Math Tutoring

Cabrillo College
Breakthroughs happen here.™
Does Math Tutoring Work?

Unfortunately our results cannot be based on an experiment where we could examine the effects of tutoring while holding other variables constant.

Our results are therefore based on an observational study…
We would like to think that tutoring works

• First define a “tutor”
  – A private instructor
  – One that gives additional, special, or remedial instruction

• Tutoring then can be defined
  – To act as a tutor
  – To instruct or teach privately

• If we believe that teaching works, then why wouldn’t we expect private teaching to work? Why wouldn’t we expect private teaching where the teacher focuses on areas where the student struggles, and then the teacher provides that student with focused feedback?
Where Did Our Data Come From?

- We looked at students who used our Math Learning Center (MLC) over the past 5 years.
- If a student used the MLC, then everyone from that student’s math section was used in the sample.
- There were over 30,000 total students (enrollments) in the sample.
Students Who Take Intermediate Algebra at Cabrillo

- American Indian, Alaskan Nativ
- Asian
- Black Non-Hispanic
- Filipino
- Latino
- Multiple Ethnicities
- Pacific Islander
- Unknown
- White Non-Hispanic
SUCCESS

\[ \chi^2 = 15.684 \]
\[ P < 0.001 \]
\[ n = 4352 \]

\[ \chi^2 = 43.779 \]
\[ P < 0.001 \]
\[ n = 8082 \]

\[ \chi^2 = 16.834 \]
\[ P < 0.001 \]
\[ n = 5666 \]

\[ \chi^2 = 33.013 \]
\[ P < 0.001 \]
\[ n = 1776 \]

\[ \chi^2 = 15.728 \]
\[ P < 0.001 \]
\[ n = 1712 \]

\[ \chi^2 = 12.702 \]
\[ P = 0.002 \]
\[ n = 1645 \]
SUCCESS RATES
For Tutored Students By Gender

Female Success  Male Success

- MATH-12 Statistics
- MATH-152 Intermediate Algebra
- MATH-154 Elementary Algebra
- MATH-254A Essential Mathematics
- MATH-4 Precalculus
- MATH-5A Calculus I
SUCCESS RATES
Tutored Students By URM Status

URM = under-represented minority (Latino, Black, Native American, Filipino, Pacific Islander)
URM vs Not URM Students Who Used Tutoring

- MATH-12: Statistics
- MATH-152: Intermediate Algebra
- MATH-154: Elementary Algebra
- MATH-254A: Essential Mathematics
- MATH-4: Precalculus
- MATH-5A: Calculus I

Used Tutoring
Students Who Used Tutoring by Gender

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Name</th>
<th>Female (%)</th>
<th>Male (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH-12</td>
<td>Statistics</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>MATH-152</td>
<td>Intermediate Algebra</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>MATH-154</td>
<td>Elementary Algebra</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>MATH-254A</td>
<td>Essential Mathematics</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>MATH-4</td>
<td>Precalculus</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>MATH-5A</td>
<td>Calculus I</td>
<td>30</td>
<td>20</td>
</tr>
</tbody>
</table>

- Used Tutoring
Percent of Students Enrolled in Intermediate Algebra that Used Tutoring by Ethnicity

- American Indian, Alaskan Nativ
- Asian
- Black Non-Hispanic
- Filipino
- Latino
- Multiple Ethnicities
- Pacific Islander
- Unknown
- White Non-Hispanic
Testing FX with PSM

Average Treatment Effect of Using Tutoring on Success (C or better) in a Math Class (95% CI)
Matching on Gender, Ethnicity, Age, GPA

Stats
Int Alg
Elem Alg
Pre Alg
Pre Calc
Calc I
Logistic Regression

Estimating the Number of Tutoring Hours Required to Succeed in Intermediate Algebra

Estimate the ln(odds of succeeding) using hours tutored, gender, URM status, tutoring use
Add overall GPA to equation to control for strength of student

\[ p = \text{probability of succeeding in Math 152} \]

\[
\ln \left( \frac{p}{1-p} \right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \varepsilon
\]

\[
\ln \left( \frac{p}{1-p} \right) = \alpha + \text{Tutoring Hours} x_1 + \text{URM} x_2 + \text{Gender} x_3 + \text{GPA} x_4 + \text{Use Tutor} x_5 + \varepsilon
\]

