

Does Math remediation have an effect on success in the first semester of College Algebra? What factors are associated with math success - High School GPA and/or Math ACT?

The data sample for this question consists of students who graduated between 2008 and 2012 and have recorded a non-withdrawal grade in their first semester of College Algebra. The total sample size is 3,109 students. It seems that the current standard measure to make a decision on Math remediation is the ACT Math sub-level score, so that has been included as a possible factor. However, since it appears that NDUS Core GPA is a strong predictor of on-time Associate Degree completion, it is also being included as a possible predictor in logistic regression analysis. In addition to a logistic regression analysis, a correlation matrix was also constructed to see the relationship between the variables under consideration.

	Coefficient	S.E.	Significance
NDUS Core GPA	1.6796	0.087	<0.0001
ACT Math	0.0534	0.015	0.0003
Constant	-4.7712	0.329	<0.0001

Table 1: Logistic Regression Coefficients

	ACT Math	NDUS Core GPA	Math Success
ACT Math		0.440	0.235
NDUS Core GPA	0.440		0.439
Math Success	0.235	0.439	

Table 2: Correlations for Success in College Algebra

Both the logistic regression analysis and correlation matrix tend to indicate a positive relationship between ACT Math sub-level score and NDUS Core GPA with success in a student’s first semester of College Algebra. The ACT Math score of a student *is* a significant predictor of College Algebra success, along with NDUS Core GPA.

To study the effect of Math remediation on first attempt College Algebra success (defined as earning a C or above), the overall success rates and differences between groups were examined.

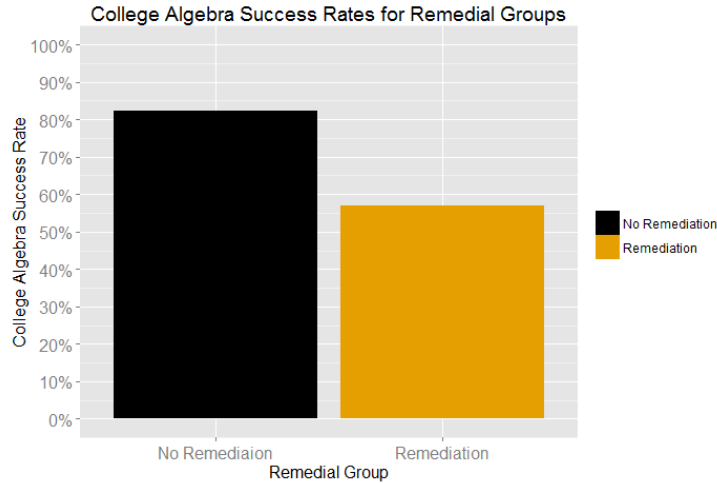


Figure 1: College Algebra Success Rates for Remedial Groups

On the surface, it appears the students who take remedial Math courses have a much lower rate of success than those students who do not take remedial Math courses. However, the average NDUS Core GPA of the remedial group was 2.647, compared to the 3.171 average NDUS Core GPA of the non-remedial group. The average ACT Math score of the remedial group was also much lower when compared to the non-remedial group, 18.12 to 22.68. Since it has already been shown that NDUS Core GPA and ACT Math score are significant predictors of success in College Algebra, some form of blocking is needed to more accurately determine the effect of remediation outside of the effect of these variables.

To further study the effect of remediation, propensity score matching was used with the logistic regression model to match remedial students to non-remedial students with very similar estimated probabilities of success based on their ACT Math sub-level score and NDUS Core GPA. In this way, the effect of ACT Math and NDUS Core GPA can be removed, and the effect of remediation more accurately observed.

There are 586 remedial math students, and 2,523 non-remedial math students in this sample. Matches were successfully found for 476 of the remedial students using propensity score matching. To compare the effect of remediation vs. non-remediation on similar students, the non-parametric McNemar test for related samples was used.

