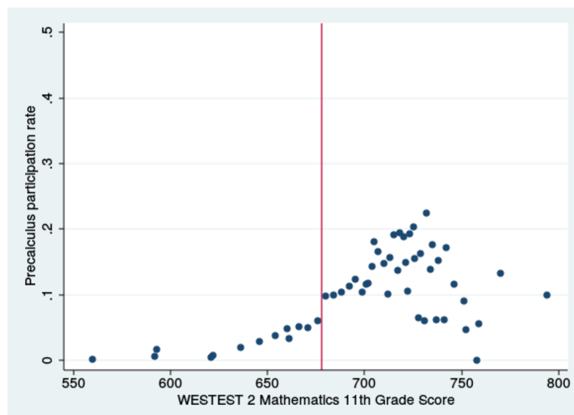
Conceptual Mathematics



Trigonometry

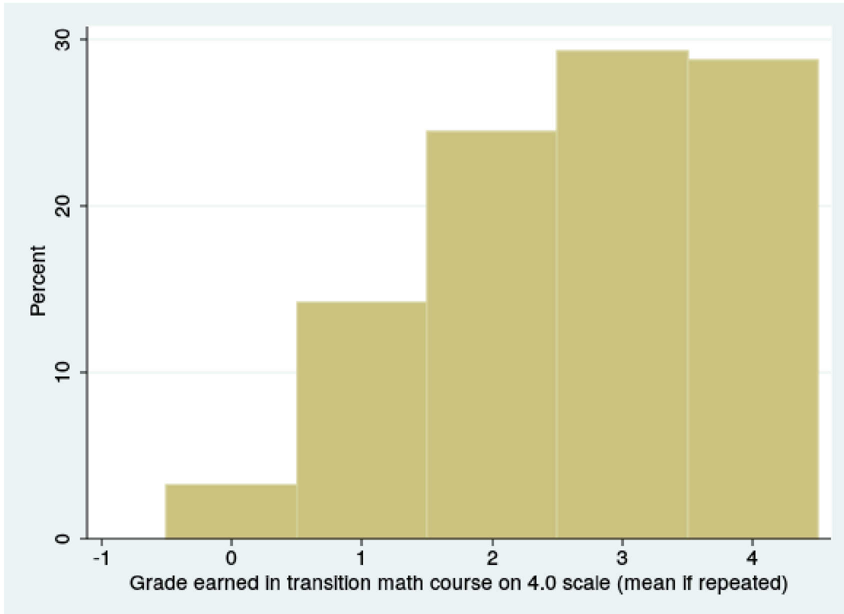


Precalculus



Finally, we come to the question of student achievement among the transition course participants. The mean grade in the course was a 2.8 on a 4.0 scale, slightly higher than transition course participants' overall average grade point average of 2.7 on a 4.0 scale (see Figure 8). The grade distribution is fairly high, with the majority of students earning A or B grades in the course. Less than 5 percent of students earned a failing grade.

Figure 8
Distribution of Grades Earned in Transition Mathematics for Seniors



This relatively high grade distribution contrasts with students' relatively low performance on the COMPASS placement test that is administered to students toward the end of the transition course. In our analytic sample, we have COMPASS test scores available for 78 percent of transition course participants. We report two different scores for students because the COMPASS placement test has two distinct sections in mathematics: first, a numerical skills and pre-algebra section ("pre-algebra"), and second, an algebra section. Students take the algebra section of the test only if they score a 55 out of 100 or higher on the pre-algebra section of the test.

Figure 9 displays the distribution of COMPASS pre-algebra scores. Only 28 percent of students scored high enough on the pre-algebra section to move on to the algebra section, and only 23 percent of students met the pre-algebra college readiness benchmark of 59 (set by West Virginia and represented by the vertical red line in Figure 9) that would exempt them from remediation in combination with a satisfactory algebra score. However, even out of those who were eligible to take the COMPASS algebra section, the majority (57 percent) did not meet West Virginia's college readiness benchmark of 36 on that section, as shown by the distribution in Figure 10.

