Impacts of Curricular Change: Implications from 8 Years of Introductory Physics Data

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Overview

We present pre- and post- conceptual scores (FMCE[1] and BEMA[2]) for over 9000 students across 16 semesters of both Physics 1 and 2 at CU Boulder.

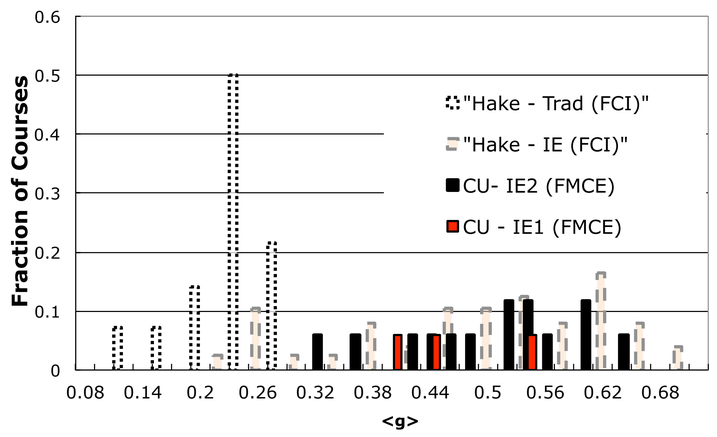
Our data confirm positive impacts of Interactive Engagement (IE) in large classes, and suggest that faculty engaging in "deliberate practice[3]" can show improved outcomes over time.

Demographics: Large lectures (~300 students) with Peer Instruction [4], weekly Tutorials [5] with learning assistants [7] , CAPA[7], and sometimes SmartPhysics preflights [8].
One lead & one backup faculty each term, many CU physics faculty cycle through this course.

Guiding Research Questions

- **What are the measured impacts of our interactive engagement (IE) environments?**
- **What roles do faculty experience and faculty use of IE techniques play in conceptual learning gains?**
- **What are the impacts of ancillary factors (e.g. the role of backup faculty, or additional research-based curricula)?**
- **What role does systematic (but uncontrolled) data collection play in sustaining change?**

Replicate well-established IE results



- **Confirms well-established results for IE [9]**
- **Confirms that more interactivity (IE2) can be more effective [10]**

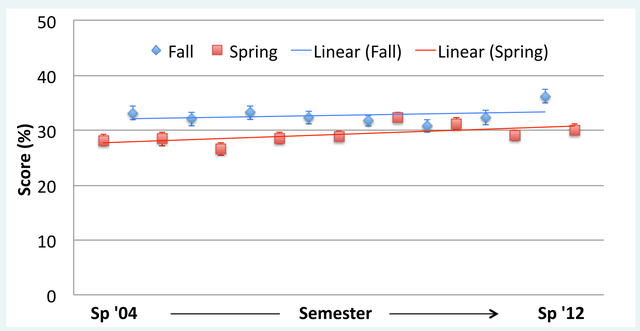
IE1: Interactive engagement in lecture (clicker questions) but not recitation
IE2: Also includes University of Washington Tutorials and trained LAs

Background data permission of Hake [9].
(Note: CU data shown is for FMCE, rather than FCI [11])

FMCE

Pretests are Stable

CU FMCE pretest scores over time

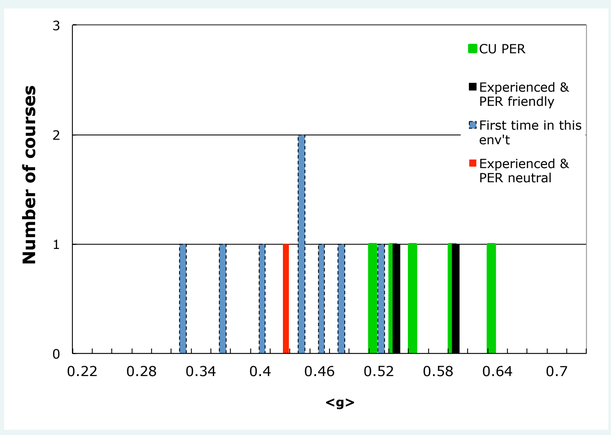


Small (but statistically significant) fall-spring difference (~3.5%), fairly stable over time.

Reproducible pretest scores cited by CU faculty as one reason they accept variation in posttest scores as evidence for impact of curriculum and teaching on student learning.

Practice and Experience Matter

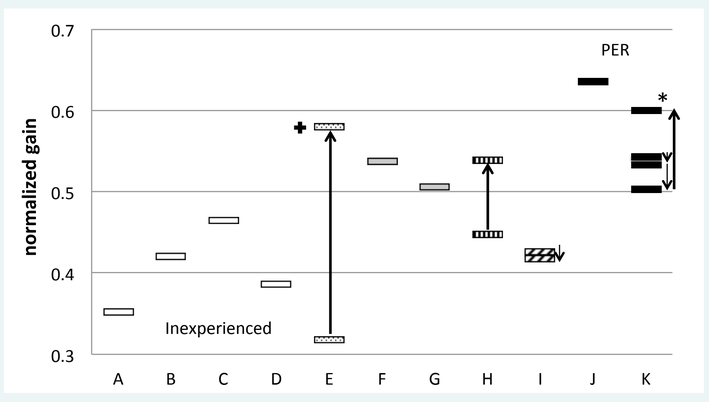
CU FMCE normalized gain distribution



- **PER and experienced faculty are similarly distributed, filling the upper half of the distribution.**
- **Inexperience dominates the bottom half**
  ("Experienced" => having taught in this env't before)

