

Associations Among Preparatory Course Taking and Student Success Outcomes

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This analysis was intended to answer the question - Is taking preparatory courses at UC Merced – specifically Math005 (Pre-Calculus) and/or Wri001 (Academic Writing) – associated with less favorable student success outcomes? We considered students who entered UC Merced as frosh (first-time first-year students) in a fall semester between 2013 and 2017. We used propensity score matching (PSM) to create matched treatment (took preparatory course) and control (did not take preparatory course) groups and examined retention and graduation outcomes across groups. Overall, the results suggest having taken Math005 (vs. not) was not associated with less favorable student success outcomes. Conversely, having taken Wri001 only (vs. not) or having taken both Math005 and Wri001 (vs. not) was associated with less favorable student success outcomes.

Background

This analysis had the following **research question**: Is taking preparatory courses at UC Merced – specifically MATH005 (Pre-Calculus) and/or WRI001 (Academic Writing) – associated with less favorable student success outcomes? The outcomes considered were 1-, 2-, and 3-year retention rates as well as 5- and 6-year graduation rates. The **analysis sample** included students who entered UC Merced as frosh (first-time first-year students) in a fall semester between 2013 and 2017 (total n = 9337). We chose these cohorts due to changes in the way that students place into preparatory Math and Writing courses in the fall of 2020 and 2022, respectively; a consideration of cohorts for which 5- and 6- year graduation rates could be calculated; and COVID-19 pandemic impacts. Note that we did not consider the timing of taking preparatory courses (e.g., first or second term) only whether they were ever taken during the student's time at UC Merced. We considered whether students took only Math005 or Writing001 as well as whether students took both courses.

Our **analysis strategy** had two steps. First, we used propensity score matching (PSM) to identify demographically comparable matched treatment and control groups (see Appendix A for detailed description of this approach and matching results for each model). Second, using the propensity score matched treatment and control groups, we examined whether there were differences in the outcomes of interest. For completeness, we provide the results of the analysis for both the matched and total samples, but we focus on the results obtained using the matched sample.

Results Summary

- The PSM procedure was quite effective at creating matched treatment and control groups for the analysis that considered whether students took Math005 only and for the analysis that considered whether students took both Wri001 and Math005. However, the matching procedure was less effective for the analysis that considered whether students took Wri001 only such that those results should be interpreted with caution.
- Having taken Math005 only (vs. not) was not associated with any differences in retention or graduation rates for the matched sample. This suggests students have similar outcomes regardless of whether they took preparatory math or not.

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- Having taken Wri001 only (vs. not) was associated with less favorable retention and graduation rates (by 3-6%) for both samples. This suggests that taking preparatory writing at UC Merced may be associated with less favorable student success outcomes.
- Having taken both Wri001 and Math005 (vs. not) was associated with somewhat less favorable retention and graduation rates (by 3-6%) for the matched sample. These differences were particularly manifest in 2-year retention and both 5- and 6-year graduation rates. This suggests that taking both preparatory math and writing courses at UC Merced may be associated with less favorable student success outcomes.

Math005

Key Question: Is taking Math005 associated with lower retention and/or graduation rates?

Table 1 provides the results of the outcome analysis for both the matched and total (matched and unmatched) samples. Having taken Math005 was not associated with any statistically significant differences in retention rates as rates did not differ between the treatment and control groups for either the matched or total samples. Conversely, having taken Math005 (vs. not) was associated with lower 5- and 6-year graduation rates by 3% but only for the total sample. That is, if one only considers the matched sample, Math005 was not associated with any significant differences in graduation rates. Overall, this suggests students have similar outcomes regardless of whether they took Math005 or not.

Table 1. Math005 Outcome Analysis Results by Analysis Group

Outcome	Matched Sample		Total (Matched & Unmatched Samples)	
	Took Math005 (Treatment)	Did not Take Math005 (Control)	Took Math005 (Treatment)	Did not Take Math005 (Control)
One-Year Retention	83%	83%	82%	83%
Two-Year Retention	75%	74%	74%	75%
Three-Year Retention	71%	69%	71%	70%
Five-Year Graduation	66%	67%	65%	68%
Six-Year Graduation	69%	70%	68%	71%

Note: Proportions were compared with a chi-squared test. Bold text denotes statistically significant differences between the respective treatment and control group ($p < .05$). The six-year graduation rate analysis excluded the fall 2017 frosh cohort.

