Postsecondary Institution Level and Student Transfer Status: Differentiated Effects of Remedial Math-Taking on Degree Attainment

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Abstract

Research is not consistent regarding the effects of taking remedial math in college on degree completion. Studies indicate that effects may be differentiated for 2-year and 4-year students as well as for students who transfer vertically to a 4-year institution. This study investigated the effects of taking remedial math in college on degree attainment for four groups of students. Students were grouped by level of the postsecondary institution first attended (2- or 4-year) and by transfer status (later transferred to a different level). Data were obtained from a large, nationally representative longitudinal data set. Remedial math-taking had a significant negative effect on completion at all institutional levels. Passing all remedial math courses taken was significantly positively correlated with degree attainment for remedial math students, specifically. However, when compared to non-remedial students, the effect of passing all remedial courses was only significant if a student began at a 4-year and then transferred to a 2-year college.

1. Background Information

Higher education institutions have been accepting underprepared students for over 150 years and have continually developed services to meet the needs of diverse student populations with varying skill sets (Boylan et al., 1999; Casazza, 1999). Approximately 75% of all postsecondary institutions offer at least one level of remediation in reading, writing, and/or mathematics (Parsad & Lewis, 2003). The aim of remedial coursework (also called developmental education) is not solely to prepare students with the necessary skills to be successful in college-level courses, but also to "reduce disparities between disadvantaged and advantaged groups" that may exist beyond academic skill gaps (Bahr, 2007, p. 695).

There is consensus that a significant proportion of students entering college take one or more remedial math courses. However, the literature is not consistent regarding the effects of taking remedial math on degree completion. Numerous studies describe negative impacts of remedial education (Bailey, 2009; Brittenham et al., 2003; Chen & Simone, 2016; Melguizo, Bos, & Prather, 2011; Xu & Dadgar, 2018). Some studies indicated that the negative impact of remediation is stronger for students attending 4-year universities than it is for junior college students (Crisp & Delgado, 2014; Shields & O'Dwyer, 2017; Valentine et al., 2017). Other studies reported that although the effects of taking remedial coursework were differentiated for 2-year and 4-year students, remediation was not negatively associated with earning an associate degree or transferring to a 4-year college (Attewell et al., 2006; Calcagno & Long, 2008; Shields & O'Dwyer, 2017). Conversely, other studies contend that remedial education can have a positive impact on degree completion and/or transfer rates (Aycaster, 2001; Bahr, 2008; Bahr, 2010). Furthermore, students who successfully remediate may perform as well or better than their non-remedial counterparts (Bahr, 2008; Bonham & Boylan, 2012). Whether remediation positively impacts degree completion remains questionable and highly debatable.

There is no doubt that significant numbers of college students enroll in remedial math courses and much of the remediation occurs in 2-year colleges. Students attending 2-year public institutions accounted for almost 40% of the total 12-month unduplicated headcount enrollment in 2015-2016 (Ginder et al., 2017). In the 2015-2016 academic year, 49% of all students who earned a bachelor's degree at a 4-year institution had been enrolled at a 2-year public college at some point in the previous 10 years (National Student Clearing House Research Center, 2017). However, only 29% of full-time students attending public 2-year institutions complete a degree within three years, compared to a six-year completion rate of 59% for full-time students attending public 4-year institutions (McFarland et al., 2017). Research has shown that 2-year students who transfer to 4-year institutions may be less likely to earn a bachelor's degree than students who begin college at a 4-year institution (Reynolds, 2012; Sandy et al., 2006; Shapiro, et al., 2017).

The numbers of students entering college at 2-year institutions, as well as those transferring to 4-year institutions, continues to rise. Many college students take one or more remedial math courses. The conflicting results found in the literature regarding the possible effects that remedial course-taking may have on degree completion necessitate further investigation. Additionally, how these effects may differ at various institution levels and for different populations of students (such as transfer students) needs to be studied.