		Remedial Students	
		Success (A,B,C)	Failure (D,F)
Matched Non-Remedial Students	Success (A,B,C)	200	131
	Failure (D,F)	76	69

Table 3: Initial McNemar Test Results

p_1 is established to be the proportion of non-remedial students who succeed in their first attempt of College Algebra, and p_2 is defined as the proportion of remedial students who succeed in their first attempt of College Algebra. Therefore,

$$\hat{p}_1 = \frac{200 + 131}{476} = 69.54\% \quad (1)$$

$$\hat{p}_2 = \frac{200 + 76}{476} = 57.98\% \quad (2)$$

Using McNemar's test:

$H_o : p_1 = p_2$ (The two proportions are the same)

$H_a : p_1 > p_2$ (The proportion of all non-remedial students who succeed in College Algebra is greater than

the proportion of all similar remedial students who succeed in College Algebra)

$$z_{test} = \frac{131 - 76}{\sqrt{131 + 76}} = 3.823 \quad (3)$$

$$p < 0.0001 \quad (4)$$

Thus, we would reject the null hypothesis, and conclude (at $\alpha = 0.05$) that students who take remedial math coursework succeed in their first attempt of College Algebra at a rate lower than that of similar students who do not take remedial coursework. Since students were matched by their Math ACT scores and NDUS Core GPA, this would seem to indicate that among similar students, students are negatively affected by remedial coursework compared to not taking remedial work.

However, one of the secondary goals of this study was to determine if there was a cut-point or some measure of determining when remedial coursework should be offered. Upon further investigation, an interesting pattern in the effect of remediation appears.

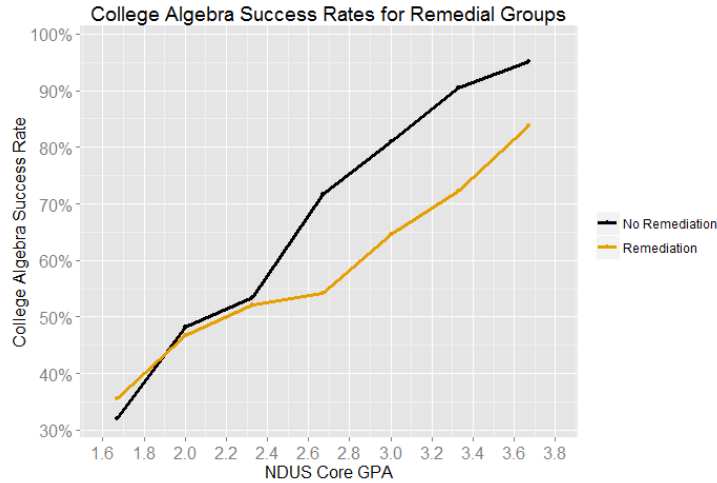


Figure 2: Observed Success Rates by NDUS Core GPA and Remedial Status

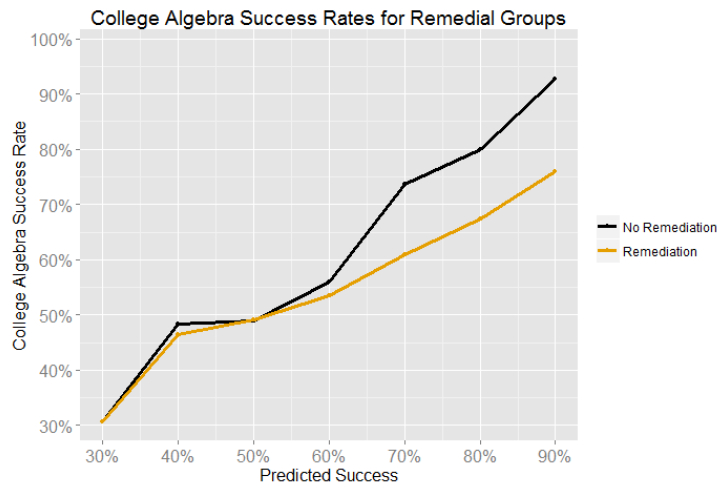


Figure 3: Observed Success Rates by Propensity Score and Remedial Status

After further study, it appears that there are two distinct areas of effect for remediation. Below a certain point, around 65% predicted success (based on the logistic regression formula used for propensity score matching), remediation seems to have neither a positive nor negative effect. However, above this point, remediation seems to have a negative effect on the observed success rate. To further study this, a McNemar test for related samples was again performed, but now splitting the analysis into two groups - those students above a 65% predicted success rate, and those below a 65% predicted success rate. Only pairs of students where both the remedial and non-remedial student were above or below 65% predicted success were kept under consideration.