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Wri001

Key Question: Is taking Wri001 associated with lower retention and/or graduation rates?

Table 2 provides the results of the outcome analysis for both the matched and total samples. Importantly the matching procedure for Wri001 was not very effective (see Appendix A), such that findings should be interpreted with caution. For both samples and across all but one outcome (3-year retention for the matched sample), students who took Wri001 had less favorable outcomes compared to students who did not take Wri001 by 3-6%. This suggests that taking preparatory writing at UC Merced may be associated with less favorable student success outcomes. However, additional analysis could examine other covariates to input into the PSM procedure to improve its ability to generate matched groups for Wri001 enrollment.

Table 2. Wri001 Outcome Analysis Results by Analysis Group

Outcome	Matched Sample		Total (Matched & Unmatched Samples)	
	Took Wri001 (Treatment)	Did not Take Wri001 (Control)	Took Wri001 (Treatment)	Did not Take Wri001 (Control)
One-Year Retention	82%	85%	81%	85%
Two-Year Retention	73%	77%	72%	77%
Three-Year Retention	70%	71%	69%	72%
Five-Year Graduation	65%	68%	64%	69%
Six-Year Graduation	68%	72%	67%	73%

Note: Proportions were compared with a chi-squared test. Bold text denotes statistically significant differences between the respective treatment and control group ($p < .05$). The six-year graduation rate analysis excluded the fall 2017 frosh cohort.

Math005 & Wri001

Key Question: Is having taken both Math005 and Wri001 associated with lower retention and/or graduation rates?

For context, Table 3 indicates how many students in the sample were in each course taking group. The majority of new frosh took both Math005 and Wri005 (42%) during their time at UC Merced.

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Table 3. Math005 and Wri001 Enrollment Rates

Course Taking Group	Count	Percentage
No Math005 or Wri001	1654	18%
Math005 Only	2050	22%
Wri001 Only	1699	18%
Both Math005 and Wri001	3934	42%

Table 4 provides the results of the outcome analysis for both the matched and total (matched and unmatched) samples. Having taken both Wri001 and Math005 was associated with several statistically significant differences in retention and graduation rates for the matched treatment and control groups. Specifically, students who took both courses had lower 2-year retention and both 5- and 6-year graduation rates compared to students who did not by between 3-6%. Considering the total sample, the same differences were present and were somewhat larger – in addition, students who took both courses also had lower 1-year retention rates compared to students who did not. Overall, this pattern of findings suggests that students who take both Wri001 and Math005 may have somewhat less favorable outcomes compared to students who do not take both courses. These differences are particularly manifest in 2-year retention and both 5- and 6-year graduation rates.

Table 4. Wri001 & Math005 Outcome Analysis Results by Analysis Group

Outcome	Matched Sample		Total (Matched & Unmatched Samples)	
	Took Wri001 & Math005 (Treatment)	Did not Take Wri001 & Math005 (Control)	Took Wri001 & Math005 (Treatment)	Did not Take Wri001 & Math005 (Control)
One-Year Retention	82%	84%	81%	84%
Two-Year Retention	73%	76%	72%	76%
Three-Year Retention	70%	71%	70%	71%
Five-Year Graduation	64%	68%	63%	68%
Six-Year Graduation	66%	72%	66%	72%

Note: Proportions were compared with a chi-squared test. Bold text denotes statistically significant differences between the respective treatment and control group ($p < .05$). The six-year graduation rate analysis excluded the fall 2017 frosh cohort.