Individual Faculty can Improve

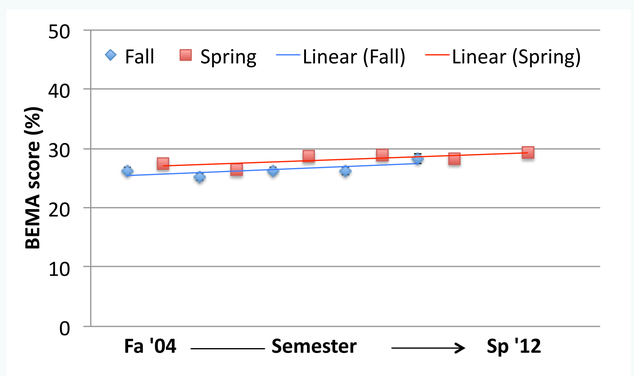
FMCE gain by individual faculty



- **Inexperienced faculty who repeat can show significant improvement**
- **Hints that SmartPhysics* and/or experienced backup faculty✚ (for TA/LA prep sessions) can play a role in student learning gains.**

BEMA

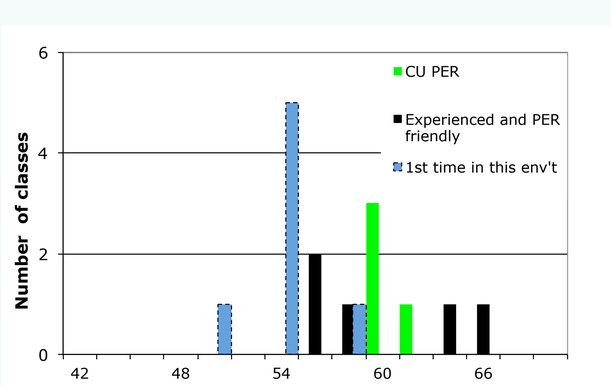
CU BEMA pretest scores over time



- **Even more stable over time than FMCE, and no residual fall-spring difference.**
- **Results are consistent with national data [12]**

Stable (and narrowly distributed) pretests allow use of posttest scores (rather than gain)

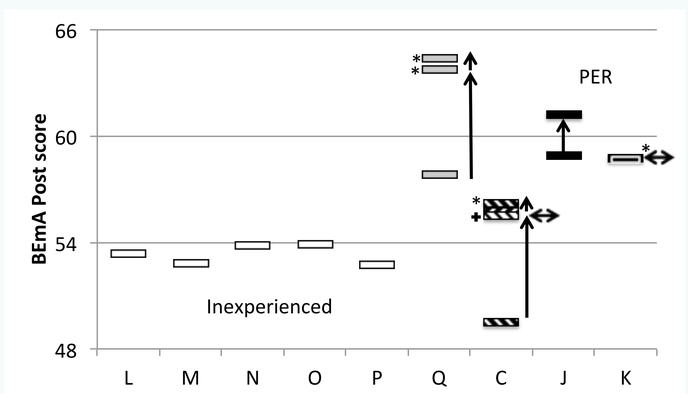
CU BEMA posttest score distribution



- **Similar conclusions as for FMCE: PER and faculty experience are associated with better student performance.**
- **Range of absolute post-scores is narrower than for FMCE**

Standard error on posttests is ~±1%.

BEMA posttest by individual faculty



- **Similar conclusions as for FMCE – faculty can show improvement**
- **First repeat shows largest improvements.**
- **Evidence for role of SmartPhysics* and/or backup faculty✚ is ambiguous.**

Conclusions and summary

33 semesters, 9000 students, 17 different lead instructors:

- Reproduce well-established finding that IE courses produce high posttests
- Degree of faculty experience appears to matter
- Faculty can develop (especially early on with "deliberative practice" [13])
- More tentative hints which require further investigation: (e.g. curricula & backup)
- We argue that such data inform us, guide future research, support transformations and intentional, sustained course transformations.
  Fits with models of institutional transformation that mix prescriptive/emergent and individual/collective approaches[14]

End Notes

[1] R. Thornton, D. Sokoloff, *Am. J. Phys.* **66,** 228 (1998)
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[3] K. Ericsson et al., *Psychological Rev.* **100(3)**, 363 (1993)
[4] E. Mazur, *Peer Instruction: a users manual* (Prentice Hall) 1977
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[6] V. Otero et al., *Am. J. Phys.78 (1218), 2010*
[7] http://www.ong-capa.org/
[8] www.smartphysics.com, Steltzer et al, *Am. J. Phys.* **77(2),** 184 (2009)
[9] R.R. Hake, *Am. J. Phys.* **66,** 64 (1998).
[10] M. Lorenzo et al., *Am. J. Phys.* **74**, 118 (2006)
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[12] M. Kohlmyer et al., *PR STPER 5, 020105 (2009)*
[13] K. Ericsson et al., *Psychological Rev* **100 (3)** 363 (1993).
[14] C. Henderson et al., *JRST* **48 (8)** 952 (2011)

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