This study focused on the effects of remedial math taking in college on the degree completion of four different groups of students. Students were first grouped by the level of institution at which they began (2-year versus 4-year). Then, each of these groups was further divided based on whether the student transferred to an institution of a different level. In general, when discussing transfer students, we understand that to mean students who transfer from a 2-year college to a 4-year. However, for our research, we considered two different types of transfer status: 2-year to 4-year versus 4-year to 2-year. The study included many of the characteristics that appear in the literature and often define advantaged or disadvantaged groups: sex, race, socioeconomic factors, and high school preparations. Using a nationally representative, publicly available, data set from the Educational Longitudinal Study (ELS), this study contains a large enough sample size for generalizable results.

Research Questions

The research questions that guided this study were:

(1) Does taking remedial math in college have an effect on degree attainment? If so, are the effects differentiated by level of institution attended and/or transfer status?

(2) Do student demographics (generational status, family composition, family income, sex, and racial groups) and/or high school preparations (urbanicity, math, reading, and college preparation program) have an effect on degree attainment? If so, are the effects differentiated by level of institution attended and transfer status?

2. Methods

The data in this study were obtained from the public use data file of ELS, which is a nationally representative longitudinal study of students' transition from high school into postsecondary education and the workforce. The data-collection method involved a multistage probability sample design consisting of approximately 15,400 high school sophomores (in 2002) in the first wave and included postsecondary transcript data for 7,637 participants in the sixth and final data collection wave in 2013 (Bozick, et al., 2007).

2.1. Sample and Variables

This study focused on the effect of remedial math-taking in college on degree attainment (the dependent variable) for four groups of students based on their level of known postsecondary institution(s) attended: (1) 2-year only, (2) 2-year, then 4-year (2-year transfer), (3) 4-year, then 2-year (4-year transfer), and (4) 4-year only. The study utilized a three-stage binary logistic regression. The initial sample of participants was selected from the final data collection wave (containing complete transcript data) using highest known degree attained, known postsecondary institution(s) attended, and known number of remedial math courses taken in college. Multiracial students and Native Americans/Pacific Islanders were filtered out. Results for multiracial students are not interpretable due to insufficient information about race; Native Americans/Pacific Islanders represented a relatively small portion of the sample. The initial sample size was N = 8,250: 2,245 2-year only, 1,022 2-year transfer, 1,004 4-year transfer, and 3,979 4-year only students.

The main predictor variable was remedial math-taking in college. This study also examined the effects of high school preparation in the form of high school math and reading proficiency scores, and participation in a college preparatory program (college prep). The study's demographic variables were students' sex, race (Black, Hispanic, Asian, or White), family composition during high school (single-parent home), family income, generational status (first-generation college student), and high school urbanicity.

2.2. Missing Value Analyses

Before conducting the main analyses, missing value analyses were conducted using SPSS's Mauchly's test (MVA) procedures to avoid the bias caused by missing cases. The results showed the largest percentages of missing values for generational status and family composition with 4.7% and 4.6% missing values, respectively. Two patterns of jointly missing data occurred in more than 1.0% of the cases. The first pattern included generational status and single parent household with 294 jointly missing cases. The second pattern included math proficiency, reading proficiency, college prep, first generation, and single parent household with 89 jointly missing cases. Little's Missing Completely at Random (MCAR) tests the null hypothesis that missing data are missing completely at random for quantitative variables. Inspection of Little's MCAR test showed a nonsignificant result, thus we concluded that the patterns of missing values for the quantitative variables did not depend on the data values themselves.

An investigation of the base year survey status indicated that students with missing data were not in the base year sample, accounting for their missing data. The effect of missingness was further investigated using dummy coding for all variables with missing cases and results showed no significant effect of missingness on any of the other variables in the study, including the dependent variable of degree attainment. Based on these results, we assumed that the missing data were missing completely at random, and we chose a listwise deletion method for missing data.

3. Results

3.1. Results of Preliminary Analyses

Preliminary analyses on differences in degree attainment included descriptive statistics, *t*-tests/Cochran and Cox test statistics, and contingency table of chi-square tests of association. If the homogeneity of variance assumption was violated for a given *t*-test, then the Cochran and Cox test statistic with Satterthwaite-calculated degrees of freedom was used.