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Appendix A

Propensity Score Matching (PSM) Description

PSM¹ has two steps. First, student characteristics thought to be associated with group membership (e.g., whether or not the student took Math005) are included as predictor variables in a logistic regression model to generate a predicted probability of group membership. Second, each student in the treatment group (e.g., took Math005) is matched to a comparable student in the control group (e.g., did not take Math005) based on the predicted probabilities. This helps to ensure that any differences between the treatment and control group are less likely to be attributable to selection effects – inherent differences between the groups unrelated to the treatment but which can contribute to differential outcomes. Background characteristics used for the PSM included: first generation status², high school GPA, underrepresented minority status³, School of major in first term⁴, and gender⁵. To confirm the effectiveness of the matching, for each analysis we provide a table that contains descriptive information about the propensity score matched background characteristics of each group.

Math005 PSM Results

Figure 1 provides the group sizes for each analysis. The matching procedure produced 685 exact matches and 2259 fuzzy matches for a total of 2944 - thus the matched analysis included 2944 students in the matched treatment group and 2944 students in the matched control group.

¹ We used the Propensity Score Matching dialog box in SPSS v. 29, which relies on R and Python modules. This dialog generates syntax for the STATS PSM extension command, which uses the FUZZY extension command to perform the matching. We used a match tolerance of .0005 and performed matching without replacement.

² In the UC system, first generation status is defined as neither parent having earned a 4-year degree. 1 = first generation, 0 = not.

³ The NSF definition of URM status was employed where URM includes the categories of Black, Hispanic, Native American, and Alaska Native. Non-URM (Asian, Pacific Islander, White) was used as the reference category. As such, two contrast codes were entered into the regression procedure: 1 = URM versus 0 = not; 1 = unknown (international, multi-racial, unknown) versus 0 = not.

⁴ School of Natural Sciences (SNS) was used as the reference category. As such, three contrast codes were entered into the regression procedure: 1 = Undeclared versus 0 = not; 1 = School of Engineering versus 0 = not; and 1 = School of Social Sciences, Humanities, and Arts versus 0 = not.

⁵ 1 = female and 0 = not (male/unknown).

Figure 1. Math005 PSM Procedure Analysis Group Results

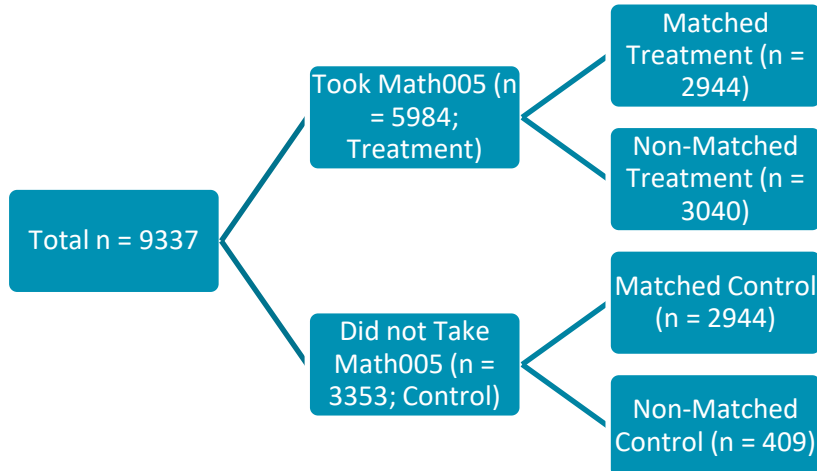


Table 5 provides the descriptive information for each PSM covariate by analysis group. In examining the logistic regression model statistics, though the overall omnibus test was significant - $\chi^2(8) = 718.17, p < .001$ – the pseudo R-squared statistics were quite low – Cox & Snell R-square = .07, Nagelkerke R-square = .10. This indicates that there may be other variables that would do a better job at identifying which students do and do not take Math005. That being said, though there were some statistically significant differences in student background characteristics between the matched treatment and control groups, these differences were generally quite small (3% or less). In contrast, differences between the total treatment and total control groups were present for nearly every background characteristic and were substantial (more than 10% in many cases). Thus, it appears that the PSM was quite effective in creating matched treatment and control groups.

