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Developmental Education and Community College Student Success: Are the Odds Ever in Their Favor?

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Developmental education has gone through various iterations and operated under numerous names across several decades, but the core purpose of ensuring that students are adequately prepared to complete their postsecondary goals has not changed (Boylan & Bonham, 2007). As student enrollment in community colleges has increased over the years, so has the need to provide effective developmental education. According to data from the National Education Longitudinal Study of 1988, approximately 60% of first-time community college students enrolled in at least one developmental course during their academic tenure at two-year institutions (Bailey, Jenkins, & Leinbach, 2005). Additionally, 44% of community college students who enrolled in developmental education took one to three of these courses, and 14% of students took more than three remedial classes (Attewell, Lavin, Domina, & Levey, 2006).

In response to a growing demand for increasing success rates of underprepared students, the American Association of Community Colleges' (AACC, n.d.) 21st-Century Commission on the Future of Community Colleges challenged institutions to double the rate of students who complete developmental programs and successfully transition to complete college-level gateway courses by 2020 (CCCSE, 2016). Developmental courses typically do not count toward degree or certificate programs because they are not college-level courses. Students who place into developmental education may need to take up to five semesters of remedial coursework before they can begin to take college-level classes (Crisp & Delgado, 2014). Many of these students do not complete their remedial sequence. Bailey, Jeong, and Cho (2010) found that nearly half of all students in their study who were placed into developmental courses did not finish their developmental courses and 30% of these students did not enroll in any courses, remedial or not, at their college.

These statistics paint a bleak picture for students who arrive at community colleges underprepared for college-level work (or at least appear unprepared based on the single criterion of a placement test score). Thus far, there is little evidence that current developmental education models are effective enough to produce the results described by the AACC's 21st Century Commission on the Future of Community Colleges.

Utilizing student-level transcript data from the Center for Community College Student Engagement (referred to as the Center), this study examines the relationship of developmental status with gateway course completion and credential (either associate degree or certificate) completion, controlling for level of entry into the developmental sequence, history of enrollment status, and other student characteristics. Many studies of the effects of developmental education find no relationship between it and outcomes or significantly negative relationships; these studies, however, focus on a restricted range of students scoring within a few points of the developmental cut off score on placement tests. Our research includes all students without consideration of placement test scores in order to examine short- and long-term outcomes for students who take remedial coursework.

History of Developmental Education

Developmental education is not a new concept in higher education. It dates back to the mid-1700s when universities created selective admissions standards that potential students struggled to meet, like providing proficiency in Greek and Latin (Arendale, 2002). Students turned to tutoring for

assistance, which is earliest manifestation of developmental education. In the following century, there was a slow period of educational expansion during the years immediately preceding the Civil War, but this changed with the passing of the Morrill Act of 1862, which led to the creation of post-secondary institutions to serve "the industrial classes" (Boylan & White, 1987, p. 4). The expansion of higher education opportunities and greater demand for higher training following the Civil War necessitated an increase of programs to address the academic needs of students who lacked the basic skills necessary to succeed in college (Boylan & White, 1987). During the mid-1800s, under the Jacksonian democracy, several new colleges were established in order to expand educational opportunities. Students seeking admission to these newly established colleges presented minimal academic preparedness (Boylan & White, 1987). As a result, universities offered remedial education courses or other types of assistance to students who were academically underprepared (Arendale, 2002).

Growing enrollment and an influx of underprepared students at newly established colleges and universities during mid-1800s made the traditional developmental model of tutoring model unsustainable. In response, college preparatory programs began to emerge, the first of which started in 1849 at the University of Wisconsin (Arendale, 2002). These programs functioned much like the current developmental education structure: both required academically underprepared students to enroll in remedial reading, writing, and/or math courses (Boylan & White, 1987). Although college preparatory programs experienced a shift away from universities and were predominantly offered through junior colleges during the early 20th century, the advent of open-admissions philosophies created a resurgence of college preparatory courses at colleges and universities in the 1970s (Boylan & White, 1987). Just as earlier generations worked to address the needs of students who are underprepared for college-level work, this continues to be a reality of today's higher education landscape.

Recent demands for greater accountability have put new pressure on postsecondary institutions to demonstrate the effectiveness of existing programs (CCCSE, 2016). Although debates over the effectiveness of developmental education date back to the mid 1800s (Arendale, 2002), new demands from state legislators have been placed upon institutions to implement developmental models that are effective (Boylan & Bonham, 2007). As such, research continues to emerge that seeks to identify effective developmental education models.

The Effects of Developmental Education

Recent research on the effects of developmental education on community college student outcomes suggests that, for the most part, enrollment in developmental education courses has no significant effects (neither positive nor negative outcomes) or that developmental education has a significantly negative effect on short-, mid-, and long-term outcomes. Jaggars and Stacey (2014) reviewed eight studies conducted at large community college systems that examined the relationship between enrollment in development math, reading, or writing courses and persistence, passing college-level courses in the corresponding subject, and the students' grades in the college-level courses. While the authors identified seven outcomes out of 79 short- and medium-/long-term impacts with positive outcomes (all but one of these in Tennessee), the remainder of the findings resulted in a null or significantly negative relationship. Additionally, Martorell, McFarlin, and Xue (2011) examined a longer-term result, post-graduation labor market outcomes in Texas, and found that taking developmental courses had no significant effect.

