

Creating Lasting Reform: Diffusion of Educational Innovations via Co-Teaching

AAPT Summer Meeting

July 24, 2006

Syracuse, NY



Charles Henderson

Andrea Beach

Michael Famiano

Western Michigan University



Overview

- Barriers to instructional change
- Co-Teaching as a promising model
- Results of a co-teaching experience



Barrier #1: Standard Dissemination Models

- Transmissionist methods not suitable for promoting fundamental changes.
- Expensive - \$10,600 per self-reported change in teaching methods*.
- Have not produced widespread change†.



Attendees at Fall 2002 meeting of the NY State Section of the American Association of Physics Teachers at Binghamton University.

*Marder et. al., 2001; †e.g. Seymour, E. (2001).

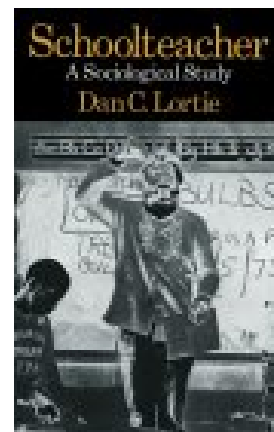
3



Barrier #2: Teaching is Complex

Like any complex task, much of a teacher's decision-making is implicit and based on experience.

Faculty often do not understand the principles and details of new instruction – thus leading to non use or inappropriate modifications*.



Dan Lortie (1975) – Teachers learn to teach through the *Apprenticeship of Observation*

* e.g., Spillane (2004); Henderson and Dancy (2005a)

4



Barrier #3: Instructional Change Can Be Dangerous

- Especially for untenured faculty*
 - May lead to lower student evaluations (at least initially)
 - May require more time than traditional instruction (thus, allowing less time for research)



Most junior faculty are very concerned about getting tenure.

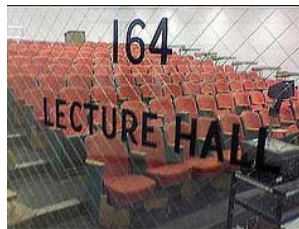
*e.g. Seymour, E. (2001).

5



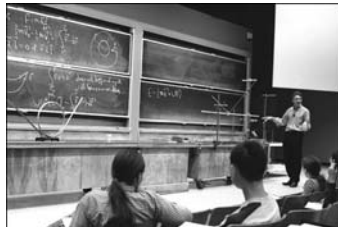
Barrier #4: Situational Factors

Institutions are set up for traditional instruction*



Physical Infrastructure

Departmental Norms



MAE-CAPE
Course and Professor Evaluation
(Please use Scantron Form #881-ES and a #2 pencil, giving only your Section Number)

COURSE PHYS 164 SECTION 1 OF 1 COURSE/SECTION COMPARISON NUMBER 164000
PROFESSOR SMITH, E. A.

| Instructor evaluation | yes | no |
|---|-----|----|
| 1. Instructor displays a proficient command of the material | a | b |
| 2. Instructor is well-prepared for classes | a | b |
| 3. Instructor's speech is clear and audible | a | b |
| 4. Instructor explains the course material in a manner that promotes learning | a | b |
| 5. Lectures hold your attention | a | b |
| 6. Instructor's lecture style facilitates note-taking | a | b |
| 7. Instructor shows concern for students' learning | a | b |
| 8. Instructor promotes questions/discussion | a | b |
| 9. Instructor is accessible outside of class | a | b |

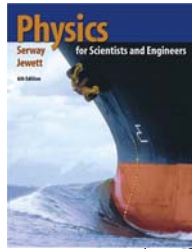
Institutional Expectations

*Dancy and Henderson (2005)

6



Barrier #4: Situational Factors - cont



Content Coverage Expectations

Instructor's Solutions Manual

Student Solutions Manual and Study Guide

Test Bank

Web site to accompany Physics for Scientists and Engineers, Sixth Edition at <http://www.pse6.com>

Transparency Acetates

Resource Availability



When is a Good Day Teaching a Bad Thing?

Timothy F. Slate, University of Arizona Astronomy Department, Tucson, AZ 85721, slate@u.arizona.edu

The state is an associate professor of astronomy and the director of the Science and Mathematics Education Center at the University of Arizona, where his scholarship is focused on the teaching and learning of astronomy and astronomy teacher education.

