Case Studies and Institutional Analysis of the Implementation of a Pedagogical Reform in Introductory Physics

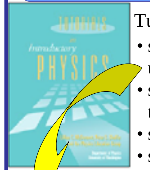
Chandra A. Turpen & Noah D. Finkelstein

Department of Physics, University of Colorado Boulder (http://per.colorado.edu)

Introduction

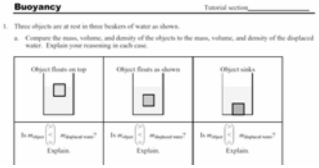
We examine how the University of Colorado has created a sustained use of a research-based curriculum in two courses simultaneously, despite the significant increases in cost and time commitment. The adoption of the research-based University of Washington *Tutorials in Introductory Physics*[1] curriculum required significant pedagogical shifts in the role of students, faculty and their interactions. We describe both successful and unsuccessful hand-offs of the curriculum to professors from traditional physics research disciplines.[2] Through faculty interviews, we capture a shift in how professors talk about this curriculum, as well as their views about teaching and learning physics before and after they implement the tutorial curriculum. We find that teaching with the Tutorials curriculum can result in shifts in professors' views about teaching and learning physics, although this does not always happen. We describe characteristics of the professor's participation in implementing this curriculum and professor's background in order to make sense of when we do and do not see shifts.

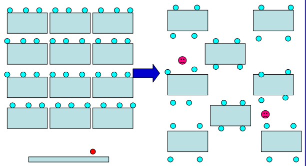
The Curricular Intervention: Tool & Tool Use



Tutorials in Introductory Physics[1]: Restructure Recitations:

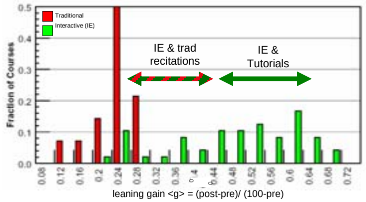
- shift in ***content emphasis*** from computation to conceptual understanding
- shift in ***student activity*** from watching, listening, transcribing to actively discussing, reasoning, & problem solving
- shift in ***student interactions*** from individual to group work
- shift in ***student-educator relationship*** from educator as a source of answers to educator as a source of guiding and focusing questions





Evidence of Student Learning of Physics Concepts [2]

Average normalized student learning grains for Tutorials and non-Tutorial recitation (horizontal arrows) and gains for IE and traditional courses from Hake [4] (histogram)



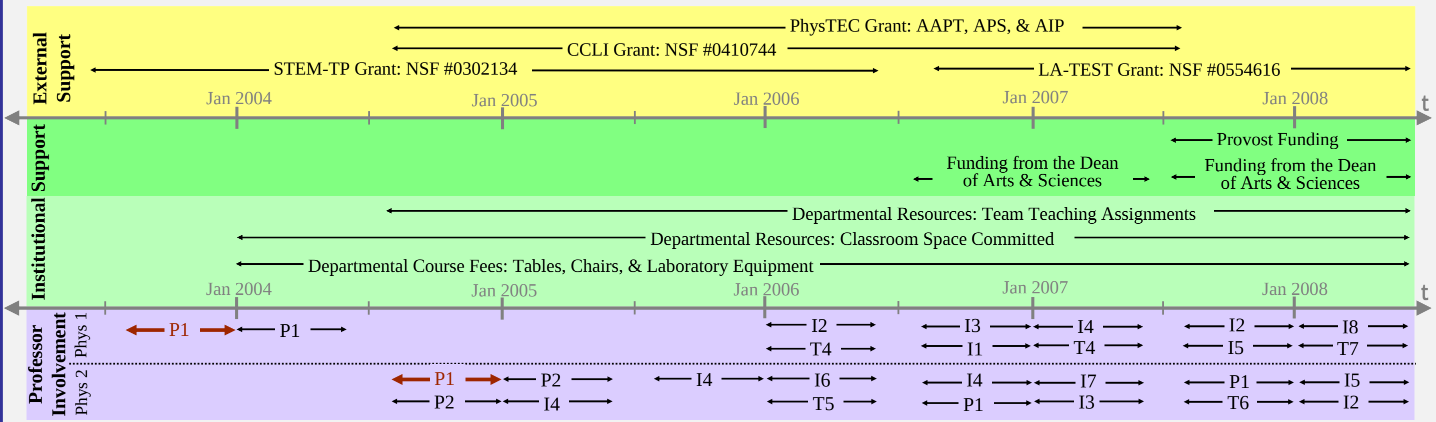
Students are learning more in courses with the Tutorials

Note: CU data use the force & motion concept evaluation; Hake data use the Force Concept Inventory

Current Questions for Change Models

1. What evidence can be used to infer causes for shifts in the beliefs and practices of individuals?
2. Is the distinction between prescriptive and emergent aspects of change useful in making sense of the changes in this system?
3. What other details may be important in describing the change in this system?
4. Does the story of change in this system fit with models of change that exist or challenge models of change that exist?

