



# But Does It Last? Creating and sustaining a research-based curriculum in upper-division physics

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## Overview

How can one use research to transform a course? What are measures of success?

How do other instructors choose to use the products of that course transformation?

We present process & outcomes from 8-semester project to develop and sustain course transformations in junior-level physics.

## The transformation process

We researched & transformed first semester of junior level Electricity & Magnetism; this is one of the **core courses** that defines what it means to be a physics major.

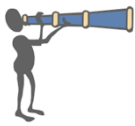
1. Developed **learning goals** with faculty working group<sup>1</sup>
2. **Observed course** & documented student thinking
3. Created **course materials** & refined over time
  - Clicker questions
  - Optional tutorials & HW help sessions
  - Modified HW
4. Developed **conceptual assessment** (the CUE<sup>2</sup>)
5. **Archived materials**
6. **Systematically tracked** material use, student demographics, interviewed all instructors, interviewed students, analyzed student attitude & feedback surveys, observed classes



More details in Chasteen et. al; "A Thoughtful Approach to Instruction," *JCST*, 40(4), 2011, 70-77.

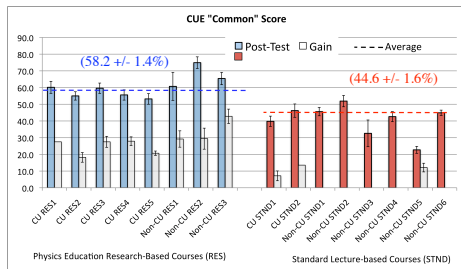
All course materials & the CUE available: [www.colorado.edu/sei/departments/physics\\_3310.htm](http://www.colorado.edu/sei/departments/physics_3310.htm)

## Findings: Student Learning



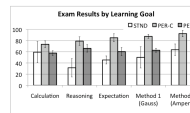
**Student centered techniques improve conceptual understanding...**

Student learning gains on the CUE was higher in all research-based courses than in standard lecture-based courses



**...but do not affect calculational success.**

Students in research-based courses perform similarly on common computational exam problems as students in lecture-based courses. Students in research-based courses show some improvement on conceptual problem-solving skills.



**Optional tutorials help student conceptual learning.**

Tutorials have a positive effect on student score on the conceptual test (the CUE), even when background variables are taken into account via multiple regression.

	CUE Model 1A	CUE Model 1B (with tutorials)	CUE Model 2A	CUE Model 2B (with tutorials)	Exam Model 1	Exam Model 2
Population	All students	All students	Students with BEMA	Students with BEMA	All students	Students with BEMA
N	156	156	87	87	192	103
Model based statistics						
Multiple R <sup>2</sup>	0.23	0.26	0.40	0.46	0.46	0.60
F statistic	47.24	27.08 <sup>†</sup>	58.38	38.77 <sup>††</sup>	166.93	156.3
Residual standard error	15.26	15.04	13.01	12.41	0.77	0.66
Predictors	$b_0$	$b_0$	$b_0$	$b_0$	$b_0$	$b_0$
Phys GPA	0.48**	0.45**			0.68**	0.78**
BEMA			0.64**	0.63**		
Tutorials		0.17*		0.24**		

\* Other course elements (lecture, clickers, textbook) are popular among students, but impact is difficult to determine.

\* Many course elements (clickers, tutorials) offer faculty a window into student thinking

**Learning is somewhat lower in two courses with (a) lower student buy-in, or (b) minimal, non-ideal use of materials**

## Findings: Instructor Decision-Making

**Most instructors use and appreciate materials**

3 out of 5 choose to use, with varying levels of fidelity. (2 non-users not shown)

Semester	Instructor →	RES1	RES2	RES3	RES4	RES5
		Developers PER1+STF	Non-PER1	Non-PER1 (tenured)	Non-PER2 (junior)	Non-PER3 (junior)
Learning Goals [Used in course prep?]	✓	✓ (3.5)	✓ (4.2)	✓ (3.1)	✓ (3.3)	0 (2.5)
Clickers [Used, and used ideally?] <sup>(daily, exp)</sup>	✓	✓ (44%)	✓ (30%)	✓ (42%)	✓ (36%)	✓ (33%)
Tutorials [Offered?]	✓	✓ (94%)	✓ (88%)	✓ (77%)	✓ (77%)	✓ (74%)
Lectures [Interactive?] <sup>(exp attendance)</sup>	✓	✓	✓	✓	✓	✓
Group homework sessions [Offered?]	✓	✓	✓	✓	✓	✓
Whiteboards [Used often?]	✓	✓	✓	✓	✓	0
Modified homework [Used?]	✓	✓	✓	✓	✓	✓
Documented student difficulties [Referred to?]	✓	✓	✓	✓	✓	✓
Implementation Fidelity (sum of ✓; % count %)	10	8	10	9.5	5	

- Factors influencing a decision to use the materials:**
1. Departmental culture & support
  2. Faculty buy-in
  3. Staff support (postdoctoral fellow)
  4. Co-seminar tutorials (early pre-sell & LA)
  5. A positive experience with the materials

**Factors not mentioned:** Data on student learning!

- Factors influencing a decision NOT to use the materials**
1. Lack of buy-in to interactive techniques (particularly at junior level)
  2. Previously taught the course (time and ego investment!)

**Resources are important:**

**Organized course archive**

- Materials organized by topic & material
- All modifiable
- Instructors can pick and choose a-la carte
- Takes time to use, but instructors find it very useful



**& staff support**

- Developed materials
- Archived materials
- Tracked data on use & learning
- Discussed with instructors



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

**Outstanding questions:**

1. Can using course materials give the *illusion* of a fully transformed course?
2. Is it important to talk to the developers or do the archives stand on their own?

**Instructor characteristics are also important: buy-in, attention to student difficulties, implementation fidelity**

## Summary & Conclusions

- We have **researched student learning in a new area** – junior level physics – and developed learning goals and instructional materials
- Those instructional materials **improve student learning** in many areas
- **Course materials were used**, and used successfully, by instructors at CU & other institutions
- These positive results are mitigated by the following **caveats**:
  - Instructor beliefs and experience influence their decisions to use materials
  - External support structures influence instructor decisions and success
  - How the course is implemented matters (e.g., implementation of clicker questions, cultivation of student buy-in).

As the research-base grows, higher levels of student learning may be possible. Or, perhaps we haven't reached the "right level of radical"?

Our inclination to "put the materials out there" for instructor use is, at least somewhat, naïve. Targeting of friendly or new faculty, and continued support, is important.

## References

- [1] "A Thoughtful Approach to Instruction," Chasteen, Pollock, Perkins, Wieman, *JCST*, 40(4), 2011, 70-77
- [2] "Tapping into Juniors' Understanding of E&M: The Colorado Upper-Division Electrostatics (CUE) Diagnostic", Stephanie V. Chasteen and Steven J. Pollock, PERC Proceedings 2009, AIP Press (2009). Full publication in preparation.
- [3] Other publications on this work at [per.colorado.edu](http://per.colorado.edu)

All course materials & the CUE available at [www.colorado.edu/sei/departments/physics.htm](http://www.colorado.edu/sei/departments/physics.htm)

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