In the initial sample, chi-square tests of association showed significant proportion differences between graduates and non-graduates for all variables except high school urbanicity. Students who attained a degree were more likely to be female, to be Asian, and to have participated in college prep in high school. Graduates were less likely to be Black or Hispanic, to be first generation, to have lived in a single-parent home, and to have taken remedial math in college. Although significant differences in proportions were found, effect sizes were small (ranging from .09 to .23). Remedial math-taking in college had the largest effect size (φ = .23). Independent sample *t*-tests showed significant mean differences between graduates and non-graduates in family income as well as high school math and reading proficiency.

3.1.1. Demographics

Chi-square tests of association showed significant proportional differences between graduates and non-graduates for all groups in sex and race. In all groups, students who attained a degree were more likely to be female; graduates were less likely to be Black or Hispanic. Significant differences in generational status were only found in the 4-year groups – first-generation students were less likely to attain a degree. Significant differences were found for family composition in all groups except the 2-year only group – graduates were less likely to have come from a single-parent home. Effect sizes (φ or V) were small for all categorical variable differences in all groups. Independent sample *t*-tests showed significant differences in mean family income between graduates and non-graduates only in the 4-year groups – graduates had higher mean family income, though the effect sizes (d) were small.

3.1.2. High School Preparation

No significant differences were found in any of the groups for high school urbanicity. College preparatory program participation was only significant in the 4-year only group. Graduates were significantly more likely to have participated in a college prep program in high school if they attended only a 4-year institution, though the effect size was small. Independent sample *t*-tests showed significant differences in mean math proficiency for all groups except the 2-year transfer group, with graduates having higher mean math scores. The effect size was small for the 2-year only group and medium for both 4-year groups. Significant mean differences in reading proficiency were found only in the 4-year groups, with graduates having higher mean reading scores. The effect size for reading was small in the 4-year transfer group and medium in the 4-year only group.

3.1.3. Remedial Math-Taking

Significant differences were found in all groups for remedial math-taking in college. In all groups, graduates were significantly less likely to have taken remedial math in college. The effect sizes ranged from -.10 to -.29, with the largest effect size found for the 4-year transfer group and the smallest for the 2-year only group.

It is worth noting that the demographics of our sample of remedial students were not entirely consistent with the literature, which indicated that remedial students were more likely to be of Black or Hispanic race, come from low-income families, urban high schools, have lower academic preparation, and be first-generation college students (Attewell et al., 2006; Bahr, 2010; Boylan et al., 1999; Chen & Simone, 2016; Crisp & Delgado, 2014; Donovan & Wheland, 2008). In our sample, approximately 56% of the remedial students were White, 50% were first-generation college students, and only 33% had attended an urban high school. Nevertheless, we did find that remedial students in our sample had lower average income and lower academic preparation than non-remedial students.

3.2. Logistic Regression Results

A three-stage standard binary logistic regression was used to model degree attainment (using no degree as the reference category) for each of the four groups of students. Prior to running the analysis, the assumption of continuous variables being linear on the logit was investigated using the Box-Tidwell test, with each variable centered at one. The linearity assumption was violated for income in the 4-year group and for math in the 2-year group. To investigate the effect of the assumption violation on regression outcomes, each variable was transformed using both the natural logarithm and the BT transformation (centered at 1). Then, separate regression analyses were performed predicting degree attainment using the original and the transformed variable. The corrected Akaike’s Information Criterion (AIC) was used to evaluate model fit. For the 2-year group, the natural log-transformed math variable (LN) was the preferred transform per the AICc. For the 4-year group, the BT transformed variable was preferred. However, after running the full regression analyses models, neither transformation resulted in a significantly improved model fit over that obtained using the original variables. Therefore, we chose to use the original, untransformed variables for the final analysis.

Although not all covariates showed significant differences in all groups during the preliminary analysis, we chose to keep them in the regression models based on the literature, which indicates they may be significant factors with respect to degree completion for particular levels of postsecondary institution attended. Student demographic predictor variables entered in the demographic model included sex, race (Black, Hispanic, and Asian), parental income, generational status (first-generation college student), and high school family composition (student lived in a single-parent home). In this model, White, male students, students who lived in a two-parent home, and students who were not first-generation were used as reference groups. High school-level preparation variables included urbanicity, college preparatory program participation, and math and reading proficiency scores and were entered in the model with high-school variables. Students not attending urban schools and those who did not participate in college prep were reference groups. Remedial math-taking was entered in the model with no remedial math as the reference group. Table 1 presents only the results of the final model, the model with remedial math, for each of the four groups to provide a more concise summary.