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Table 5. PSM Covariate Comparison by Math005 Analysis Group

Covariate	Matched Sample		Total (Matched & Unmatched Samples)	
	Took Math005 (Treatment)	Did not Take Math005 (Control)	Took Math005 (Treatment)	Did not Take Math005 (Control)
High School GPA [Mean (SD)]	3.55 (.30)	3.55 (.32)	3.51 (.29)	3.58 (.33)
Race/Ethnicity				
% URM	53%	56%	63%	51%
% Non-URM	37%	34%	26%	39%
% Unknown	10%	11%	11%	11%
School				
% SNS	26%	25%	36%	23%
% SOE	28%	29%	21%	33%
% SSHA	28%	31%	24%	30%
% Undeclared	18%	15%	20%	14%
First Generation Status (% First Generation)	67%	70%	77%	65%
Gender (% female)	47%	48%	56%	45%

Note: Means were compared with a one-way ANOVA; proportions were compared with a chi-squared test (as appropriate, column proportions were compared via the b-prop command and p-values were Bonferroni corrected for multiple comparisons). Bold text denotes statistically significant differences between the respective treatment and control group ($p < .05$).

Wri001 PSM Results

Figure 2 provides the group sizes for each analysis. The matching procedure produced 761 exact matches and 2535 fuzzy matches for a total of 3296 - thus the matched analysis included 3296 students in the matched treatment group and 3296 students in the matched control group.

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Figure 2. Wri001 PSM Procedure Analysis Group Results

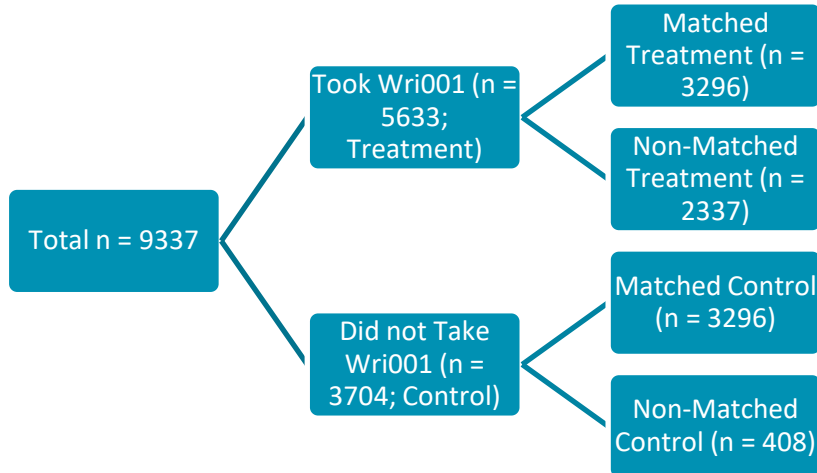


Table 6 provides the descriptive information for each PSM covariate by analysis group. The PSM procedure was largely not effective at creating matched treatment and control groups. In fact, for several variables, using the total sample results in smaller differences between the treatment and control groups than does using the matched sample. In examining the logistic regression model statistics, though the overall omnibus test was significant - $\chi^2(8) = 343.12, p < .001$ – the pseudo R-squared statistics were very poor – Cox & Snell R-square = .03, Nagelkerke R-square = .05. This suggests that the covariates used to perform the matching do not do well at identifying which students do and do not take Wri001. As such, the results that used the matched sample should be interpreted with caution.

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Table 6. PSM Covariate Comparison by Wri001 Analysis Group

Covariate	Matched Sample		Total (Matched & Unmatched Samples)	
	Took Wri001 (Treatment)	Did not Take Wri001 (Control)	Took Wri001 (Treatment)	Did not Take Wri001 (Control)
High School GPA [Mean (SD)]	3.54 (.31)	3.55 (.31)	3.50 (.31)	3.58 (.32)
Race/Ethnicity				
% URM	51%	57%	62%	53%
% Non-URM	35%	32%	27%	37%
% Unknown	14%	11%	12%	10%
School				
% SNS	18%	33%	30%	33%
% SOE	34%	26%	25%	27%
% SSHA	36%	26%	27%	25%
% Undeclared	13%	16%	19%	15%
First Generation Status (% First Generation)	69%	71%	77%	65%
Gender (% female)	43%	52%	52%	52%

Note: Means were compared with a one-way ANOVA; proportions were compared with a chi-squared test (as appropriate, column proportions were compared via the b-prop command and p-values were Bonferroni corrected for multiple comparisons). Bold text denotes statistically significant differences between the respective treatment and control group ($p < .05$).