One limitation of many of the recent studies of developmental education is the use of regression discontinuity (RD) design which, under typical use, limits the population studied to students who score within a narrow range of the college-level/developmental placement test cut score (e.g., -5 to +5 points). Other studies have used RD testing different cut scores, but these studies also include a restricted subpopulation (Bailey, Jaggars, & Scott-Clayton, 2013; Scott-Clayton, Crosta, &

Belfield, 2014), which limits the generalizability of the research findings (Scott-Clayton & Rodriguez, 2012).

Additional findings have shown that developmental education has had no negative impact on community college student success. Bettinger and Long (2005) found that remedial education was unrelated to student academic outcomes once student background characteristics were held constant. Crisp and Delgado (2014) also investigated the effect of developmental education on community college student persistence and upward transfer using Beginning Postsecondary Students Longitudinal Study (BPS 04:09) self-reported survey data and found there was no significant relationship between remedial education and student persistence. Research from Attewell et al. (2006) revealed that, after controlling for high school academic preparation, there was a positive relationship between taking developmental courses and completing degrees in community colleges suggests that taking developmental courses explains variance over and above high school academic preparation.

The literature though is not clear regarding the success or failure of developmental education to fulfill its mission of preparing underprepared students for college-level work. Some of the disparities in findings may be due in part to the use of different sources and types of data (e.g., national survey data, student transcript data, or administrative data) as well as different analytical approaches. Often, studies focus solely on degree completion. While statistical methods allow some flexibility to control for confounding variables, community college students' lives are very complex so capturing all (or most) of the key variables for large numbers of individuals is simply not possible. The current study detailed in this paper attempts to address these issues using course transcript data for students spanning the full spectrum of college-readiness, from the lowest level of developmental education through college-ready. Another distinguishing feature of this study is the focus on short-term outcomes (completion of gateway courses) as well as long-term outcomes (completion of a certificate or associate degree).

Theoretical Framework

Various theoretical foundations of learning, borrowed from several contemporary disciplines, inform the field of developmental education. Each theoretical foundation contributes to a greater framework of developmental education that is integrative and addresses student development in a multi-dimensional way. The humanist approach, for example, provides an essential philosophical premise for the existence of developmental education in that it emphasizes the individual worth of each student and recognizes the inherent desire of individuals to learn (Boylan & Kerstiens, 1988). On the most basic level, this philosophical stance espouses the idea that even underprepared students are worthy of an opportunity for advancement.

Although various learning theories inform remedial education, at the core, its practice is grounded in developmental theory, which holds that students move from one level of knowledge to the next through the process of learning (Boylan & White, 1987). From this perspective, the role of education is to provide individuals with opportunities for growth and learning by engaging them in appropriately challenging work designed to facilitate their progress to the next level. The cornerstone of this framework rests upon Vygotsky's Zone of Proximal Development (ZPD) (Vygotsky, 1987). The ZPD is defined as "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers*" (Vygotsky, 1978, p. 86, italics in the original). If the concepts being taught are either below the ZPD (concepts the student has already mastered) or above the "zone of insurmountable difficulty" (ZID) (Zaretskii, 2009), then they are not contributing to growth. The case of the ZID could actually be detrimental as continued exposure to tasks that a student cannot

successfully complete either independently or with assistance sets up a cycle of failure. The ZPD, therefore, emphasizes the role of the educator in providing the appropriate levels of challenge and support to produce learning—a dynamic that enables scaffolding—whereby a student is able to grow by completing tasks which they may not have been able to do on their own (Hammond & Gibbons, 2005). Engaging students in learning development in this way rests on several key tenets of developmental theory:

> 1. Growth and learning take place in stages; 2. each stage of development is an integrated whole; 3. as individuals pass from one level of development to another, all previous stages are integrated into the next; and 4. each individual develops in a direction and at a rate that is unique. (Boylan & Kersteins, 1988, p. 6)

As such, developmental education models have typically been organized in course sequences with the ultimate goal of preparing students for college-level English or mathematics courses commonly referred to as "gateway" courses (Asmussen & Horn, 2014).

Academic momentum framework also informs our study. According to this proposition, student initial course load and subsequent course enrollment exerts a strong influence on student persistence and credential completion (Adelman, 1999, 2006; Attewell, Heil, & Reisel, 2012; Martin, Wilson, Liem, & Ginns, 2013). Attending full-time helps students to have more opportunities to interact with faculty and students, which facilitate students' academic and social integration into college environment (Tinto, 1975). This is particularly true for non-residential community college students, whose interaction with their peers and faculty members are more likely to be limited to coursework. In addition, having momentum might help students accumulate college credits and promote academic self-efficacy/self-concept, both of which are associated with student persistence and credential completion (Bong & Skaalvik, 2003; Martin et al., 2013).

Research Questions

Based on gaps in the literature, this study seeks to answer the following research questions:

1. Which students are enrolled in developmental education coursework?
2. Based on entry-level into the developmental sequence for math, reading, and writing, what is the extent of remediation needed among community college students?
3. Is there a relationship between the starting level of developmental education course-taking and student gateway math or English completion?
4. Is there a relationship between the starting level of developmental education course-taking and credential completion?

Methods

Student course transcript data collected by the Center for Community College Student Engagement (the Center) was used to answer the research questions. These data include a sample of 17,085 students from 28 community colleges across the United States. Additionally, these data include transcripts for students who completed the Community College Survey of Student Engagement (CCSSE) between 2005 and 2013 and voluntarily provided their student ID on the survey form. Colleges were requested to match the IDs against their student information systems and provide demographic and all course transcript data for these students. The colleges were asked to encrypt the student ID and return the data to the Center. Center staff then cleaned the data and created analysis variables. Students whose first year at their college was after 2011 were excluded from the

analyses because there was insufficient time[1] for the majority of these students to earn an associate degree.

