

But Does it Last?

Sustaining a Research-Based Curriculum in
Upper-Division Electricity & Magnetism

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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]

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 Staff support gradually withdrawn over time.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.



Data: Material Use

Tracked use of course materials since development.

- ✓+ exemplary
- ✓- minimal
- ✓ simply documented (when no data justify a +/-)

TABLE 1. Sustainability of Course Structure

Semester	RES1	RES2	RES3	RES4	RES5
Instructor →	Developers PER1+STF	PER2 + Non-PER1	Non-PER1 (tenured)	Non-PER2 (junior)	Non-PER3 (junior)
Learning Goals [Used in course prep?]	✓+	✓	✓+	✓	0
Clickers [Used, and used ideally? ⁸] <i>(daily ave)</i>	✓+ (3.5)	✓ (4.2)	✓+ (3.1)	✓+ (3.3)	✓- (2.5)
Tutorials [Offered?] <i>(ave attendance)</i>	✓ (44%)	✓ (30%)	✓ (42%)	✓ (36%)	✓ (35%)
Lectures [Interactive?] <i>(ave attendance)</i>	✓+ (94%)	✓+ (86%)	✓+ (77%)	✓+ (77%)	✓ (74%)
Group homework sessions [Offered?]	✓	✓	✓	✓	✓
Whiteboards [Used often?]	✓+	✓-	✓	✓	0
Modified homework [Used?]	✓	✓	✓	✓	✓
Documented student difficulties [Referred to?]	Not avail.	✓	✓+	✓+	✓-
Implementation Fidelity (sum of ✓; +/- count ½)	10	8	10	9.5	5

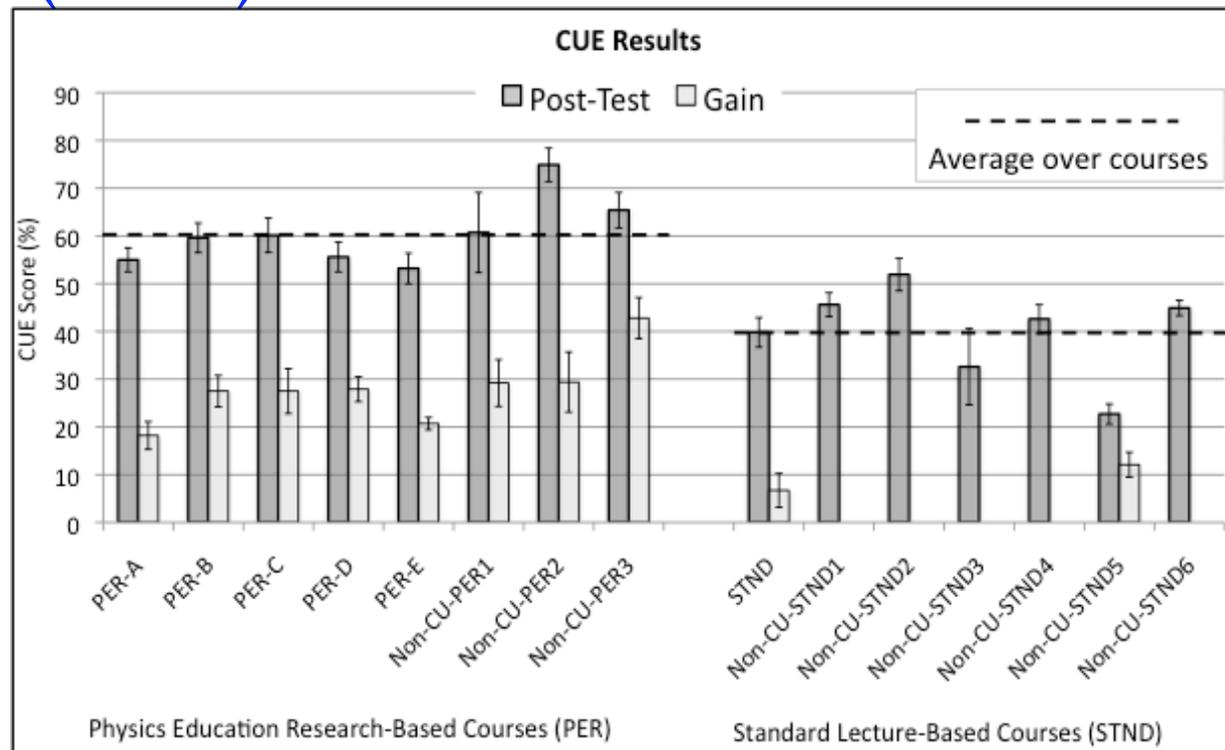
★ RES5 has lower “implementation fidelity”. Does this affect student learning? (Yes, it seems to...)

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

Student Learning



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



Not related to student prep or class size

But why are gains lower in RES2 and RES5? ☆

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).

Student Experience

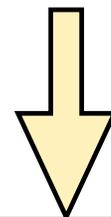


Students found all aspects of course enjoyable and useful, and well-connected to one another.

- “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)



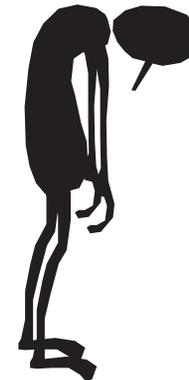
With one exception. Why?



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

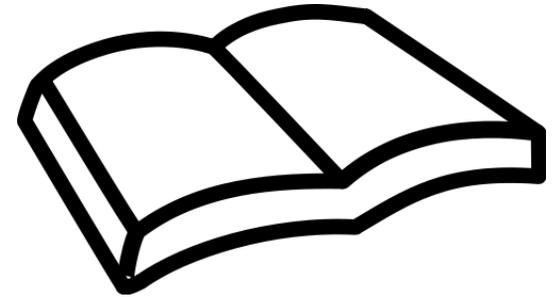
Dedicated staff reduced work burden on instructors.
Crucial in creation and documentation of course.

- Developed transformations
- Created and sustained course archives
- Documented impact of transformations
- Undergraduate learning assistants assisted with tutorials



Course Archives

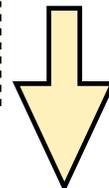
Materials organized by topic and type of material. All modifiable. Instructors can pick and choose.



- 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?



Instructor Quotes

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

– Instructor for RES2

What might take the place of developer discussions?

Can using course materials give illusion of fully transformed course?

“[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

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References & Acknowledgements

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1. S. V. Chasteen, K.K. Perkins, P. D. Beale, S. J. Pollock, C.E. Wieman, *J. Coll. Sci. Teach.* (in press).
2. S. V. Chasteen and S. J. Pollock, “Tapping into Juniors’ Understanding of E&M: The Colorado Upper-Division Electrostatics (CUE) Diagnostic” and S. V. Chasteen and S. J. Pollock, “A Research-Based Approach to Assessing Student Learning Issues in Upper-Division Electricity & Magnetism” both in *PERC Proceedings 2009*; S. V. Chasteen and S. J. Pollock, “Transforming Upper-Division E&M” in *PERC Proceedings 2008*.
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