Have you ever had one of those days teaching when, at the end of the day, you are able to sigh and pat yourself on the back because it was a "good day"? You know the kind - where all the class interruptions were manageable, most of the students turned in their homework, you got through most of the amount of material you planned, the students mostly sat quietly and were able to answer the questions you posed, and asked you questions you were able to answer. All in all, this is the textbook definition of a "good day" in the classroom. Think for a moment, most scientists would be excited if this description occurred once each week!

Now, before you get too excited that this is the perfect I hope, allow me to pose a few seemingly simple questions about your class. How much day thinking were the students really doing? How do you know? Did you ask students "Do you everyone understand?" or did you craft a series of particularly thought-provoking questions to check specifically for depth of student understanding and students' abilities to transfer across conceptual boundaries? I admit to you that when ever they sense time, it is probably the perfection to carefully find out exactly what depth of learning is actually occurring in your class.

Many teachers and students alike have no other angle to define a "Hidden Contract." This Hidden Contract has been agreed to and reinforced by teachers and students since antiquity. It ranges in subtlety across school classrooms and college lecture halls alike, and goes something like this. First, the students' responsibilities are to do exactly what everything the teacher puts on the board, publicly and privately ask for portions of clarification, and memorize their notes, summary review sheets, and notes for the exam. They are obligated to do well on the exam as well as promptly forget everything that they studiously memorized last year. Students who break this contract by coming to class late, posing questions about the material, or asking to see the material, or talking to adaptively memorize the material are considered to be troublemakers or unwilling to play the game of "school."

On the other hand, the Hidden Contract stipulates that it is the teacher's responsibility to clearly organize and present lectures, preferably enthusiastic ones, to describe, summarize and often create examples, to assign exercises that allow students to practice tasks not terribly different from the examples given in class, and to monitor to specify the curriculum aspects that will be covered on the next exam. The Hidden Contract clearly stipulates that teachers who provide answers for extra credit, who tell homework assignments in class, who further elaborate the possible questions from a wealth of possible questions, and an flexible on assignments due dates are held in the highest regard. Teachers who break this Hidden Contract by writing two questions that are either ambiguous or go beyond the examples presented in class are labeled as being unfair, unresponsive, or simply just bad teachers.

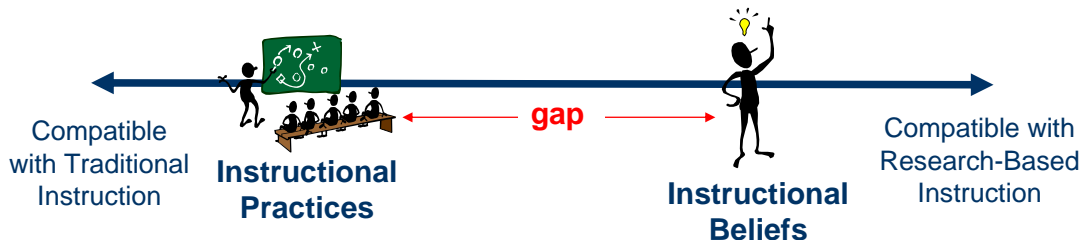
In short, this time sound Hidden Contract tells students how to behave in class and what they must memorize to earn an A, as well as guide teachers on when to get as many students as possible to earn passing marks in their class and maintain a reputation as a good teacher. The students get what they want. The teachers get what they want. Everyone's happy.

Student Expectations - the hidden contract



Opportunity: Faculty Beliefs and Values

Traditional Practices : PER-Compatible Beliefs



Many faculty have instructional goals and beliefs about teaching and learning that are more compatible with the results of educational research than with traditional instruction*.

*Henderson and Dancy (2005b), Yerushalmi et. al. (accepted)



Co-Teaching: Who?



CH: Experienced faculty member in WMU PhysTEC courses, experienced PER researcher with knowledge about many PER instructional interventions, co-teaching participant



MF: New faculty member in WMU Physics Dept., all prior teaching experience as a TA, some familiarity with PER via. grad study at OSU, co-teaching participant



AB: Faculty member in college of education, experience evaluating instructional changes in college faculty, outside observer of co-teaching

9



Co-Teaching: Why?

