From research to practice:
Why hasn't educational research had more of an influence on teachers and what can we do about it?

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http://homepages.wmich.edu/~chenders/

Main Point

The current situation

Physics Education Research (PER)-based curricula and research results are not used as much as they should be.

An important problem

PER dissemination activities are not usually connected to any explicit model or theory of change.

- **makes it difficult to plan and coordinate effective dissemination activities**
- **inhibits the development and testing of theory**

Overview

1. The current situation
    a) PER research and development (brief)
    b) PER dissemination activities (brief)
    c) How much of an impact have #1 and #2 had?
2. Change Models/Strategies
    a) Your models/strategies
    b) Tools for thinking about change models/strategies
    c) Expanding models/strategies

Focus of this workshop is on change in college-level physics instruction.
The issues in K-12 are not so different.

What physics education research has done…

Identified many problems with traditional methods of instruction.

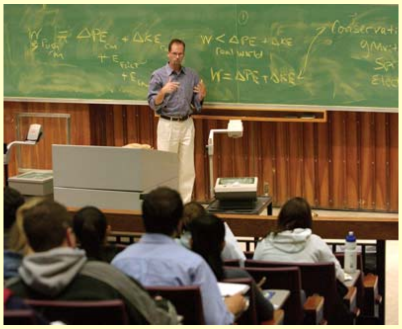
- Ineffective at developing understanding of physics concepts, problem-solving skills, and understanding of the processes of science
- Students often develop negative attitudes towards science.
- High attrition rates, especially for women and racial minorities.

Found Solutions!

Replace lecture with hands-on, inquiry based activities.

Encourage and support cooperative learning.

Explicitly teach problem solving.



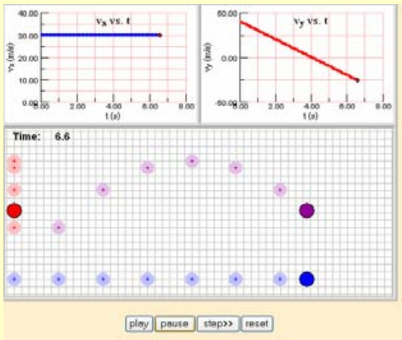
Traditional Physics class at
University of Rochester

SCALE-UP Physics class at
Clemson University

Technology

Classroom Response Systems

Java Applets



Research-Based Nationally-Normed Assessments

From: http://www.ncsu.edu/per/TestInfo.html

NC STATE UNIVERSITY
Physics Education R & D Group

Assessment Instrument Information Page

Please do not allow students to keep copies of any of these tests. It takes years of development effort to create and validate a reliable assessment instrument. If it is released to the public domain, students will locate it and all that work will be for naught. In fact, you might not want to use the formal name of the test on the versions you have students take. None of these tests are to be incorporated into a web-based question delivery system without adequate security to prevent printing or other unauthorized access by students. Contact the authors for more details.

If you have any questions, please contact phone 919-515-7226 or e-mail *Robert J. Beichner, NC State Physics Department*

TUG-K Beichner's *Test of Understanding Graphs in Kinematics* is available in English, Spanish, French, German, Finnish, and Portugese by sending e-mail to beichner@ncsu.edu. A discussion of the test is in R. Beichner, "Testing student interpretation of kinematics graphs," Am. J. Phys., 62, 750-762, (1994).

Deardorff & Beichner's *Test of Measurement Uncertainty Concepts* can be requested from beichner@ncsu.edu.

BEMA Chabay & Sherwood's Brief Electricity and Magnetism Assessment attempts to assess what students know about the most basic and central concepts of the calculus-based introductory E&M course. It is comprehensive, covering topics from the Coulomb force law to magnetic induction, but omitting radiation because it is so common for the intro course not to get that far. It has been used by various instructors in various settings and has been judged an appropriate and fair assessment of introductory E&M by physicists experienced in teaching E&M at various levels. It is not aimed at any particular curriculum but contains only those elements common to all calculus-based introductory courses. You will see on the cover page that some special grading can be imposed to make a more accurate measurement, and a spreadsheet is available from rwchabay@unity.ncsu.edu and basherwo@unity.ncsu.edu that performs these adjustments. Details about the test can be found in L. Ding, R. Chabay, B. Sherwood, and R. Beichner, "Evaluating an electricity and magnetism assessment tool: Brief electricity and magnetism assessment", Phys. Rev. ST Phys. Educ. Res. 2, 010105 (2006).

CSEM The Maloney, van Heuvelen, Hieggelke, and O'Kuma Conceptual Survey in Electricity and Magnetism (along with a separate test on electricity and another on magnetism) is available from curth@jjc.edu. More info can be found at the Two Year College Physics website and from D. Maloney, T. O'Kuma, C. Hieggelke, and A. Van Heuvelen, "Surveying students' conceptual knowledge of electricity and magnetism", Am. J. Phys. 69, S12 (2001).

DEEM Marx and Wilson have developed an E & M test that is available by contacting Jeff Marx at jmarx@mcdaniel.edu.