Below 0.65 Predicted Success

		Remedial Students	
		Success (A,B,C)	Failure (D,F)
Matched Non-Remedial Students	Success (A,B,C)	23	19
	Failure (D,F)	19	36

Table 4: Below 0.65 McNemar Test Results

If, again, p_1 is defined to be the proportion of successful non-remedial students and p_2 is defined to be the proportion of matched successful remedial students, then:

$$\hat{p}_1 = \frac{23 + 19}{97} = 43.30\% \tag{5}$$

$$\hat{p}_2 = \frac{23 + 19}{97} = 43.30\% \tag{6}$$

Using McNemar's test:

$H_o : p_1 = p_2$ (The two proportions are the same)

$H_a : p_1 > p_2$ (The proportion of all non-remedial students who succeed in College Algebra is greater than the proportion of all similar remedial students who succeed in College Algebra - for only those students with a predicted probability of success below 0.65)

$$z_{test} = \frac{19 - 19}{\sqrt{19 + 19}} = 0 \tag{7}$$

$$p = 0.5 \tag{8}$$

Above 0.65 Predicted Success (Including 0.65)

		Remedial Students	
		Success (A,B,C)	Failure (D,F)
Matched Non-Remedial Students	Success (A,B,C)	108	57
	Failure (D,F)	23	8

Table 5: Above 0.65 McNemar Test Results

$$\hat{p}_1 = \frac{108 + 57}{196} = 84.18\% \tag{9}$$

$$\hat{p}_2 = \frac{108 + 23}{196} = 66.84\% \tag{10}$$

Using McNemar's test:

$H_o : p_1 = p_2$ (The two proportions are the same)

$H_a : p_1 > p_2$ (The proportion of all non-remedial students who succeed in College Algebra is greater than the proportion of all similar remedial students who succeed in College Algebra - for only those students with a predicted probability of success above 0.65)

$$z_{test} = \frac{57 - 23}{\sqrt{57 + 23}} = 3.801 \tag{11}$$

$$p < 0.0001 \tag{12}$$

Interpretation

By splitting the analysis into two groups, those above and below 0.65 predicted success, the results are now quite different from the original McNemar test results from table 3 on page 2. Below 0.65 predicted success, there is no statistically significant difference between those groups taking remedial coursework and those not. However, above the 0.65 predicted success line, the success rate for those students who did not take remediation is significantly higher than those similar students who did take remedial work. Since these are **matched** students, this seems to indicate that if a student has a predicted probability of above 0.65, remediation may have a negative effect on their success in their first College Algebra class.

Remedial Cut Line

Knowing that there is a point above 0.65 predicted probability of success where remediation does not appear to be effective, and below 0.65 where it may (or may not) be effective, a formula to determine when Math remediation may be necessary and effective can then be formulated from the logistic regression coefficients.

$$ACT_{Math} < 100.941 - 31.453(NDUSCoreGPA) \quad (13)$$

Formulas 13 above shows the formula for determining the remediation cut-line, based on the logistic regression formula and the results from the McNemar tests. If a student's Math ACT is lower than $100.941 - 31.453(NDUSCoreGPA)$, then that student would be flagged for needing remedial coursework. This formula takes into account both a student's Math ACT sub-level score and NDUS Core GPA, as opposed to the current method which seems to rely solely on the Math ACT.

Effect of Using the Proposed Cut Line

In the original sample of students, there were 586 remedial students, 2,523 non-remedial, for a remedial percentage of 18.8%. If the proposed cut line were in effect for this sample, it would result in 681 remedial students and 2,428 non-remedial students, for a new remedial percentage of 21.9%.

Original Status - New Status	% Successful	Count
No Remediation - No Remediation	88.62%	2117
No Remediation - Remediation	48.77%	406
Remediation - No Remediation	67.52%	311
Remediation - Remediation	45.10%	275

Table 6: Effect of proposed cut line on remedial status

While increasing the overall percentage of students receiving Math remediation may not be overly desirable, the proposed cut line seems to categorize students more accurately. For example, 406 students were not originally identified as taking remediation and had a success rate of 48.77% who would now be identified as needing remediation (which, with a success rate below 50%, would seem accurate). This would seem to indicate that there are a number of students currently not being identified as needing remedial work that could perhaps otherwise benefit from it.