What factors affect students’ learning through *Carbon TIME*?

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Outline

1. How successful is *CTIME*?
2. What factors affect students’ learning about *CTIME*?
3. How do student and teacher success change over time?
4. How do students learn from first unit to third unit in *CTIME*?
5. How can we use these data to construct value-added models that provide evidence about the success of individual teachers?
1. HOW SUCCESSFUL IS CTIME?
Two-ways to think about how well CTIME works

• **Approach 1 (Pre vs. Post):** Compare pre and post from same students taught by same teachers with CTIME

• **Approach 2 (CTIME vs. non-CTIME):** Compare posttest from two groups of students taught by same teachers with CTIME and other curricula

Pretest before CTIME

Posttest after CTIME

CTIME effect

Compare CTIME with other curricula

CTIME effect

Posttest after other curricula
• **Approach 1 (Pre vs. Post):**
  – can check the gain score for each student since we can match pretest and posttest
  – *Students’ prior knowledge* can be controlled by pretest
  – We report results over a four-year period, from 2015-16 to 2018-19 students from classrooms, taught by 133 teachers

• **Approach 2 (CTIME vs. non-CTIME):**
  – can only compare at the mean level because we can NOT match pretest and posttest
  – *Students’ prior knowledge* controlled by assuming the two groups of students have similar prior knowledge on average
  – We report results over a 2-year period, from 2016-17 to 2017-18, 3,191 students for other curriculum and 3,615 students for CTIME from 57 teachers

• All student learning levels are results generated by IRT analyses.
  – Focus on Carbon Dimension/macroscopic scale explanations
  – Overlapping items made it possible to calibrate items and test difficulties across years and across tests on the same scale
  – Measures: calculated proficiencies in logits
    • *0 represents the overall student mean across all tests*
    • Thresholds for translating to learning progression levels:
      – Below -0.34: most likely at level 2
      – Between -0.34 and 0.96: most likely at level 3
      – Above 0.96: most likely at level 4, this is expectation of NGSS
• Pretest: Overall Pretest
• Posttest: Average Unit Post
  • Near transfer
  • Better validity
Approach 1 (Pre vs. Post):

Average increased from -1.435 to 0.396

LV4 (0.32% to 30.06%)

<table>
<thead>
<tr>
<th>Level</th>
<th>Pretest</th>
<th>Posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV2</td>
<td>93.3%</td>
<td>30.5%</td>
</tr>
<tr>
<td>LV3</td>
<td>6.4%</td>
<td>39.5%</td>
</tr>
<tr>
<td>LV4</td>
<td>0.3%</td>
<td>30.0%</td>
</tr>
</tbody>
</table>

Level 4 is equivalent to NGSS HS performance expectations
Approach 2 (CTIME vs. non-CTIME):

The two averages are -1.274 and 0.264.

<table>
<thead>
<tr>
<th>Level</th>
<th>Non-CTIME</th>
<th>CTIME</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV2</td>
<td>84.6%</td>
<td>34.3%</td>
</tr>
<tr>
<td>LV3</td>
<td>12.9%</td>
<td>39.2%</td>
</tr>
<tr>
<td>LV4</td>
<td>2.5%</td>
<td>26.5%</td>
</tr>
</tbody>
</table>

Level 4 is equivalent to NGSS HS performance expectations.
2. HOW DO VARIOUS FACTORS AFFECT STUDENTS’ LEARNING THROUGH CTIME?
How to figure out the effects of these factors on students’ learning through CTIME?

- We know there are many factors that may affect students’ learning outcomes in general.

- Question is: how these factors affect students’ learning through CTIME?
**Approach 1 (Pre vs. Post):**
Distribution of gain scores (Average Unit Post – Full Pre)

*Distribution of all students’ learning gains (N = 16,195)*
Important factors that affect students’ learning from CTIME

Lower pretest scores are associated with higher gain scores

Higher FRL or more marginalized students of color is associated with lower gain scores
The other factors that we have excluded because they do not have significant unique contributions:

- Students’ prior knowledge (Pretest)
- Grade band (whether high school or middle school)
- School factors (%FRL & %Marginalized students of color)
- Teachers
Importance of different factors affecting students' gain (average Unit Post – Full Pre)

- **Teacher-Year**: 31.4%
- **Students' prior knowledge**: Max 9.6%, Min 9.7%
- **School factors**: Max 3.9%, Min 4.0%

Legend: Max, Min
3. HOW DO STUDENT AND TEACHER SUCCESS CHANGE OVER TIME?
More teachers achieved Level 4 class averages over time.