Figure 9
Distribution for COMPASS Pre-Algebra Scores

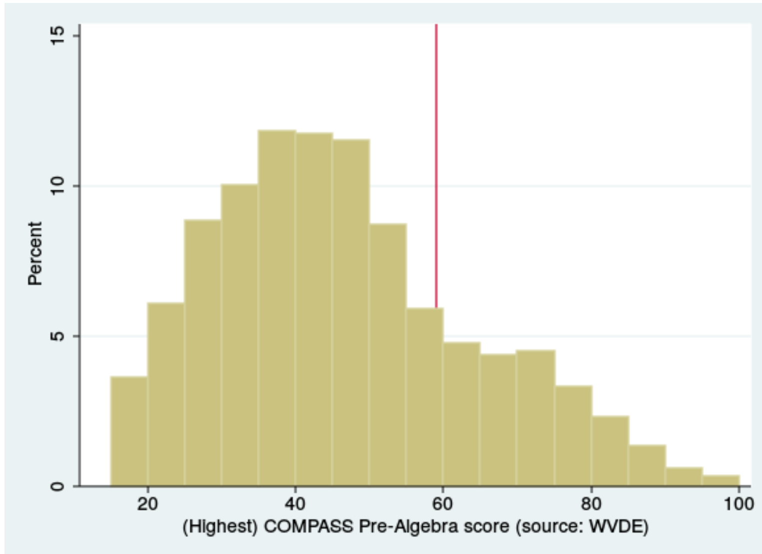
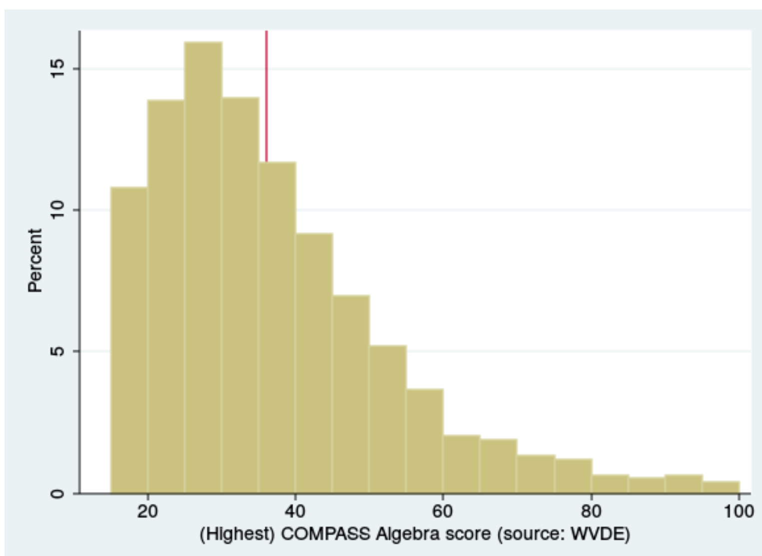


Figure 10
Distribution for COMPASS Algebra Scores



Overall, only 10 percent of transition course students met both the pre-algebra and algebra college readiness benchmarks. Moreover, even out of the 327 high-performing transition course students who met the benchmarks *and* subsequently enrolled in a West Virginia college, 31 percent were not designated as college-ready in mathematics by their college, suggesting that they did not report their COMPASS test scores.

Considering the results in full, it may have been unrealistic to expect students to meet college readiness benchmarks at the end of the course. While most students earned As and Bs, suggesting they were prepared to advance, students' skill levels may still be too low to realistically expect them to meet college readiness benchmarks by the end of the year. Alternatively, students might not meet the benchmark because the transition course is not tightly aligned with the content covered by the COMPASS. This latter theory is supported by comments from some system leaders who stated that the course emphasized high school level content areas rather than pre-algebra, which is considered a middle school level course. Either way, given the low rate of success on the COMPASS, the primary mechanism through which high school transition courses were expected to reduce the need for remediation, it is not surprising that there were no positive impacts on mathematics progression at the college level.