Wri001 & Math005 PSM Results

Figure 3 provides the group sizes for each analysis. The matching procedure produced 860 exact matches and 2544 fuzzy matches for a total of 3404 - thus the matched analysis included 3404 students in the matched treatment group and 3404 students in the matched control group.

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Figure 3. Wri001 & Math005 PSM Procedure Analysis Group Results

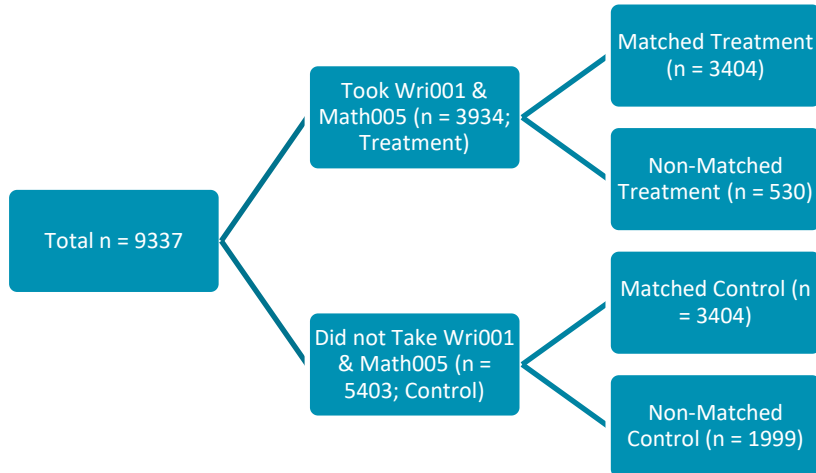


Table 7 provides the descriptive information for each PSM covariate by analysis group. In examining the logistic regression model statistics, though the overall omnibus test was significant - $\chi^2(8) = 469.49, p < .001$ – the pseudo R-squared statistics were quite low – Cox & Snell R-square = .05, Nagelkerke R-square = .07. This indicates that there may be other variables that would do a better job at identifying which students do and do not take both Writing 001 and Math005. That being said, there were no statistically significant differences in student background characteristics between the matched treatment and control groups. In contrast, differences between the total treatment and total control groups were present for every background characteristic and were sometimes substantial (more than 10%). Thus, it appears that the PSM was quite effective in creating matched treatment and control groups.

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Table 7. PSM Covariate Comparison by Wri001 & Math005 Analysis Group

Covariate	Matched Sample		Total (Matched & Unmatched Samples)	
	Took Wri001 & Math005 (Treatment)	Did not Take Wri001 & Math005 (Control)	Took Wri001 & Math005 (Treatment)	Did not Take Wri001 & Math005 (Control)
High School GPA [Mean (SD)]	3.51 (.29)	3.52 (.30)	3.49 (.28)	3.56 (.32)
Race/Ethnicity				
% URM	62%	64%	65%	54%
% Non-URM	27%	25%	24%	36%
% Unknown	11%	11%	12%	10%
School				
% SNS	32%	31%	34%	29%
% SOE	24%	24%	22%	28%
% SSHA	26%	27%	24%	28%
% Undeclared	20%	18%	21%	15%
First Generation Status (% First Generation)	77%	77%	80%	68%
Gender (% female)	54%	53%	55%	50%

Note: Means were compared with a one-way ANOVA; proportions were compared with a chi-squared test (as appropriate, column proportions were compared via the b-prop command and p-values were Bonferroni corrected for multiple comparisons). Bold text denotes statistically significant differences between the respective treatment and control group ($p < .05$).