DIRECT 1.2 Engelhardt & Beichner's test of simple resistive electrical circuit concepts is available in English, Spanish, and Finnish by mailing a request to beichner@ncsu.edu. More details are in P. Engelhardt, and R. Beichner, "Students' understanding of direct current resistive electrical circuits", Am. J. of Phys, 72, 98-115, (2004).

ECCE The Electric Circuits Conceptual Evaluation is available from the Workshop Physics site. You'll need a password.

EMCI Notaros has created an instrument to assess learning in upper division E & M courses...the Electromagnetics Concept Inventory. Contact him at Branislav Notaros or visit the website.

RAPT Two parallel versions of Allain & Beichner's *Rate and Potential Test* is available by sending e-mail to beichner@ncsu.edu.

FCI The Force Concept Inventory by Halloun, Hake, Mosca, and Hestenes is available from http://modeling.asu.edu/R&E/Research.html You'll need to request a password to open the file. Several articles describing the test are at the above page.

MBT The Mechanics Baseline Test by Hestenes and Wells is available from http://modeling.asu.edu/R&E/Research.html You'll need a password to open the file. An article describing the test is available at above page.

FMCE The Force and Motion Conceptual Evaluation was developed by Ron Thornton & David Sokoloff. Information can be see in R. Thornton, and D. Sokoloff, "Assessing student learning of Newton's laws: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Curricula", Am. J. Phys., 66, Issue 4, 338-352 (1998).

HCTE The Heat and Temperature Conceptual Evaluation is available from the Workshop Physics site. You'll need a password.

TCI Midkiff created an upper division engineering thermodynamics concept test. Contact Clark Midkiff or visit the website.

Light and Optics: Rumor has it that a light & optics test is in the works from the Workshop Physics site.

NC State has also working on a geometric optics test.

ECS The Energy Concepts Survey looks at concepts in *energy and momentum*, contact Chandralekha Singh, 100 Allen Hall, Department of Physics, University of Pittsburgh, Pittsburgh, PA 15260 singh@bondi.phyast.pitt.edu, 412-624-9045

QMVI The Quantum Mechanics Visualization Instrument by Robinett is available.

ADT Mike Zeilik and others have developed an astronomy diagnostic test. It is available from Mike Zeilik at MZeilik@aol.com. (You can copy it directly from a web page, if you'd like.) A collection of classroom assessment instruments can be found a FLAG.

LPCI Rebecca Lindell has created The Lunar Phases Concept Inventory, which is available from us.

WCI Teri Rhodes and Ron Roedel have written a Wave Concept Inventory appropriate for upper division students

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The Solomon & Felder Index of Learning Styles is available on the web. Information giving many details on the Felder & Silverman Learning Styles Model is also available.

Lawson's Classroom Test of Scientific Reasoning is available from Anthony Lawson by e-mailing him directly. Tell him we sent you!

MMCE The Mathematical Modeling Conceptual Evaluation is available from the Workshop Physics site. You'll need a password.

MPEX The Maryland Expectations Survey can be found at http://www.physics.umd.edu/perg/expects/ex.htm

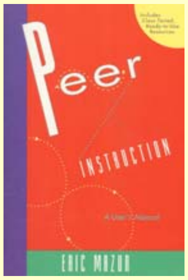
VASS Views About Science Survey is available from http://modeling.asu.edu/R&E/Research.html You'll need to request a password to open the file.

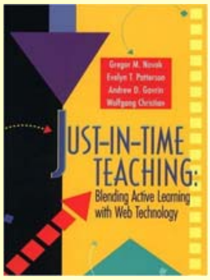
CLASS Colorado Learning Attitudes about Science Survey and a scoring spreadsheet are available from http://CLASS.colorado.edu. Additional information can be found in W. K. Adams, K. K. Perkins, N. S. Podolefsky, M. Dubson, N. D. Finkelstein, and C. E. Wieman, "New instrument for measuring student beliefs about physics and learning physics: The Colorado Learning Attitudes about Science Survey", Phys. Rev. ST Phys. Educ. Res. 2, 010101 (2006).

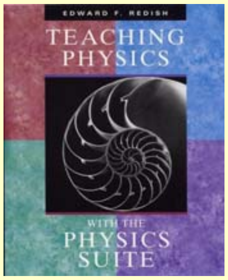
Two tests related to collaborative teams are available by contacting Ted Powers. His website has more information.