3.2.1. 2-Year Only Group

Sex, Black race, and Hispanic race were significant predictors of degree attainment. The odds of attaining a degree for a female student were estimated to be 1.46 times larger than the odds for a male student with similar conditions (with respect to the other covariates). A Black student was approximately .65 times as likely, and a Hispanic student .71 times as likely, to graduate as a White student. The addition of high school-level variables provided a statistically significant prediction of degree attainment, but the predictive accuracy of the model remained unchanged. None of the high school-level variables were significant predictors. The addition of remedial math-taking in the final model also provided a statistically significant prediction of degree attainment, $\chi^2(12, N = 2{,}119) = 51.22$, $p < .05$. The deviance residuals and analog of Cook’s influence values were all less than 4 in the final model and the leverage values were less than 1, indicating there were no significantly influential outliers in the data that would affect the predicted values. Although the predictive accuracy remained virtually unchanged, the change in the log likelihood showed a statistically significant improved model fit over the model with high-school variables, $\left(\chi^2(1) = 17.11,\ p < .01\right)$. Remedial math-taking, after controlling for the effects of demographic and high-school preparation covariates, was a significant predictor and was negatively correlated with degree attainment. The odds of attaining a degree for a student who took remedial math were .67 times as large as the odds for a student who had not taken remedial math.

3.2.2. *2-Year Transfer Group*

The demographic model provided a statistically significant prediction of degree attainment with a significant effect of sex. The odds of attaining a degree for a female student were estimated to be 1.83 times larger than the odds for a male student.

The addition of high school-level variables in the second model provided a statistically significant prediction of degree attainment, but the change in the restricted log likelihood did not show a significant improvement in model fit over the demographic model. The predictive accuracy remained virtually unchanged. None of the high school-level variables were significant predictors. The addition of remedial math-taking in the third model also provided a statistically significant prediction of degree attainment, $\chi^2(12, N = 977) = 46.06$, $p < .001$. The deviance residuals, analog of Cook's influence, and the leverage values were within acceptable ranges. The change in the log likelihood showed a significantly improved model fit over the model with high school variables $\left(\chi^2(1) = 10.19,\ p < .01\right)$. The predictive accuracy was relatively unchanged. Remedial math-taking was a significant predictor and was negatively correlated with degree attainment. The odds of attaining a degree for a student who took remedial math were .59 times as large as the odds for a similar student who had not taken remedial math.

3.2.3. *4-Year Transfer Group*

The demographic model provided a statistically significant prediction of degree attainment. The odds of attaining a degree for a female student were estimated to be 1.92 times larger than the odds for a similar male student.

The addition of high school-level variables in the second model provided a statistically significant prediction of degree attainment and the change in the restricted log likelihood showed a significant improvement in model fit over the demographic model. Math proficiency was the only significant high school-level predictor and was positively correlated with degree attainment. A one unit increase in math proficiency increased the odds of degree attainment by a factor of 1.03, indicating a 3% increase in the odds of attaining a degree for every one-unit score increase in math.

The addition of remedial math-taking in the third model also provided a statistically significant prediction of degree attainment, $\chi^2(12, N = 962) = 127.01$, $p < .001$. The deviance residuals, analog of Cook's influence, and the leverage values were within acceptable ranges. The change in the log likelihood showed a significantly improved model fit over the model with high-school variables $\left(\chi^2(1) = 37.81,\ p < .001\right)$. The predictive accuracy of the model increased slightly from 71.4% to 72.9%. Remedial math-taking was a significant predictor and was negatively correlated with degree attainment. The odds of attaining a degree for a student who took remedial math were .37 times as large as the odds for a similar student who had not taken remedial math.

3.2.4. *4-Year Only Group*

The demographic model provided a statistically significant prediction of degree attainment, and the predictive accuracy of the model was 74.8%. Almost all demographic variables were significant predictors of degree attainment except single-parent household. The odds of attaining a degree for a female student were estimated to be 1.78 times larger than the odds for a male student. The odds of attaining a degree for a student of Black race were .62 times as large as the odds for a student of White race. The odds of attaining a degree for a student of Hispanic race were .79 times as large as the odds for a student of White race although it did not turn out to be significant in the final model. Conversely, the odds of attaining a degree for a student of Asian race were estimated to be 1.59 times larger than the odds for a similar student of White race. The odds of attaining a degree for a first-generation student were .64 times as large as the odds for a similar student who was not first-generation.