Rather than focus on students whose placement test scores were within a few points above or below a threshold for college-level or developmental level placement (e.g., Bailey, Jaggars, & Scott-Clayton, 2013; Scott-Clayton, Crosta, & Belfield, 2014), the analyses presented here included all students, both developmental and non-developmental, to develop a more complete view of the effect of developmental education on student outcomes.

The analyses included three distinct outcomes that reflect both short- and long-term learning outcomes: completion of gateway English courses with a grade of C or better, completion of a gateway math course with a grade of C or better, and completion of a certificate or associate degree. For this study, no distinction was made between completion of an associate degree or certificate; both were considered completion. When the data were originally requested, colleges were asked to indicate each term a credential was awarded for each student without specifying the type of credential, because the award of either a credential or an associate degree constitutes a successful completion. Some students in the data set used for analysis had multiple credential awards while others had none. For those with multiple awards, data following their first award was removed from the analysis data set. As such, the term "graduation" is used to refer to the first credential awarded.

The primary explanatory variables of interest were student entry-level in developmental math, reading, and writing. For identification of the developmental courses, Center researchers relied on information provided by the colleges and/or information in the colleges' course catalogs. The hierarchical sequences of the developmental courses were determined through the catalog reviews. To rank the developmental level of courses, all developmental math, reading, and writing courses in the transcript files were identified and two Center researchers independently reviewed the course descriptions in the appropriate course catalog. If a course had no prerequisites, it was coded as the lowest developmental level. Following the numbering sequence of the courses and the list of prerequisites for each course, each subsequent course in the sequence was assigned a higher developmental level. Multiple courses from the same institution could potentially have the same developmental level ranking as long as they shared the same prerequisite courses. The two ranking lists were then compared; rankings that matched were considered final. For courses where the rankings did not match, a third Center researcher arbitrated between the two mismatched rankings; the ranking was finalized once all three researchers unanimously agreed upon a single ranking. In the end, developmental math courses were categorized into three levels (low, middle, and high) and two levels (low and high) were coded for developmental reading and writing courses. These level of entry variables were included in the models to control for the overall level of developmental need, where the lower the entry level, the greater the remediation need in that subject area.

These developmental course entry-level variables were included in the statistical analyses as three series of dummy variables, one series for each subject area. Within each area, the reference group consisted of students who never enrolled in a developmental course.

Several control variables were also included in all analyses: gender, age, race/ethnicity, and enrollment status. Additional control variables included in the analyses for the graduation model include overall GPA, total terms a student enrolled, and number of courses a student dropped during their academic studies.[2] Enrollment status was defined in two ways, depending on the outcome vari-

[1] According to data from the National Student Clearinghouse, students who started at a community college in the fall of 2011, only 37.5 percent completed a 2-year degree within six years (Shapiro et al., 2017).

[2] The latter group of variables was not included in the gateway completion models as students typically complete gateway courses earlier in their enrollment history, and these variables would possibly bias the results because they would include enrollment and course-taking information that occurred after the completion of the gateway courses.

able. For the two gateway completion models, the enrollment status of the student during his or her first term at the college (full-time (FT) or part-time (PT)) was used. The second definition of enrollment status was designed to acknowledge the fluidity of student enrollment over time. Most community college research has treated enrollment status as a dichotomous static concept; in reality, it is anything but static (CCCSE, 2017; Crosta, 2014). To capture this realistic fluidity, a variable with the following levels were created:

1. Always FT
2. Always PT
3. Started as FT and subsequently switched to PT and remained PT throughout the remainder of his or her attendance at the college
4. Started as PT and subsequently switched to FT and remained FT throughout the remainder of his or her attendance at the college
5. Started as FT, switched to PT and switched between PT and FT multiple times
6. Started as PT, switched to FT and switched between FT and PT multiple times

Dummy variables were created for each level of this new enrollment variable, and five of the six were included in the graduation model; the "Always PT" level was omitted as the reference group.

Given that all dependent variables were dichotomous, logistic regression was used. The results are reported as odd ratios with 95% confidence limits. Variables where the odd ratio and both confidence limits are greater than one are interpreted as having a significant and positive relationship with the dependent variable; where the full range of confidence intervals is less than one, the variables have a significantly negative influence on the dependent variable. If the confidence limit boundaries include 1.0, the variable is not significantly significant.

List-wise deletion was used in all analyses. As a result, the number of observations in the graduation model was 13,798 (80.8% of the full data set) and 16,537 (96.8%) were available for the English and math gateway models.

Results

The characteristics of students in this study do not align closely with the overall community college population across the United States in 2013. The one exception to this was gender (see Table 1).

Table 1
Comparison of Study Population and National Population

	Overall Distribution of Participants		
	Analysis Data		**National Data**
Demographic	**N**	**%**	**Percent***
All Students	17085	100	
Gender			
Male	6984	41.03	41
Female	10038	58.97	59
Age			
Traditional	10732	63.27	51
Non-traditional	6229	36.73	49

(Table 1 cont.)