Institutional History: Funding, Resources, and Individuals



Professor Coding P: Physics Education Research (PER) Faculty; I: Informed, familiar with PER research; T: Traditional, Has not participated in departmental PER-activities [2]

14 faculty members (PER: 2; Informed: 8; Traditional: 4)

Change at the Scale of the Department

Foundational Efforts [3]:

- ***Legacy*** of dedicated and innovative educators: George Gamow, Frank Oppenheimer, Al Bartlett, and John Taylor.
- Support and involvement by ***Nobel Laureate***, Carl Wieman
- ***Personal response system*** adoption & diffusion
- ***Brown Bag discussions*** in education begin 2002-2003 (16 meetings)
- First physics ***PhD in Physics Education Research*** 2002
- Tenure faculty line in ***Physics Education Research***
- Physics department partners with ***Graduate Teacher Program*** (GTP)

Departmental Change concurrent with Tutorial Implementation (2003-08):

- ***Departmental resources committed*** (tables, chairs, classroom space, & assistant personal)
- ***Team teaching*** assignments committed
- Elective physics course added in ***Teaching and Learning Physics*** (offered-Fa2004, Fa2005, Fa2006, Fa2008)
- ***Brown Bag discussions*** in education continue 2003-05; Intermittent 2005-present
- Faculty ***Teaching Evaluation*** Committee modifies evaluation criteria (Sp2003 & Sp2005): increasing emphasis on evidence of student engagement and coordination of course learning goals & course activities
- Tenure awarded to ***Physics Education Research*** Professor

Institutional Change concurrent with Tutorial Implementation:

- ***Funding from the Dean*** of Arts & Sciences (intermittent)
- ***Funding from the Provost*** and Deans for foreseeable future
- Physics department partners with the ***Faculty Teaching Excellence Program (FTEP)*** - faculty summer salary
- Physics department continues to partner with the GTP to fund ***Lead TA position***

Change at the Scale of Individuals

Interviews were conducted with a subset of seven faculty members ***before and after*** they participated in implementing the Tutorials. Interview transcripts are currently being analyzed according (See coding categories to the right). Preliminary trends are discussed below for one case study.

Initial Analysis Codes
Instructor Background
Decisions concerning Curriculum Adoption
Content Emphasis: Traditional Problem Solving vs. Conceptual
Physics Department: Culture & Individuals
The Role of Educators
The Role of Students

Shifts in Instructor Beliefs: A case study of Professor T5

Theme	Pre	Post
Role of Students	Collaboration not preferable	Student discussion valued
Role of Educator	Focus on top ten percent	Benefit the majority of students
Content Emphasis	Traditional HW sufficient	Conceptual focus useful

*"I would **prefer that they do their homework by themselves.** I don't really encourage them to form study groups. I just don't like that kind of idea…Of course, some weaker students they may want to form some study groups."* → *"If you don't give them somewhat close supervision they tend to drift away. You really need to… **not necessarily interfere with their discussions**, but make it clear why we are here."*

*"…in physics education **the focus is to produce the brightest**. The focus is really more on the top ten percent of the students. The other ninety percent of students mostly people say: okay you can not follow."* → *"For the intro-level classes, seeing the students with such diverse backgrounds maybe the way we are doing it now is better… We really focus on the average student not really the top one or five percent. I think that **most of the students actually benefit** from this type of practice."*

*"I'll choose a certain good textbook. I like to really get the material through …**I can tell from the homework problems** I assign to them that they… if they try hard, they can get most of them."* → *"…most of the students don't read their book, **they do the homework problems, but they are not really tuned for the ideas or concepts…** The Tutorial really provides a good opportunity for the student to get down to the basics and understand these basics without having to worry about these equations or formulas."*

➢ **Participating in implementing the Tutorials may result in shifts in individual instructors' conceptions about teaching and learning physics.**

References & Acknowledgements

[1] L.C. McDermott & P.S. Schaffer, *Tutorials in Introductory Physics*, Prentice Hall. (1988).
[2] S.J. Pollock & N.D. Finkelstein, "Sustaining educational reforms in introductory physics." *Phys. Rev. ST Physics Ed. Research* **4**, 010110 (2008).
[3] S.J. Pollock & K. Perkins, "Increasing student engagement in large classes: a departmental case study." *APS Fed Newsletter* (Spring 2004).
[4] RR. Hake, "Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses." *Am. J. Phys.* **66**(1) 1998

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