Family income was positively correlated with degree attainment. A one unit increase in income increased the odds of degree attainment by a factor of 1.08, indicating an 8% increase in the odds of attaining a degree for every one-unit increase in income. The family income variable was an ordinal variable with 13 levels and was treated as a continuous variable with a range of 1 to 13. To investigate the effects of the various levels of the original ordinal income variable, the regression was rerun, treating income as categorical. Interestingly, none of the individual levels of income (treating no income as the reference category) were significant predictors in the final model.

The addition of high school-level variables in the second model provided a statistically significant prediction of degree attainment and the predictive accuracy of the model increased slightly from 74.8% to 75.9%. The change in the restricted log likelihood showed a significant improvement in model fit over the demographic model. College prep participation and math proficiency were significant high school-level predictors.

The odds of attaining a degree for a student who participated in college prep in high school were estimated to be 1.45 times larger than the odds for a student who had not participated in college prep. A one unit increase in math proficiency increased the odds of degree attainment by a factor of 1.04.

The addition of remedial math-taking in the third model also provided a statistically significant prediction of degree attainment, $\chi^2(12, N = 3792) = 530.84$, $p < .001$. The deviance residuals, analog of Cook's influence, and the leverage values were within acceptable ranges. The change in the log likelihood showed a significantly improved model fit over the model with high school variables, $\left(\chi^2(1) = 15.07,\ p < .001\right)$. The predictive accuracy remained relatively unchanged. Remedial math-taking was a significant predictor and was negatively correlated with degree attainment. The odds of attaining a degree for a student who took remedial math were .69 times as large as the odds for a student who had not taken remedial math.

3.2.5. *Summary of Logistic Regression Analyses*

Demographic variables included sex, race, family income, generational status, and family composition. These variables combined provided a statistically significant prediction of degree attainment in all four groups. The final models for all four groups indicated that the odds of graduating were significantly higher for females than for males and sex had the largest odds ratio of any significant predictors in the final model for all four groups. The odds of graduating were significantly lower for Black students who attended only 2-year or only 4-year colleges. The odds of graduating were significantly lower for Hispanic students if they attended only a 2-year college. The odds of graduating were significantly higher for Asian students attending only a 4-year college.

Family income was significant and positively correlated with degree attainment in the 4-year only group. The odds of graduating were significantly lower for first-generation students attending only a 4-year college. For students who began college at a 2-year institution and for those who transferred from a 4-year to a 2-year college, family income and generational status were not significant predictors of degree attainment. Family composition was not a significant predictor in the final model for any of the groups.

High school preparation variables included urbanicity, college preparatory program participation, and math and reading proficiency scores. The addition of these variables also provided a statistically significant prediction of degree attainment in all four groups. However, the addition of high school preparations did not improve the model fit over the demographics model for either of the 2-year groups. High school preparations were not significant predictors of degree attainment for students beginning college at a 2-year institution, regardless of whether they later transferred to a 4-year college. High school urbanicity was not significant for any of the groups. The odds of graduating were significantly higher for students who participated in a college preparatory program participation if they attended only a 4-year college. Math proficiency was a significant predictor for students who began college at a 4-year institution, regardless of whether they later transferred to a 2-year. However, high school math proficiency was not significant for students beginning at 2-year colleges.

Adding remedial math-taking in college, the main predictor, provided a statistically significant prediction of degree attainment and resulted in a significant improvement in fit over the demographics and high-school preparations models for all four groups. Results indicated that remedial math-taking was a significant predictor and negatively correlated with degree attainment in all four groups of students. The effect of remedial math-taking was most notable for students who first attended a 4-year college and later transferred to a 2-year.