Race/Ethnicity			
African American	1724	10.32	14
White	10248	61.32	60
Latino/Hispanic	3453	20.66	13
Other	1286	7.70	13

*Source: CCSSE 2013 Standard Reports, Appendix Table 1

As noted in the methods section, enrollment was treated as a fluid concept in this study instead of a static construct based on the student's first term enrollment, as much of the literature has done. First term enrollment status was used for the gateway math and English models, but the six-level enrollment history variable was used for the graduation model. The distribution of the study participants is presented in Table 2.

Table 2
Distribution of Enrollment History

Enrollment Pattern	**Count**	**Percent**
Always full-time	2,569	15.0
Always part-time	2,960	17.3
Start as full-time, switch to part-time, no other changes	2,586	15.1
Start as part-time, switch to full-time, no other changes	1,380	8.1
Start as full-time, multiple changes	3,480	20.4
Start as part-time, multiple changes	4,110	24.1
Total	17,085	100.0

Considering enrollment in any developmental math, reading, or writing course, approximately 54% of students included in this study were classified as developmental. Developmental students could have enrolled in one or more of three subject areas (math, reading, and/or writing). Table 3 presents the distribution of students enrolled in one, two, or three subject areas by demographic category.

Table 3
Distribution of Students Enrolled in One, Two, or Three Developmental Subject Areas

	Number of Development Areas Student Enrolled In					
	One		**Two**		**Three**	
Demographic	**N**	**%**	**N**	**%**	**N**	**%**
All Students	5280	57.21	2226	24.12	1675	18.15
Gender	**n**	**%**	**n**	**%**	**n**	**%**
Male	2026	58.18	866	24.87	590	16.94
Female	3237	57.14	1351	23.85	1077	19.01

(Table 3 cont.)

Age	**n**	**%**	**n**	**%**	**n**	**%**
Traditional	3135	54.21	1460	25.25	1188	20.54
Non-traditional	2138	63.16	761	22.48	486	14.36
Race/Ethnicity	**n**	**%**	**n**	**%**	**n**	**%**
African American	460	8.92	372	17.1	407	24.61
White	3278	63.55	1079	49.59	686	41.48
Latino/Hispanic	1088	21.09	543	24.95	410	24.79
Other	332	6.44	182	8.36	151	9.13

The first research question asks which students are enrolled in developmental education. Table 4 presents the distribution of developmental and non-developmental students overall by demographic characteristic for each developmental area. Note that remediation in math is needed more frequently, with 46.7% of all students in this sample having enrolled in one or more developmental math courses. Female students tended to start their developmental math sequence at lower levels than male students: approximately half of all female students enrolled in developmental math compared to approximately 42% of males. The differences in enrollment in developmental math between traditional and non-traditional aged students is negligible (46.0% and 48.7%, respectively). Proportionately more African American and Latino students began their developmental math sequence at the lowest level while White and Other students began at the same rate (see Table 4).

Less than 20% of the students in the current data set enrolled in one or more developmental reading courses; 5.7% of all students began at the lower of the two levels, and 13.3% began at the higher level. Overall, a larger percentage of non-traditional age students in this sample did not take a developmental course in reading compared to traditional age. Only 13% of White students were classified as developmental in reading, followed by Latino and Other students, with both groups being approximately 25% remedial in reading. However, approximately 39% of African American students enrolled in one or more developmental reading courses. See Table 4 for a detailed breakout for these demographic groups.

Finally, approximately 21% of all students in this sample enrolled in at least one developmental writing course. There were effectively no differences between males and females in developmental writing participation or in the level at which they started. Proportionately more traditional-aged students enrolled in developmental writing and the same is true for African American students. See Table 4 in the appendix for a detailed breakout for these demographic groups.

Completion of Gateway English with C or Better

Preliminary bivariate analyses reveal that, regardless of the entry level into the developmental math sequence, students who took developmental math had higher rates of gateway English completion than students who did not take these courses (see Table 5). Community college students who entered developmental reading at the higher level also have higher rates of gateway English completion than students who never took developmental reading. Students who entered the developmental writing sequence at either the low or high level were more likely to complete gateway English than students who never took developmental writing; students who started at the higher level were much more likely to pass the gateway English course than the students who began at the lower level (see Table 5).

Table 5
Developmental Students Passing Gateway English vs. Non-Developmental Students in Each Subject Area

	Not Developmental in Subject Area		Developmental Entry Level					
			Low		Middle		High	
Subject Area	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Math	9109	45.3	2825	64.7	2920	64.1	2231	66.4
Reading	13839	52.6	968	47.9	N/A	N/A	2278	68.6
Writing	13550	52.4	1399	54.3	N/A	N/A	2136	68.0

The hypothesized logistic model for completion of gateway English with a grade of C or better fits the data. Compared to a model without any independent variables, the addition of independent variables led to a lower Akaike Information Criterion (AIC) (decreased from 22768.39 to 21374.70), which suggests the model was better than the baseline model without any predictors. The Wald statistic (1271.23, df =13, p<.0001) also indicated the hypothesized model fits the data. The results of this model are presented in Figure 1. Surprisingly, students who began their developmental math sequence at any level were more than twice as likely to pass a gateway English course with a grade of C or better as students who never enrolled in a developmental math course at their college. Students who started at the higher level of developmental reading or writing were more likely to complete a gateway English course than students who were not developmental in either of these areas. On the other hand, students who began their reading or writing developmental sequences at the lower level were less likely to complete a gateway English course compared to the reference group for the explanatory variables.