<table>
<thead>
<tr>
<th>Variables in the Equation</th>
<th>Beta</th>
<th>Std. Error</th>
<th>Wald</th>
<th>df</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.541</td>
<td>0.055</td>
<td>95.802</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Tutoring Hours</td>
<td>0.046</td>
<td>0.012</td>
<td>16.288</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>URM (Y = 1)</td>
<td>-0.420</td>
<td>0.046</td>
<td>83.445</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Gender (F = 1)</td>
<td>0.339</td>
<td>0.046</td>
<td>54.537</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Overall GPA</td>
<td>0.229</td>
<td>0.017</td>
<td>172.508</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Use Tutoring (Y = 1)</td>
<td>0.104</td>
<td>0.063</td>
<td>2.668</td>
<td>1</td>
<td>P = 0.102</td>
</tr>
</tbody>
</table>

\[
\ln \left( \frac{p}{1-p} \right) = -0.541 + 0.046 x_1 - 0.420 x_2 + 0.339 x_3 + 0.229 x_4 + 0.104 x_5 + \varepsilon
\]
Logistic Regression
Estimating the Number of Tutoring Hours Required to Succeed in Intermediate Algebra

Estimate the ln(odds of succeeding) using hours tutored, gender, and URM status. Add overall GPA to equation to control for strength of student

\[ p = \text{probability of succeeding in Math 152} \]

\[ \ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \varepsilon \]

\[ \ln\left(\frac{p}{1-p}\right) = \alpha + \text{Tutoring Hours}x_1 + \text{URM}x_2 + \text{Gender}x_3 + \text{GPA}x_4 + \varepsilon \]

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<tbody>
<tr>
<td>Constant</td>
<td>-0.142</td>
<td>0.133</td>
<td>1.15</td>
<td>1</td>
<td>P = 0.284</td>
</tr>
<tr>
<td>Tutoring Hours</td>
<td>0.048</td>
<td>0.012</td>
<td>17.39</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>URM (Y = 1)</td>
<td>-0.610</td>
<td>0.100</td>
<td>37.15</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Gender (F = 1)</td>
<td>0.303</td>
<td>0.100</td>
<td>9.21</td>
<td>1</td>
<td>P = 0.002</td>
</tr>
<tr>
<td>Overall GPA</td>
<td>0.148</td>
<td>0.040</td>
<td>13.43</td>
<td>1</td>
<td>P &lt; 0.001</td>
</tr>
</tbody>
</table>

\[ \ln\left(\frac{p}{1-p}\right) = -0.142 + 0.048x_1 - 0.610x_2 + 0.303x_3 + 0.148x_4 + \varepsilon \]

Note: Sample only includes those who used tutoring.


Logistic Regression

Estimating the Number of Tutoring Hours Required to Succeed in Intermediate Algebra

Estimate the ln(odds of succeeding) using hours tutored, gender, and URM status.

\[
p = \text{probability of succeeding in Math 152}
\]

\[
\ln\left(\frac{p}{1-p}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \varepsilon
\]

\[
\ln\left(\frac{p}{1-p}\right) = \alpha + \text{TutoringHours} x_1 + \text{URM} x_2 + \text{Gender} x_3 + \varepsilon
\]

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</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.213</td>
<td>0.091</td>
<td>5.499</td>
<td>1</td>
<td>p = 0.019</td>
</tr>
<tr>
<td>Tutoring Hours</td>
<td>0.052</td>
<td>0.012</td>
<td>20.32</td>
<td>1</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>URM (Y = 1)</td>
<td>-0.645</td>
<td>0.099</td>
<td>42.169</td>
<td>1</td>
<td>p &lt; 0.001</td>
</tr>
<tr>
<td>Gender (F = 1)</td>
<td>0.322</td>
<td>0.099</td>
<td>10.52</td>
<td>1</td>
<td>p = 0.001</td>
</tr>
</tbody>
</table>

Note: Sample only includes those who used tutoring.
Hours of Tutoring Estimated for Under-Represented Minority Male Success in Intermediate Algebra

The equation for an under-represented minority male simplifies to

\[ \ln \left( \frac{p}{1-p} \right) = -0.432 + 0.052x_1 + \epsilon \]

- Among the 1467 Male URM students who were not tutored, 560 succeeded (38%)
- Among the 316 Male URM students who were tutored at all, 129 succeeded (41%)
- For \( p = 0.5 \) we estimate that a URM male needs 8.3 hours of tutoring (about 0.5 hours per week)
- 29 Male URM students were tutored for at least 8.3 hours and 17 succeeded (59%)
- For \( p = 0.75 \) we estimate that a URM male needs 29.5 hours of tutoring (about 2 hours per week)
- The two URM male students who had at least 29.5 hours of tutoring both succeeded.