5. Discussion and Conclusion

The number of studies on the impacts of transition courses on college outcomes is increasing due in no small part to their growing popularity. Policymakers and practitioners have struggled to improve outcomes for students who are deemed underprepared for college-level work. At this point, there is no clear evidence that supports any one existing solution. Our study helps to move the field forward by using a quasi-experimental strategy to identify the impact of math transition course participation on short-term college outcomes in West Virginia among students near the assessment cutoff score. We examine whether transition courses improve college readiness at college entry and whether students pass entry-level math courses within their first year following high school graduation.

Our results suggest that the intervention does not improve academic outcomes for underprepared students who were near the assessment cutoff for being placed into transition courses. In the case of passing gatekeeper math courses, students did worse than if they had not taken the transition math class at all. We find a 5 percentage point reduction in passing entry-level college math within the first year due to falling below the cutoff score (thus being recommended for enrollment in the transition course).

Additionally, we find that students who took the transition course also fared worse in terms of total college credits earned and in enrollment in a gatekeeper math course.

A number of factors might help to explain these negative results. First, most students in West Virginia did not immediately enroll in college, which limits the possible effectiveness of transition courses. Additionally, students who took the transition course were separated from their higher ability peers and from higher level courses. As we established in our analysis on the counterfactual (that is, the math course taken instead of transition courses), students who take an alternate math course may benefit because they are grouped with higher ability peers in a more rigorous math class. This hypothesis is consistent with results of other studies that have found that placing students into courses with lower ability peers may negatively impact outcomes (Vardardottir, 2013).

In this study, we rely on the current definitions of college readiness provided by the existing public college system. Usually, a state college system determines a benchmark on the SAT, ACT, COMPASS, and ACCUPLACER that indicates that a student is college-ready. The problem with this generic college readiness definition is the mismatch between what students are tested on and what is actually required for good performance in college. College readiness assessments may be testing skills and knowledge that are not indicative of what students actually need to know to do well. For example, having trigonometry and introductory statistics skills might be predictive of and helpful for college success, but these are not the skills tested on the COMPASS pre-algebra and algebra tests that are used for placement out of remediation. In contrast, the ability to do intermediate algebra and factoring may not be an important skill for students getting a general baccalaureate degree, but they are topics on which students are assessed. What is more, there may be other important non-cognitive skills that help students to succeed in college, regardless of their performance on an algebra test, which are not assessed and therefore are not accounted for in determining whether a student is or is not ready for college. Thus a “college readiness” score alone may not be the most appropriate outcome measure. If students actually possess the knowledge and skills to do well in college but are prevented from enrolling in gatekeeper courses because of the test score, then these college readiness benchmarks may become more of a barrier than a facilitator to improved college outcomes.[9]

Regardless of how predictive scores on college readiness tests are for short-term college success, the point remains that transition courses are intended to improve students' readiness for college. Yet operationalizing the amount and type of impact these courses have on early college outcomes is difficult to accomplish. Student progress and success is measured by passing the COMPASS test at the end of the course, but as we discussed, passing (or not passing) the test does not guarantee that students are ready for college-level courses (see Scott-Clayton, Crosta, & Belfield, 2014). A few other states have automatic mechanisms built into their courses by which students are automatically eligible for college-level coursework after successfully completing the course. In Tennessee, for example, students who successfully finish the course are automatically eligible to enroll in college-level math (see Barnett et al., 2016).

Thus, it is important to ask if the overarching goal of a transition course program is to reduce the need for remediation or if it is to prepare students for success in college-level coursework? The measures and methods we used in this study primarily evaluate the goal of remediation reduction rather than the goal of broad-based skill development associated with success in college. To the extent that these two goals are not congruent, we may fail to capture the true impact of transition course participation by focusing on the former rather than the latter goal.