Table 1. *Binary Logistic Regression Results Predicting Degree Attainment*

	2-Year Only			2-Year Transfer			4-Year Transfer			4-Year Only		
Predictor	B	S.E.	OR	B	S.E.	OR	B	S.E.	OR	B	S.E.	OR
Constant	-0.65	0.33		1.5	0.6		-0.69	0.63		-1.98	0.32	
Sex	0.38	0.1	1.46**	0.6	0.16	1.83**	0.65	0.16	1.92**	0.58	0.08	1.78**
Black	-0.44	0.17	.65*	-0.49	0.26	0.61	-0.21	0.25	0.81	-0.48	0.12	.62**
Hispanic	-0.35	0.14	.71*	-0.26	0.23	0.77	-0.03	0.27	0.98	-0.24	0.14	0.79
Asian	0.04	0.18	1.04	0.38	0.27	1.47	0.42	0.25	1.52	0.47	0.16	1.59**
Income	-0.03	0.03	0.97	-0.02	0.04	0.98	0.05	0.04	1.05	0.08	0.02	1.08**
First-Gen.	0.01	0.1	1.01	-0.03	0.17	0.98	-0.3	0.17	0.74	-0.45	0.09	.64**
Single-Parent	-0.09	0.13	0.92	-0.32	0.2	0.73	-0.27	0.2	0.77	-0.07	0.11	0.93
Urban HS	-0.04	0.12	0.97	-0.13	0.17	0.88	0.32	0.17	1.37	0.04	0.08	1.04
College Prep	0.01	0.1	1.01	0.16	0.16	1.18	-0.06	0.16	0.94	0.37	0.09	1.45**
Math IRT	0.01	0.01	1.01	0	0.01	1	0.02	0.01	1.03*	0.04	0.01	1.04**
Reading IRT	-0.01	0.01	0.99	0	0.01	1	0	0.01	1	0.01	0.01	1.01
Remedial	-0.41	0.1	.67**	-0.52	0.16	.59**	-0.99	0.16	.37**	-0.38	0.1	.69**
Test	χ^2	*df*		χ^2	*df*		χ^2	*df*		χ^2	*df*	
Block	17.11**	1		10.19**	1		37.81**	1		15.07**	1	
Model	51.22**	12		46.06**	12		127.01**	12		530.84**	12	
Hosmer & Lem.	18.92*	8		6.74	8		4.11	8		17.74*	8	
Model Summary												
Cox & Snell	0.02			0.05			0.12			0.13		
Nagelkerke	0.03			0.07			0.17			0.19		
-2LL	2505.14			1052.19			1060.56			3823.73		
Pred. accuracy	70.90%			74.60%			72.90%			76.00%		

Notes. *p < .05, **p < .01. -2LL = -2 Log Likelihood

3.3. Post-Hoc Investigation of the Effects of Remedial Math-Taking

When we compared degree attainment of non-remedial versus remedial students, significant differences were found at all institution levels – remedial math students were less likely to attain a degree. Some literature indicates that there may be differences in the effects of taking remedial math if the students pass all remedial courses in which they enroll (Bahr, 2008; Bonham & Boylan, 2012). We conducted a separate investigation using a subsample that included only those students who had taken remedial math to explore the effect of passing all remedial courses. We created a new dichotomous variable that indicated whether the student had passed all remedial math courses in which they enrolled. This became the new main predictor in the logistic regression model predicting degree attainment. We included the same covariates for student demographics and high school preparations as were used in the full sample models.

The final regression models provided statistically significant predictions of degree attainment at all institution levels. Due to space considerations, only the odds ratios for the final models predicting degree attainment of remedial students (column label *Rem.*) are presented in Table 5.

For comparison, the odds ratios from the final models of the full-sample analyses are also included (column label *Full*). The main predictor, passing all remedial math courses taken, was significant at all institution levels. The odds of attaining a degree were significantly higher for a student who passed all their remedial math courses compared to the odds for a student who took, but did not pass, all their remedial courses. Just as in the full-sample analysis, the most salient effect related to remedial math-taking was found in the 4-year transfer group. The odds of attaining a degree for a 4-year transfer student who passed all their remedial courses taken were estimated to be 4.22 times larger than the odds for a student who did not pass all their remedial math courses.