Examining the demographic covariates in the model, female students were slightly but significantly more likely to complete an English gateway course compared to males, given that other variables in the model are held constant (see Appendix B for figure). Students who enroll FT in their first academic term were 1.4 times more likely to successfully complete a gateway English course with a grade of C or better than students who enrolled PT in their first term. Non-traditional aged students were half as likely to complete a gateway English course compared to traditional aged students. While African American students were less likely to complete a gateway English course than White students, Latino students were 1.32 times more likely to pass than White students; students of other race/ethnic groups were not significantly more or less likely to pass a gateway English course than White students given that other variables in the model are held constant.

Completion of Gateway Math with C or Better

Initial bivariate analyses suggested that, on average, students whose initial entry into the developmental math sequence was medium or high had higher rates of gateway math completion than students who were not developmental in math (see Table 6). Students who entered the developmental math sequence at the lowest level, had the lowest success rate. Surprisingly, community college students who began developmental reading at the upper level had higher rates of gateway math completion than students who never took developmental reading coursework. Similarly, students whose first developmental writing class was the higher-level course were more likely to complete a gateway math course than students who were not developmental in writing; however, students who started at the lower level were less likely to pass the gateway math course than students who never enrolled in a developmental writing course.

Table 6
Developmental Students Passing Gateway Math vs. Non-Developmental Students in Each Subject Area

Outcome Measure: Pass Gateway Math								
	Not Developmental in Subject Area		**Developmental Entry Level**					
			Low		**Middle**		**High**	
Subject Area	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Math	9109	34.2	2825	28.3	2920	38.9	2231	54.8
Reading	13839	36.8	968	25	N/A	N/A	2278	40.8
Writing	13550	36.8	1399	31.3	N/A	N/A	2316	39.8

The hypothesized logistic model for completion of gateway math with a grade C or better fits the data. Compared with the baseline model without any independent variables, the addition of these independent variables resulted in a lower AIC (decreased from 21770.94 to 21044.02), which suggests the model better fits the data. The Wald statistic (709.78, df =13, p<.0001) also indicated the hypothesized model fits the data. The results of this model are presented in Figure 2. As one might expect, students who entered the developmental math sequence at the lowest level were significantly less likely to pass a gateway math course than students who were not developmental in math. However, students who entered the developmental math sequence at the middle or high level were 1.21 and 2.35 times more likely to pass a gateway math course than students who never enrolled in a developmental math course, respectively.

Unlike the bivariate statistics which showed that more students who entered the developmental writing sequence at the higher level successfully completed a gateway math course, there were no significant differences in the likelihood of passing a gateway math course between students who entered the developmental writing sequence at either the higher or lower level and students who were not developmental in writing, holding all other variables in the model constant. Likewise, for students who entered the developmental reading sequence at the higher level, there was no statistical difference in the likelihood of passing a gateway math course. Students who entered developmental reading at the lower level were, however, significantly less likely to pass a gateway math course than students who were not developmental in reading, controlling for the other variables in the model.

In the gateway math model, female students were 1.12 times more likely to complete a gateway math course than males. Students who were enrolled FT in their first term were 1.22 times more likely than students who were enrolled PT during their first term to pass a gateway math course with a grade of C or better. There was a significant difference in gateway math completion for age with non-traditional students being significantly less likely to pass (see Appendix C for figure). African American students were less likely than White students to pass a gateway math course; Hispanic and Other students, on the other hand, were 1.66 and 1.18 times more likely to pass a gateway math course, respectively, compared to White students.

Graduation

Initial bivariate analysis (summarized in Table 7) suggested that, on average, students who took developmental math, regardless of which level they entered the developmental math sequence, had lower graduation rates than students who did not enroll in any developmental math courses. However, among students who did take developmental math, the proportion of students graduating

increased for each level higher a student started, although this never exceeded 30% (see Table 7). Similarly, community college students who entered developmental reading at either level, had lower graduation rates than students who did not enroll in any developmental reading courses. Additionally, fewer students who entered the developmental writing sequence at either level were less likely to complete a certificate or associate degree than students who never took a developmental English course.

Table 7
Graduation of Students in Developmental Education vs. Non-Developmental Students in Each Subject Area

Outcome Measure: Graduation								
	Not Developmental in Subject Area		**Developmental Entry Level**					
			Low		**Middle**		**High**	
Subject Area	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Math	9108	42.7	2825	20.1	2920	26.3	2231	29.9
Reading	13838	37.5	968	15.1	N/A	N/A	2278	15.5
Writing	13549	37.9	1399	13.7	N/A	N/A	2136	24.49

The hypothesized logistic model for graduation fits the data. Compared with the baseline model without any independent variables, the inclusion of the independent variables resulted in a decreased AIC (decreased from 18135.54 to 14858.25), which suggests the full model is a better fit. The Wald statistic (2198.99, df = 20, $p<.0001$) also indicates the hypothesized model fits the data.

In the previous models for gateway course completion, the entry level into the various developmental areas had varying influence on the outcome measure, some positive, some negative, and a few had no significant relationship. In the completion model, with the exception of beginning the developmental writing sequence at the higher level, any enrollment in a developmental course significantly lowered a students' likelihood of completing a certificate or associate degree. Entering the developmental writing sequence at the higher level was not significantly related to completion, given that all other variables in the model are held constant. See Appendix D for the full model estimates.