The course we examined was the first course of its kind in West Virginia; since then, the state replaced it with an entirely new course. While they did not yet have the findings from this study to evaluate the impacts of the original course, we do wonder whether the Transition Math for Seniors was simply too new to be able to produce

[9] To take an extreme hypothetical counterexample, imagine that colleges statewide declared that anyone who even attempts a senior year mathematics transition course is college-ready in mathematics and automatically exempt from developmental education—but that the transition course in reality consisted solely of watching funny videos on YouTube. On our first outcome measure—college readiness in mathematics at college entry—any student who attempts the transition course and subsequently attends college would be coded as "1." We would therefore almost certainly see a dramatic positive "impact" of the transition course. On our second outcome measure—passing a gatekeeper course in mathematics within one year—we would also be likely to see a positive impact, because more students would take gatekeeper courses directly upon college entry without having to take developmental mathematics first, and some of those students would pass. However, whether participation in the course actually improved students' mathematics skills and their "true" college readiness would remain unanswered.

positive results. It takes time for programs to mature and perhaps with a longer tenure results would have been better.

There is substantial variation in transition courses from state to state and school to school, so our findings are hard to generalize, but they do point to challenges that these courses must overcome. A clearer image of the impact of transition courses more broadly will emerge once other impact studies underway are released. Tennessee, California, Illinois, Florida, and New Jersey are all conducting important research on transition courses. Future studies on the newly revamped transition courses in West Virginia will also benefit the field.

We caution readers against rejecting the usefulness of transition courses, but instead encourage more research on how to improve their effectiveness. Two major issues become apparent in our study. First, the transition course as it was offered in the years under analysis was a less rigorous course than what many other students would have otherwise taken in their fourth year. Second, the course does not appear to have been well-aligned with the college readiness assessment (the COMPASS test), given that most students were not scoring college-ready at the conclusion of the course. These findings should not dissuade schools, states, or districts from implementing transition courses but instead should encourage them to invest in areas that might strengthen the effectiveness of the course. Indeed, identifying students who are not quite college-ready and refining their skills while they are still in high school could be a highly effective strategy for reducing remediation rates and increasing persistence and degree completion. But better yet would be to identify the specific areas of skills that students need to have strengthened, and to focus on building these skills prior to student entry in college. In addition to strengthening these skills, it might also be beneficial to look at the ways transition courses could facilitate discussions about such issues as what it means to be college- or career-ready; choice of major; and the social, cognitive, and behavioral expectations of going to college—ideas that have been put forth by Bailey, Jaggars, and Jenkins (2015) in their book on how to redesign community colleges. And it could also be helpful to consider providing different types of support to teachers in order to fortify students' skills and college preparedness. Given the findings of this paper, policymakers, researchers, and educators might do well to put more resources toward identifying interventions and reforms that will improve numeracy and literacy skills rather than continue to focus strongly on the results of placement assessments.