Goal: Enculturate MF into PhysTEC teaching

- Help MF understand how and why PhysTEC courses work through **direct experience** – and to see that it does work.
- **Reduce the risks** of instructional experimentation by working with an experienced instructor.
- Help MF **develop a repertoire of materials and strategies** that can be used in subsequent PhysTEC-style courses.

10



Co-Teaching*: What?

- Fall 2005: CH and MF co-taught Phys 2050: Introductory Calculus-Based Mechanics
 - CH and MF alternate being in charge of class each week
 - Weekly meetings between CH and MF to reflect on previous week and discuss initial plans for coming week
 - Course structure set up by CH to support PhysTEC design principles
 - MF had access to materials used by CH in previous semesters
- Spring 2006: MF teaches Phys 2050 on his own
- Data Collected
 - Individual interviews (conducted by AB) with CH and MF at beginning, middle, end of semester.
 - Teaching observations (conducted by AB) of CH and MF at beginning, middle, end of semester.

* More info about co-teaching in K-12 settings is available in Roth and Tobin (2002).

11



Design Principles of WMU PhysTEC Courses

(Departures from traditional instruction)

1. Students should be **actively engaged** with the material during class time. This is best accomplished via student-student interaction.
2. Students should **read the text before coming to class** and most will not do this unless there is some external incentive.
3. Class discussions and tests should place significant emphasis on **conceptual issues** and qualitative questions.
4. Class discussions and tests should place significant emphasis on the solving of **multi-step problems** (i.e., ones that cannot be solved by substituting numbers into a single equation).
5. Student problem solutions should start from basic principles and contain **written explanation of reasoning**.
6. Test questions should require students to engage in the **desired thinking processes**. This means that test questions should not be similar enough to questions students have previously seen that a rote strategy is fruitful.
7. **Formative assessment**, both informal and formal, should be used to determine students' current understanding for the purpose of designing appropriate subsequent instruction.
8. **Depth of student understanding** should be valued more than breadth of content covered during the course.

12



Results: MF Instructional Practices

- Observed instructional practices were consistent with PhysTEC principles from the start
 - Few differences observed between MF and CH
- MF instruction likely would have been more traditional without co-teaching:
 - *“I probably wouldn’t do as many in-class activities as we are doing now. . . . and so it will probably be a little bit more like the formal lecture.”* (F1#228-233)

13



Results: MF Beliefs

- Initial Beliefs: **Skeptical**
 - *“When I first came I was skeptical about having students do nothing but problems in class. Just sort of standing by while they do problems.”* (F2#84-87)
- Mid-term Beliefs: **Some parts are OK**
 - *“It taught me something that I am going to adopt aspects of in future courses. You know, pick up the things that I think are working really well and the interactive and the discussions, things that are really useful.”* (F2#194-198)
- End of term Beliefs: **It is working very well**
 - *“My class is going to be very similar to what we did last semester, even the structure will be the same structure. It’s going to be almost identical.”* (F3#272-273)

14



Results: Course Comparisons

| | CH and MF Co-Teaching (Fall 2005) | MF (Spring 2006) |
|----------------------|--|--|
| Reading Text | Students submit reading question via WebCT. (Weekly) | Reading quiz via WebCT. (Weekly) |
| Use of class time | Short lectures (5-10 minutes). Students spend most time working in assigned groups (usually with white boards). Tasks ranged from conceptual questions to quantitative problems. | |
| Assignment of groups | Students are assigned to groups of 3-4 based on where they live (as homogeneous as possible) and their performance in the prerequisite math course and FCI pretest (as heterogeneous as possible). | |
| Online Exercises | 6-12 conceptually-oriented questions (often multiple-choice) or relatively simple calculations. (Weekly) | Used many exercises as part of reading quiz. |
| Student Solution | Students required to include General Approach, Procedure, Implementation in problem solutions. This was modeled by instructor during class. | Student solutions were expected to start from basic principles and show reasoning. Fall 2005 framework was modeled by instructor during class. |
| Homework Problems | 4 problems each week. Multiple steps and specifically chosen to not be easily solvable by rote. Each student was responsible for submitting a numerical answer online (different numbers). Each group was responsible for turning in a written solution. | 6-10 problems each week. Each student was responsible for turning in a written solution. Problems were similar (or identical) to Fall 2005 problems. |
| Use of Main Ideas | The important physics concepts were broken into 21 main ideas that were referred to in class and provided to on exams. Student problem solutions were expected to be based on one or more main idea. | |
| Testing | Each quiz and exam had 2-4 conceptually-oriented short answer questions and one multi-step quantitative problem. Complete written solutions were available shortly after each. (Weekly) | |
| Quiz Corrections | Students had option to reflect on graded quiz in order to increase score. | Not used |



