But Does it Last?
Sustaining a Research-Based Curriculum in Upper-Division Electricity & Magnetism

Stephanie Chasteen, Rachel Pepper, Steven Pollock, Katherine Perkins
University of Colorado - Boulder
Introduction & Claims

Research-based course materials for junior E&M *sustained over 5 semesters*.

**Key aspects of the transformation process that aided transfer:**

- Positive *departmental culture* & support
- **Staff** dedicated to developing and disseminating materials
- Institutionalized *co-seminar tutorial*
- Instructors’ *positive experiences* with course
- Easily modified materials in organized *course archive*
We investigated the **role of the instructor** in creating a successful course transformation. We suggest that:

- **Teaching experience not necessary.** Student learning high for new and experienced instructors.

- **Instructors’ attention to upper-level student difficulties is important**

- **Interpersonal relationships** (such as word-of-mouth and discussions with colleagues) are important.

*Look for the two examples of less effective transfer that suggest some necessary features in successful course transformation.*
Methods

- Transformed first-semester of junior-level E&M
- Developed research-based materials with staff support and co-teaching [1,2]
  - Concept Tests / Clicker Questions
  - Learning Goals
  - Tutorials
  - Modified Homework
  - Student Difficulties
- Developed conceptual diagnostic, the CUE* [2]

*Colorado Upper-Division Electrostatics assessment*
WHAT WAS SUSTAINED?
Course Structure

Implementation varied, but only whiteboards and learning goal use changed significantly in later semesters.

Materials developed in first semester (RES1), tracked through 5 semesters (RES5). Staff support gradually withdrawn over time.

Does not include two more recent semesters: One did not use materials, one using minimally.
Ideal" clicker use as defined by best practices in the Instructor's Guide at http://STEMclickers.colorado.edu

RES5 has lower “implementation fidelity”. Does this affect student learning? (Yes, it seems to...)

“Ideal” clicker use as defined by best practices in the Instructor's Guide at http://STEMclickers.colorado.edu

### TABLE 1. Sustainability of Course Structure

<table>
<thead>
<tr>
<th>Semester</th>
<th>Instructor</th>
<th>RES1</th>
<th>RES2</th>
<th>RES3</th>
<th>RES4</th>
<th>RES5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Developers</td>
<td>PER1+STF</td>
<td>PER2 + Non-PER1</td>
<td>Non-PER1 (tenured)</td>
<td>Non-PER2 (junior)</td>
<td>Non-PER3 (junior)</td>
</tr>
<tr>
<td>Learning Goals [Used in course prep?]</td>
<td>✓ + (3.5)</td>
<td>✓  (4.2)</td>
<td>✓ + (3.1)</td>
<td>✓ + (3.3)</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Clickers [Used, and used ideally? daily avg]</td>
<td>✓ + (44%)</td>
<td>✓  (30%)</td>
<td>✓  (42%)</td>
<td>✓  (36%)</td>
<td>✓  (35%)</td>
<td></td>
</tr>
<tr>
<td>Tutorials [Offered?] [ave attendance]</td>
<td>✓ + (94%)</td>
<td>✓  (86%)</td>
<td>✓  (77%)</td>
<td>✓  (77%)</td>
<td>✓  (74%)</td>
<td></td>
</tr>
<tr>
<td>Lectures [Interactive?] [ave attendance]</td>
<td>✓ +</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Group homework sessions [Offered?]</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Whiteboards [Used often?]</td>
<td>✓ +</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Modified homework [Used?]</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Documented student difficulties [Referred to?]</td>
<td>Not avail.</td>
<td>✓</td>
<td>✓ +</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Implementation Fidelity (sum of ✓; +/- count ½)</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>9.5</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>
Student Learning

Student learning gains higher in all research-based (RES) courses than in traditionally-taught (TRAD) courses

Error bar represent ±1 SE of mean. “Gain” represents student absolute gains on the 7-questions on the Post-test which match the 7-question Pre-test; Gain (and SE) estimated for TRAD and RES1 (based on consistent Pre-test data in later semesters). Non-CU TRAD is an average of three courses at another large research university. Non-CU RES is the average of three courses at three institutions that used our research-based materials. Post-test N’s are as follows: CU TRAD(27), RES1-5 (20, 42, 27, 35, 59), Non-CU TRAD (221), Non-CU RES (31).

But why are gains lower in RES2 and RES5? 🌟
Student Experience

Students found all aspects of course enjoyable and useful, and well-connected to one another.

- “Homework” received highest ratings
- “Tutorials” varied, but overall positive
- “Whiteboards” generally seen as less useful
- Students in RES courses spend more time on homework (7-9 hours) than in TRAD (3-4 hours)

🌟 With one exception. Why?
Poor student ratings

One course (RES2) had consistently lower student ratings:
- Less connection between in-class time, homework, and exams
- Lower usefulness of tutorials
- Lower enjoyment of pure lecture & tutorials
- Less comfort asking questions during class
- Less satisfaction and learning in the course overall

Course also had:
- Lower CUE gains
- More clicker questions
- Lower course implementation fidelity

But this was an award-winning instructor. What happened?
- Students complained that lectures were “too easy” for exams
- Instructor unusually busy and less invested in course

Instructor may have been following lower-division beliefs and practices too much, and course may have suffered from instructor inattention.
WHAT AIDS TRANSFER?
**Department Support**

Department provided both tangible supports and a generally receptive culture

- Faculty contributed to discussions
- Chair & associate chair buy-in
- Team allowed to help choose E&M instructors

**Team Teaching**

Instructor mentored in PER techniques in one semester of co-teaching (RES2), and then used those techniques in following semester (RES3)
Staff Support

Dedicated staff reduced work burden on instructors. Crucial in creation and documentation of course.

- Developed transformations
- Created and sustained course archives
- Documented impact of transformations
- Undergraduate learning assistants assisted with tutorials
Most instructors found archive takes time but is well organized.

Most discussed the course with developers.

RES5 instructor did not discuss with developers, said materials stood on their own.

What do instructors say?
“Just taking those materials and reading them isn’t the same thing [as talking to developers about the approach]”

-- Instructor for RES2

“[These materials] allow the interested person to start teaching a transformed course without the huge time investment that it might otherwise have required”

-- Instructor for RES5

Note: RES5 mentored in PER, but had lower course fidelity, lower learning gains, and did not feel the need to discuss the course with developers.
Instructor experiences

Instructors very positive about experience, student learning, student feedback, and bigger impact for the same preparation time.

- Could lead to word-of-mouth spread of materials

Co-seminar Course

Co-seminar course legitimized tutorials and required PER faculty to approach instructors in advance to commit to tutorial, pre-selling the idea [3].

- Also provided insight into student difficulties, as did homework help sessions
What do you think?

- What are some alternative explanations for our data?
  
  Write on this post-it and attach here or in appropriate spot on poster

- Share your related experiences as an instructor or curriculum developer
  
  Write on this post-it and attach here or in appropriate spot on poster
References & Acknowledgements

This work is funded by the SEI, CU-Boulder and NSF-CCLI grant #0737118.

We are grateful to the faculty at CU-Boulder who participated in the course transformations, and/or assisted in development of course learning goals and the CUE.