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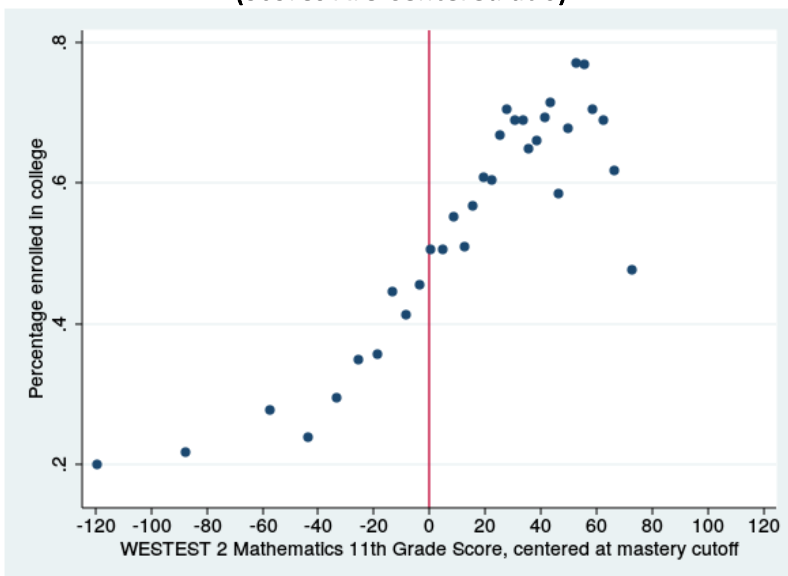
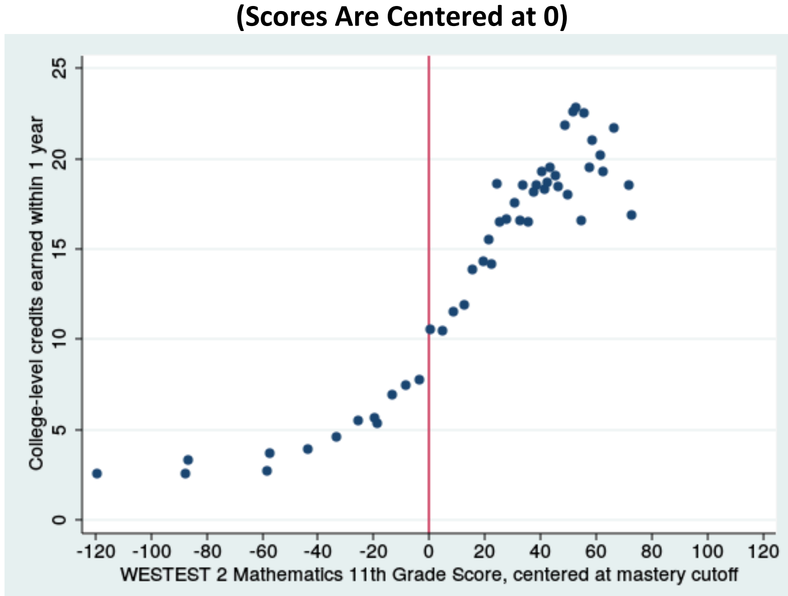
Appendix
Scatter Plots of WESTEST 2 Mathematics Test Scores in Relation to Secondary Outcomes of Interest (2011–12 and 2012–13 Senior Cohorts)

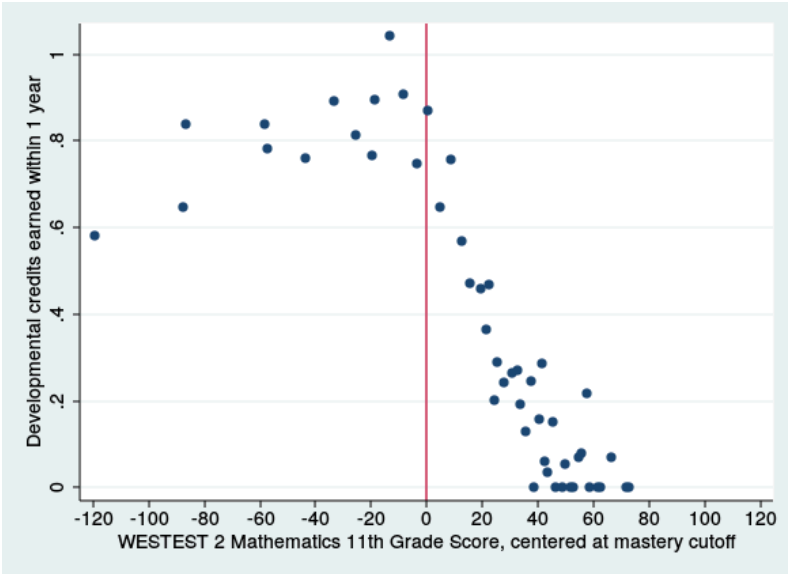
Appendix Figure A.1
College Enrollment by 11th Grade WESTEST 2 Math Score
(Scores Are Centered at 0)



Appendix Figure A.2
College-Level Credits Earned According to 11th Grade WESTEST 2 Math Score
(Scores Are Centered at 0)



Appendix Figure A.3
Developmental Credits Earned According to 11th Grade WESTEST 2 Math Score
(Scores Are Centered at 0)



Appendix Figure A.4
Percentage of Students Taking a Gatekeeper Math Course
According to 11th Grade WESTEST 2 Math Score
(Scores Are Centered at 0)