Results: Course Comparisons

Contribution of course components to the course grade.

| Component | Co-Teaching (Fall 2005) | MF (Spring 2006) |
|--|----------------------------------|------------------------------|
| Exam Average | 40% (4 exams) | 30% (3 exams) |
| Final Exam (comprehensive) | 20% | 20% |
| Quiz Average | 15% | 15% |
| Online Problems | 5% | |
| Written Problems | 5% (group) | 20% (individual) |
| Online Exercises | 5% | |
| Reading Assignment | 5% (reading questions) | 10% (reading quiz) |
| In-Class Group Work (all members get same score) | 5% | 5% |
| | 100% | 100% |



Conclusions

1. It worked!
 - Significant changes documented in beliefs and intentions.
2. Course structure was important.
 - Practices started out in PhysTEC mode and did not change. This was likely due to **course structure that constrained possibilities.**
3. Affordable
 - Cost \$2,800 to hire a part-time instructor to cover 1 class.
4. The entire semester was necessary
 - Although practices did not change, **beliefs and intentions continued to change throughout the semester.**
5. Co-teaching was important
 - **Not student-teacher or mentor-mentee, but collegial relationship.** *“Well the thing that I liked the most about this is it wasn’t like I was Charles’ protégé. He recognizes me as a colleague and we were teaching this class together. . . . it wasn’t like teacher-apprenticeship which at this level it might seem sort of insulting.”* (F3#283-286)

17



Implications

- Co-teaching is a cost-effective model that shows significant promise as a way to promote research-consistent instruction in new faculty.
- It may also be an applicable for graduate students or experienced faculty.
- Limitations
 - MF began co-teaching with neutral to favorable views of research-compatible instructional practices. It is not clear that this model would be successful with a co-teacher hostile to new methods.
 - Co-teaching only works when there is a teacher available who teaches in a research-consistent manner.
 - This is a single case -- clearly more work is needed.

18



References

- Dancy, M. and Henderson, C. (2005) Beyond the individual instructor: Systemic constraints in the implementation of research-informed practices. In *Proceedings (peer reviewed) of the 2004 AAPT Physics Education Research Conference* (Vol. 790) (Franklin, S. Marx, J. and Heron, P., eds.), American Institute of Physics. (Available online: <http://homepages.wmich.edu/~chenders/Publications/PERC2004Dancy.pdf>)
- Henderson, C. and Dancy, M. (2005a) When one instructor's interactive classroom activity is another's lecture: Communication difficulties between faculty and educational researchers. Paper presented at the American Association of Physics Teachers Winter Meeting, Albuquerque, NM.
- Henderson, C. and Dancy, M. (2005b) Teaching, learning and physics education research: Views of mainstream physics professors. In *Proceedings (peer reviewed) of the 2004 AAPT Physics Education Research Conference* (Vol. 790) (Franklin, S. Marx, J. and Heron, P., eds.), American Institute of Physics. (Available online: <http://homepages.wmich.edu/~chenders/Publications/PERC2004Henderson.pdf>)
- Lortie, D. (1975) *Schoolteacher: A sociological study*, University of Chicago Press.
- Marder, C., McCullough, J. and Perakis, S. (2001) *Evaluation of the National Science Foundation's Undergraduate Faculty Enhancement (UFE) Program*, SRI International.
- Roth, W.-M. and Tobin, K. (2002) *At the elbow of another: Learning to teach by coteaching*, Peter Lang.
- Seymour, E. (2001) Tracking the process of change in us undergraduate education in science, mathematics, engineering, and technology. *Science Education* 86, 79-105.
- Spillane, J. P. (2004) *Standards deviation: How schools misunderstand educational policy*, Harvard University Press.
- Yerushalmi, E., Henderson, C., Heller, K., Heller, P. and Kuo, V. (accepted) Physics Faculty Beliefs and Values about the Teaching and Learning of Problem Solving Part I: Mapping the Common Core, *Physical Review Special Topics: Physics Education Research*.