Table 2. *Final Logistic Regression Model Predicting Degree Attainment: Comparison of Odds Ratios of the Full Sample and the Remedial Students Only Subsample*

	2-Year Only		2-Year Transfer		4-Year Transfer		4-Year Only	
Predictor	Full	Rem.	Full	Rem.	Full	Rem.	Full	Rem.
Sex	1.46**	1.42*	1.83**	1.35	1.92**	1.65	1.78**	1.82**
Black	.65*	.71	.61	.83	.81	1.29	.62**	.67
Hispanic	.71*	.67*	.77	.62	.98	.89	.79	.80
Asian	1.04	1.08	1.47	1.26	1.52	1.53	1.59**	1.29
Income	.97	.95	.98	.99	1.05	1.02	1.08**	1.05
First-Gen.	1.01	1.01	.98	1.01	.74	0.58*	.64**	0.69*
Single-Parent	.92	1.00	.73	.71	.77	.79	.93	1.02
Urban HS	.97	1.16	.88	.92	1.37	1.50	1.04	1.28
College Prep	1.01	1.12	1.18	1.25	.94	.96	1.45**	1.23
Math	1.01	.99	1.00	.99	1.03*	1.03	1.04**	1.02
Reading	.99	1.00	1.00	.99	1.00	1.01	1.01	1.02
Took Remedial	.67**		.59**		.37**		.69**	
Passed All Taken		2.34**		2.83**		4.22**		1.97**

Note. *$p < .05$, **$p < .01$

Results of this full-sample analyses indicated that taking remedial math had a negative effect on degree attainment regardless of the level of institution attended. The post-hoc analysis of only remedial math students indicated that, for students who did take remedial math, passing all remedial courses in which they enrolled was a significant predictor of, and positively correlated with, degree attainment at all institution levels. These results led us to ask, if students do pass all remedial courses they take, does this remove the negative effect of remedial math-taking on degree attainment in general?

We investigated this question by returning to our full sample and filtering out students who did not pass all remedial courses taken. We then looked for differences in degree attainment between non-remedial students and remedial students who passed all their remedial math courses. Chi-square tests of association showed no significant differences in degree attainment for students who attended a 2-year institution, regardless of whether they later transferred to a 4-year. However, significant differences in degree attainment were found for both 4-year only $\left(\chi^2(1) = 28.79,\ p < .001\right)$ and 4-year transfer students $\left(\chi^2(1) = 18.07,\ p < .001\right)$.

Logistic regression predicting degree attainment was rerun for the 4-year groups, once again using remedial math-taking as the main predictor variable along with all the same demographic and high school preparation covariates included in the previous models. The final regression models provided statistically significant predictions of degree attainments for both 4-year groups, however, found differentiated results between the groups. Due to space considerations, only the odds ratios for the final models predicting degree attainment (column label *Passed All*) are presented in Table 6. For comparison, also included in the table are the odds ratios from the final models of the full-sample analyses (column label *Full*).

Table 3.
Final Logistic Regression Model Predicting Degree Attainment in the 4-Year Groups: Comparison of Odds Ratios of the Full Sample and the Remedial Students Who Passed All Courses Subsample

	4-Year Transfer		4-Year Only	
Predictor	Full	Passed All	Full	Passed All
Sex	1.92**	1.86**	1.78**	1.76**
Black	.81	.84	.62**	.63**
Hispanic	.98	.87	.79	.80
Asian	1.52	1.35	1.59**	1.57**
Income	1.05	1.05	1.08**	1.09**
First-Gen.	.74	.70	.64**	.64**
Single-Parent	.77	.78	.93	.90
Urban HS	1.37	1.26	1.04	1.02
College Prep	.94	.91	1.45**	1.50**
Math	1.03*	1.02	1.04**	1.04**
Reading	1.00	1.01	1.01	1.01
Took Remedial	.37**	.64*	.69**	.87

Note. $*p < .05$, $**p < .01$

For 4-year transfer students, taking remedial math still had a significant negative effect on degree attainment even though these remedial students passed all their remedial courses. The odds of attaining a degree for a remedial student were estimated to be .64 times as large as the odds for a non-remedial student. However, if a student attended only a 4-year college, taking remedial math was no longer a significant predictor of degree attainment after controlling for demographics and high school preparations. Therefore, passing all remedial courses did remove the negative effect of remedial math-taking for students at 4-year only institutions, but not for 4-year transfer students.