Again, females were significantly more likely to graduate than males and older students were slightly but statistically more likely to graduate. As one might expect, overall GPA had a significant positive relationship with completion: for each unit increase in GPA, a student was 2.53 times more likely to graduate. Also, for each additional term enrolled, a student was 1.23 times more likely to graduate. As anticipated, each course a student withdrew from or dropped significantly reduced his or her likelihood of credential completion. In this model, there were no significant differences in the likelihood of completing between White students and all other race/ethnicity subgroups.

The final series of variables in the model was a set of five dummy variables reflecting the enrollment history for each student. The six levels of enrollment history were 1. always FT, 2. always PT, 3. started FT then switched to PT and remained PT, 4. started PT then switched to FT and remained FT, 5. started FT and then switched between FT and PT multiple times, and 6. started PT and then switched between FT and PT multiple times. Always PT students were the reference group. Always FT students, as expected, had the largest parameter estimate; they were 4.02 times more likely to graduate than always PT students. Compared to the reference group, students with all remaining enrollment patterns were significantly more likely to graduate than always PT students, controlling for all other variables in the model. In summary, students with any FT enrollment during their attendance at one college were significantly more likely to complete a certificate or an associate degree than students who have no FT attendance.

Limitations

One limitation of this study is that the data are not completely representative of the national community college population. As such, research findings based on this sample might not be generalizable to the overall student population at community colleges in the United States. Nonetheless, the sample is a large multi-state, multi-campus sample of more than 17,000 students from 28 community colleges and the utilization of transcript data can provide some new insights into the effectiveness of developmental education.

An additional limitation is that information about students after they left their colleges is not available. Students who transfer to other institutions prior to completing a credential (and may have successfully completed a credential at the new institution) are treated the same as students who dropped out, which might lead to biased results. Another potentially important variable that is not available on the analysis data set is an indication of students' pre-college academic preparation (e.g., number of years of math or English or overall high school GPA). Inclusion of these variables would provide more power to understand whether and/or how developmental entry levels in math, reading, and writing are associated with student short-term and long-term learning outcomes.

Discussion

This study utilized a large transcript data set to investigate who takes developmental coursework; the magnitude of developmental education among community college students; whether the starting level of developmental education relates to student short-term and long-term learning outcomes, and if so, how.

Research findings confirm that developmental/remedial education has been a component of most community college students' experience. In line with the existing literature (Attewell et al., 2006; Bettinger & Long, 2005; Crisp & Delgado, 2014; Jaggars & Stacey, 2014; Martorell, McFarlin, & Xue, 2011) this study provided evidence that the impact of developmental education on student learning outcomes is mixed. For short-term outcomes (passing gateway math and English with a grade of C or better), enrolling in developmental courses had either a significant positive effect or no significant influence on the likelihood of success. Only four of the parameter estimates for enrolling in developmental education across the two gateway models were significantly negative; these four estimates are for the odds of successfully completing a gateway course for students who started the developmental sequence at the lowest level, compared to students who were not developmental in the corresponding content area. Students who started at the middle or higher level of developmental math had greater odds of gateway math or English completion with a grade of C or better than college-ready students. Students who started at the higher level of the developmental reading and writing sequences also had better odds of completing gateway English than students who were not developmental in the corresponding content area. The odds of completing a gateway math course for the students who started developmental reading and writing at the higher level were not significantly different from students who were not developmental in these areas.

Through the lens of Vygotsky's Zone of Proximal Development (ZPD) theory (Vygotsky, 1987; Zaretskii, 2009), these results make sense. Students who entered developmental reading and writing at the higher level were 1.2 times more likely to pass the gateway English course than students who were not developmental in these areas. However, students who entered developmental reading and writing courses at the lower level were statistically significantly less likely to complete the gateway English course with a grade of C or better than students who were not developmental in these subjects. For those students who entered the developmental reading and/or writing sequence at the lower level, their significantly lower odds of successfully completing the gateway English

course suggests that, at some point, the instruction these students received was not within their zone of proximal development. It is important to keep in mind that the ZPD has both an upper and lower bound, so misplacement in either direction could potentially account, at least in part, for these results.

Turning to the gateway math analysis, a similar picture emerges. The students entering at the lowest level of the developmental sequence were significantly less likely to successfully complete the gateway math course with a grade of C or better than students who were not developmental in math. Students who entered the math sequence at the middle or high levels were 1.2 and 2.3 times more likely to successfully complete the gateway math course than students who enrolled directly into the gateway course as their first math course. From the perspective of the ZPD, these results could suggest that by entering the developmental math sequence where they did, the course content was appropriately aligned with their ZPD, allowing them to push the development of their math skills at a pace that maximized their ability to master the material.

Unlike the near-term outcomes of gateway completion, there were no significantly positive relationships between developmental education and credential completion after controlling for all other variables in the model. In fact, all but two estimates indicate that students who enrolled in developmental education courses had significantly lower odds of completion than college-ready students. The remaining two parameters showed no significant difference between developmental and college-ready students.

The fact that developmental education did not have a consistent and negative influence on the odds of passing gateway courses suggests that developmental education may not be as broken as some literature suggests (e.g., Boatman & Long, 2018; Dadgar, 2012). The findings presented here demonstrate that, for some students, some developmental education may significantly increase their chance of advancing to and succeeding in college-level coursework, provided they are placed in the correct level.