Level 4 is equivalent to NGSS HS performance expectations.
The overall success of *CTIME* increased over time

(Gain = average Unit Post – Full Pre)

<table>
<thead>
<tr>
<th>Year Difference</th>
<th>Mean Gain</th>
<th>SE</th>
</tr>
</thead>
<tbody>
<tr>
<td>201617 - 201516</td>
<td>0.22*</td>
<td>0.08</td>
</tr>
<tr>
<td>201718 - 201516</td>
<td>0.54***</td>
<td>0.09</td>
</tr>
<tr>
<td>201819 - 201516</td>
<td>0.45***</td>
<td>0.12</td>
</tr>
</tbody>
</table>
Class average gain increased as teachers gained more experience in teaching CTIME.

(Gain = average Unit Post – Full Pre)

Mean and 95% Confidence Interval of Average Learning Gain for Each Teacher-Year

<table>
<thead>
<tr>
<th>Year</th>
<th>Learning Gain in Logit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y1</td>
<td>0</td>
</tr>
<tr>
<td>Y2</td>
<td>0.32** (0.06)</td>
</tr>
<tr>
<td>Y3</td>
<td>0.62*** (0.15)</td>
</tr>
<tr>
<td>Y4</td>
<td>0.66** (0.24)</td>
</tr>
</tbody>
</table>

Teacher by years of teaching CTIME
Interpret the increasing overall success over time.

• Explanation 1: The effect of Carbon TIME increased during the 4-year period, from 2015-16 to 2018-19.

• Explanation 2: Teacher effectiveness also increased as they gained more experience in teaching Carbon TIME.

• However, we cannot statistically distinguish between (a) teachers gaining experience and learning from professional development, and (b) improvements in Carbon TIME units and professional development.

<table>
<thead>
<tr>
<th></th>
<th>Y1</th>
<th>Y2</th>
<th>Y3</th>
<th>Y4</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015-16</td>
<td>26</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2016-17</td>
<td>56</td>
<td>19</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017-18</td>
<td>40</td>
<td>42</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>2018-19</td>
<td></td>
<td>31</td>
<td>15</td>
<td>7</td>
</tr>
</tbody>
</table>
4. HOW DO STUDENTS LEARN FROM FIRST UNIT TO THIRD UNIT IN CTIME?
### Distribution of Learning Gains in Different Units

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>S&amp;S gain</td>
<td>10,832</td>
<td>1.90</td>
<td>1.60</td>
<td>-3.68</td>
<td>10.75</td>
</tr>
<tr>
<td>Animal gain</td>
<td>10,832</td>
<td>1.95</td>
<td>1.30</td>
<td>-3.84</td>
<td>9.07</td>
</tr>
<tr>
<td>Plant gain</td>
<td>10,832</td>
<td>2.13</td>
<td>1.35</td>
<td>-3.51</td>
<td>8.14</td>
</tr>
</tbody>
</table>

Paired t test between S&S and Animal: difference = 0.06, SE = 0.01, p < 0.001.

Paired t test between Animal and Plant: difference = 0.18, SE = 0.01, p < 0.001.

Paired t test between S&S and Plant: difference = 0.23, SE = 0.01, p < 0.001.
5. HOW CAN WE USE THESE DATA TO CONSTRUCT VALUE-ADDED MODELS THAT PROVIDE EVIDENCE ABOUT THE SUCCESS OF INDIVIDUAL TEACHERS?
What is value-added?

• “Gain score”
  – adjust for other covariates (remove the effects from factors other than the teacher: free/reduced lunch and percent minorities)
  – the “deflection” between expected and observed score is assumed to be the effect of teacher

– Each teacher’s value-added score is the average “estimate of teacher effectiveness” of all her students

After removing the effect from school factors & students’ prior knowledge – estimate for teachers’ effectiveness…

Case study data in Paper 4 come from circled years
Thank you!

(Back-up slides from here.)
More teachers achieved Level 4 class averages over time

Level 4 is equivalent to NGSS HS performance expectations
The effect of Carbon TIME increased during the 4-year period, from 2015-16 to 2018-19.
Teacher effectiveness also increased as they gained more experience in teaching Carbon TIME.

<table>
<thead>
<tr>
<th>Year</th>
<th>Value Added Measure</th>
<th>p-value</th>
<th>CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y2</td>
<td>0.257** (0.089)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y3</td>
<td>0.531*** (0.144)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Y4</td>
<td>0.430 (0.250)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Case study data in Paper 4 come from circled years.