4. Discussion

In our sample, the completion rate of non-remedial students was about 24% higher than that of remedial students, which is consistent with much of the literature (Bailey, 2009; Brittenham et al., 2003; Chen & Simone, 2016; Melguizo et al., 2011; Xu & Dadgar, 2018). It may be that students who take remedial math are lower academic performers in general, accounting for their lower completion rates. Nonetheless, if remedial math-taking aids students in graduating (in part by removing disparities between groups of students), it should be positively correlated with degree attainment. Students who have taken it should have completion rates comparable to those of non-remedial students with similar characteristics, regardless of the level of postsecondary institution they attend, yet we did not find that in our main analysis. Despite the inclusion of student demographics and high school preparations, remedial math-taking in college was a significant, negative predictor of degree completion at all institutional levels. Moreover, commonly cited group disparities such as race and socioeconomic factors were not consistently significant factors in degree attainment unless students attended a 4-year only institution.

Prior research (Crisp & Delgado, 2014; Shields and O'Dwyer, 2017; Valentine, et al., 2017) indicated that the effects of taking remedial math may be more severe for students attending 4-year institutions and/or those who transfer from a 2-year to a 4-year institution. Our results were consistent with the bulk of prior research and suggested that the negative effects of taking remedial math were differentiated based on the level of postsecondary institution a student attended, with the odds of degree attainment by remedial student decreasing as we move up in institution level. Our study shed some light on one group of students that have largely been ignored – students who transfer in reverse (from a 4-year to a 2-year college). This group represented more than 12% of our sample and we found that, compared to all other groups, the negative effect of remedial math-taking was most salient for this group of students in every analysis conducted. However, assuming a remedial student passes all the remedial courses they take, remediation may not have a significant effect on degree attainment (Aycaster, 2001; Bahr, 2008; Bahr, 2010). The results of our initial investigation naturally led us to consider the effects of remedial math-taking for students who passed all remedial courses they took.

Would the negative effects on degree completion that we initially found disappear for these students? The answer was, it depends. Notably, we found that passing all remedial courses taken did positively impact degree completion when considering only those students who took remedial math. On the other hand, when we compared non-remedial students to only remedial students who had passed all the remedial courses they took, we found that successfully remediating did not hurt most of the students in this study, but it did not significantly help either. A recent trend in higher education has been to eliminate remedial coursework in many institutions. Indeed, if remediation does not help students graduate, then why offer it? We have reservations about this trend.

Ultimately, our findings indicated that if students passed all their remedial courses, most had equivalent outcomes to those of non-remedial students, which is the desired outcome of remediation. However, if they did not pass all remedial coursework, we saw a negative impact on degree attainment. That makes sense. Remedial students in our sample took as many as five remedial courses. For those students who did not pass them all, this number probably included courses a student had to repeat. As mathematics is a prerequisite for many college-level courses aside from just math, a student who does not successfully remediate will obviously be less likely to earn a degree if math is a prerequisite for any of their core courses. Therefore, eliminating remediation seems counterproductive.

We have yet to answer the question of *why* we see such differences in outcomes for various groups of students. Our study left us with more questions than answers. We believe that to make substantial progress in this area of research, future data collections must look for new variables. Research tells us there is little doubt that remedial and non-remedial students are different.

The question we need to address is, “what makes students who successfully remediate different from those who do not?”. To collect the right data, we must ask the right questions. Large scale data sets have been, for the most part, collecting the same data for years. A mixed-methods approach might be more beneficial in gleaning some insight into important variables we have yet to consider and account for.

Several limitations in this study were related specifically to remedial math-taking. We did not know at what point in time remedial courses were taken. Timing of remediation could be a significant factor in the effect of remediation on graduation. For example, one possible explanation in the drastically different results for 4-year transfer students is that remediation occurred later at the 2-year institution *after* transfer. It was also unknown if remediation was optional, which could have introduced self-selection bias. The format and credit hours of the remedial course(s) was unknown. Finally, we did not distinguish between the type of degree a student earned. For instance, a student could have started at a 2-year college, earned an associate degree, transferred to a 4-year institution, but not have earned a bachelor’s degree. Should we consider this as a failure? Maybe. Maybe not. We recommend that future studies incorporate credential type into the analysis.

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