At least to some extent, these findings provide a level of support for the co-requisite model of instruction, in which students enroll in the gateway course while simultaneously enrolling in a course designed to bolster the student's understanding of the content that will facilitate success in the college-level course. However, the existing literature on co-requisite models has, for the most part, only studied the effects of these courses on students within a narrow range of placement test cut scores; thus, more inclusive studies of the co-requisite model are needed to understand exactly who will benefit the most. If the distance between the skills a student possesses (meaning those that they can complete independently) and those skills that a student can successfully complete in collaboration with an instructor or mentor is too great,[3] then the co-requisite model may not work for these students. On the other hand, as we saw in the gateway models, students who entered a developmental sequence above the lowest level had a greater chance of successfully completing the gateway courses than students who were enrolled directly into the gateway course; in other words, these courses, especially the highest level, may have been within the ZPD for most of the students supporting the possibility that co-requisite courses may be appropriate for some students.

Another interesting finding in this study is the relationship between developmental math and completion of a gateway English course: regardless of the level of entry into the developmental math sequence, enrollment in developmental math was a strong positive predictor of the likelihood of successful gateway English completion. It is very common to hear students say "I am not a math person" as an excuse for doing poorly in math or not attempting it at all. Do these results point to the possibility that self-confidence, motivation, or some combination of both mediate the relationship between developmental math and English gateway completion?

[3] Zaretskii (2009) called the level above the zone of proximal development, the "zone of insurmountable difficulty."

Conclusion

The purpose of this study was to examine the likelihood of students who enrolled in developmental coursework passing gateway English and math courses compared to non-developmental students, as well as completion of an associate degree or a certificate. The guiding principal for this study was Vygotsky's ZPD, which theorizes that students will continue to develop only when instruction stimulates the maturation of knowledge or skills beyond the student's current development as long as that instruction is "within the zone of his [or her] own intellectual potential" (Vygotsky, 1987, p 209).

Among the population in this study, there is evidence that developmental education has a positive impact on short-term leaning outcomes (completion of gateway English and math courses with a grade of C or better) depending on the level of entry into the developmental sequence. Those students who entered at the higher levels of math, reading, and writing were more likely to successfully complete the corresponding gateway course; however, those who entered at the lowest level were not successful. From the perspective of the zone of proximal development, this finding suggests that the concepts of gateway courses were outside the intellectual potential of the students entering at the lowest developmental level, even though the concepts were supposed to be scaffolded such that each progressive level built on the previous. For completion of a certificate, the results show that students who enter at any developmental level in either reading, writing, or math, are either significantly less likely to complete a certification or that the difference is not significant, although it does trend toward negative outcomes.

Future analyses should investigate more extensively the trajectories of students entering developmental education, including high school courses and placement test scores, to more fully understand the effect of developmental education on student persistence and success. When considered in unison, these data sources may help identify a student's zone of proximal development and provide the necessary scaffolding upon which to build a successful postsecondary career.

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Appendix A

Table 4: Distribution of Students' Initial Level of Entry into Each Subject Area

	Students' Initial Level of Developmental Math							
	Low Level		**Middle Level**		**High Level**		**Not Developmental**	
Demographic	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
All Students	2825	16.53	2920	17.09	2231	13.06	9109	53.32
Gender	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Male	889	12.73	1,111	15.91	945	13.53	4039	57.83
Female	1913	19.06	1801	17.94	1286	12.81	5038	50.19
Age	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Traditional	1623	15.12	1781	16.60	1530	14.26	5798	54.03
Non-traditional	1200	19.26	1133	18.19	698	11.21	3198	51.34
Race/Ethnicity	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
African American	451	26.16	385	22.33	251	14.56	637	36.95
White	1372	13.39	1664	16.24	1388	13.54	5824	56.83
Latino/Hispanic	764	22.13	637	18.45	391	11.32	1661	48.1
Other	173	13.45	163	12.67	177	13.76	773	60.11
Students' Initial Level of Developmental Reading								
	Low Level		**Middle Level**		**High Level**		**Not Developmental**	
Demographic	**N**	**%**	N/A	N/A	**N**	**%**	**N**	**%**
All Students	968	5.67	N/A	N/A	2278	13.33	13839	81.00
Gender	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Male	354	5.07	N/A	N/A	805	11.53	5825	83.40
Female	611	6.09	N/A	N/A	1460	14.54	7967	79.37
Age	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Traditional	681	6.35	N/A	N/A	1600	14.91	8451	78.75
Non-traditional	286	4.59	N/A	N/A	674	10.82	5269	84.59
Race/Ethnicity	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
African American	210	12.18	N/A	N/A	456	26.45	1058	61.37
White	428	4.18	N/A	N/A	899	8.77	8921	87.05
Latino/Hispanic	182	5.27	N/A	N/A	681	19.72	2590	75.01
Other	116	9.02	N/A	N/A	202	15.71	968	75.27

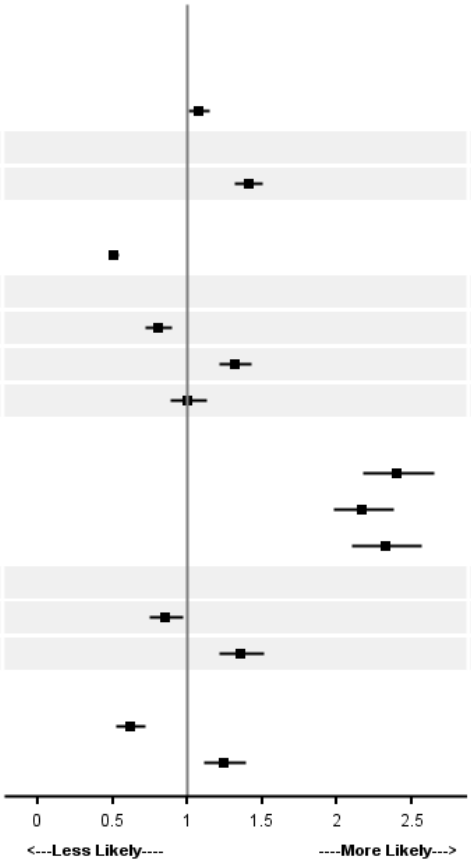
Students' Initial Level of Developmental Writing

	Low Level		**Middle Level**		**High Level**		**Not Developmental**	
Demographic	**N**	**%**	N/A	N/A	**N**	**%**	**N**	**%**
All Students	1399	8.19 `	N/A	N/A	2136	12.50	13550	79.31
Gender	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Male	581	8.32	N/A	N/A	843	12.07	5560	79.61
Female	816	8.13	N/A	N/A	1283	12.78	7939	79.09
Age	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
Traditional	967	9.01	N/A	N/A	1437	13.39	8328	77.60
Non-traditional	431	6.92	N/A	N/A	696	11.17	5102	81.91
Race/Ethnicity	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
African Ameri-can	289	16.76	N/A	N/A	383	22.22	1052	61.02
White	624	6.09	N/A	N/A	1119	10.92	8505	82.99
Latino/Hispanic	305	8.83	N/A	N/A	444	12.86	2704	78.31
Other	164	12.75	N/A	N/A	154	11.98	968	75.27

Appendix B

Logistic Regression Results for Completion of Gateway English Course with a Grade of C or Better

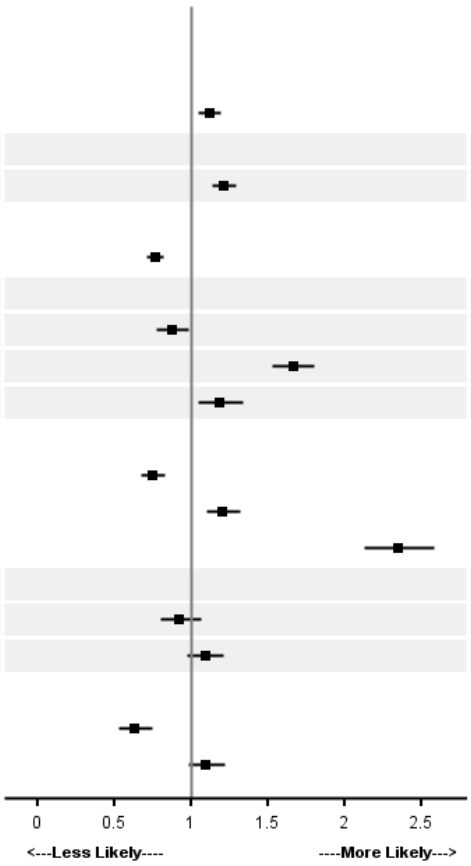
Model Variables	Odds Ratios For Completing English Gateway Course	Odds Ratio Estimates		
		Odds Ratio Estimate	Lower 95% CL	Higher 95% CL
Gender				
Female vs Male		1.071	1.003	1.143
Full-Time 1st Semester				
Full-Time vs Part-Time		1.405	1.317	1.499
Traditional Age				
Nontraditional-Age vs Traditional-Age		0.507	0.473	0.542
Race/Ethnicity				
Black/African-American vs White		0.8	0.716	0.894
Latino vs White		1.316	1.21	1.431
Other vs White		0.999	0.884	1.129
Entering Developmental Math Level				
Low vs Non-Dev (Math)		2.398	2.17	2.649
Medium vs Non-Dev (Math)		2.166	1.974	2.376
High vs Non-Dev (Math)		2.318	2.095	2.564
Entering Developmental Writing Level				
Low vs Non-Dev (Writing)		0.85	0.742	0.973
High vs Non-Dev (Writing)		1.351	1.208	1.511
Entering Developmental Reading Level				
Low vs Non-Dev (Reading)		0.614	0.524	0.72
High vs Non-Dev (Reading)		1.244	1.112	1.393



Appendix C

Logistic Regression Results for Completion of Gateway Math Course with a Grade of C or Better

Model Variables	Odds Ratios For Completing Math Gateway Course	Odds Ratio Estimates		
		Odds Ratio Estimate	Lower 95% CL	Higher 95% CL
Gender				
Female vs Male		1.119	1.047	1.196
Full-Time 1st Semester				
Full-Time vs Part-Time		1.216	1.138	1.298
Traditional Age				
Nontraditional-Age vs Traditional-Age		0.765	0.713	0.82
Race/Ethnicity				
Black/African-American vs White		0.874	0.779	0.981
Latino vs White		1.664	1.533	1.806
Other vs White		1.181	1.045	1.336
Entering Developmental Math Level				
Low vs Non-Dev (Math)		0.745	0.672	0.826
Medium vs Non-Dev (Math)		1.207	1.102	1.323
High vs Non-Dev (Math)		2.349	2.132	2.587
Entering Developmental Writing Level				
Low vs Non-Dev (Writing)		0.924	0.803	1.063
High vs Non-Dev (Writing)		1.089	0.977	1.214
Entering Developmental Reading Level				
Low vs Non-Dev (Reading)		0.626	0.526	0.744
High vs Non-Dev (Reading)		1.097	0.984	1.223



Appendix D

Logistic Regression Results for Credential Completion