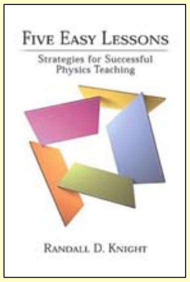
Since any funding test designers get for developing additional tests depends on showing our funding agencies that the tests are useful, all of us would really appreciate hearing about how you are utilizing them. The NCSU projects mentioned on this page were supported, in part, by the Department of Education and the National Science Foundation. Opinions expressed are those of the authors and not necessarily those of the sponsors. P116B71905, P116B000659, DUE-9752313, DGE-9714546, DGE-9554526, DUE-9981107

Classroom-Tested Strategies

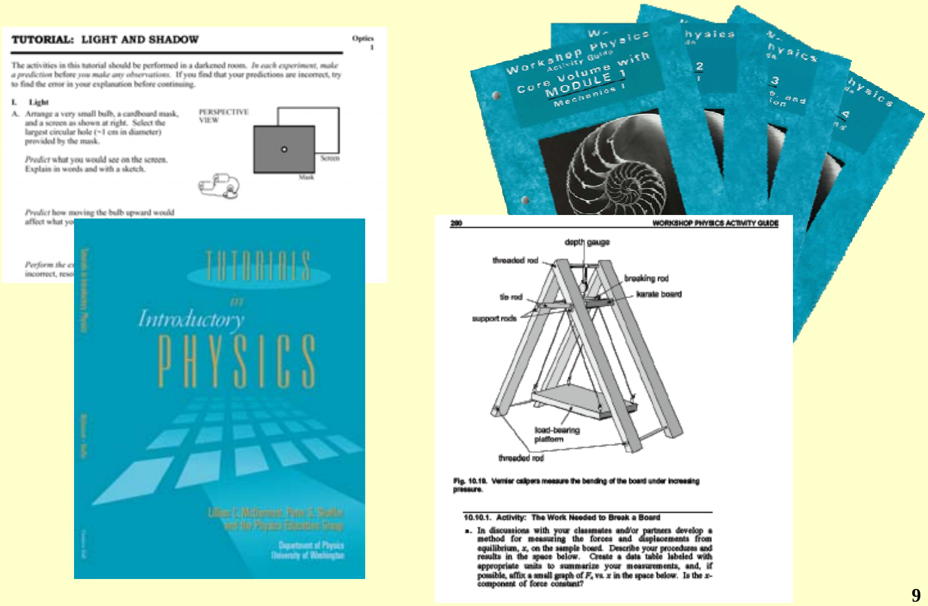








Research-Based Materials



TUTORIAL: LIGHT AND SHADOW

Optics
1

The activities in this tutorial should be performed in a darkened room. *In each experiment, make a prediction* before *you make any observations.* If you find that your predictions are incorrect, try to find the error in your explanation before continuing.

I. Light

A. Arrange a very small bulb, a cardboard mask, and a screen as shown at right. Select the largest circular hole (~1 cm in diameter) provided by the mask.

Predict what you would see on the screen. Explain in words and with a sketch.

Predict how moving the bulb upward would affect what yo

Perform the ex
incorrect, reso

200 WORKSHOP PHYSICS ACTIVITY GUIDE

Fig. 10.19. Vernier calipers measure the bending of the board under increasing pressure.

10.10.1. Activity: The Work Needed to Break a Board

a. In discussions with your classmates and/or partners develop a method for measuring the forces and displacements from equilibrium, *x*, on the sample board. Describe your procedures and results in the space below. Create a data table labeled with appropriate units to summarize your measurements, and, if possible, affix a small graph of F_x vs. x in the space below. Is the x-component of force constant?

More Research-Based Materials

Mechanics Problems - Linear Kinematics

1. **One-Dimensional, Constant Velocity**

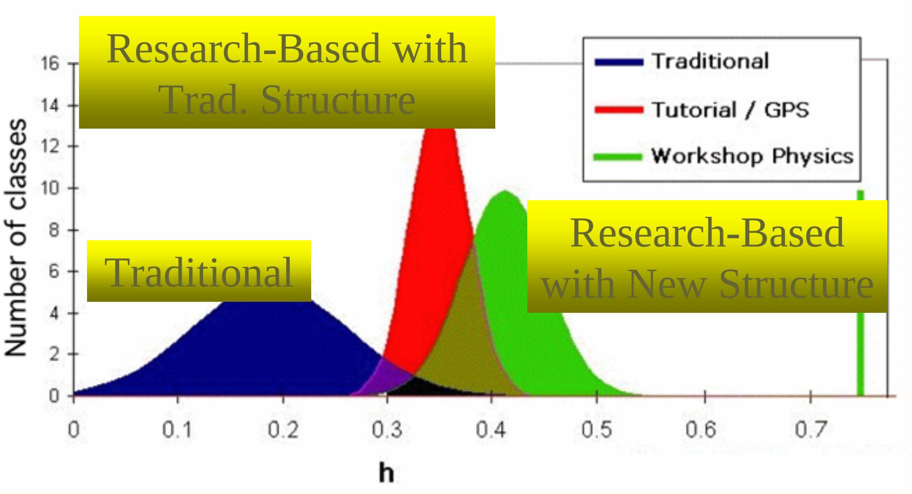
1. You are writing a short adventure story for your English class. In your story, two submarines on a
mission need to arrive at a place in the middle of the Atlantic ocean at the same time. They start o
time from positions equally distant from the rendezvous point. They travel at different velocities b
a straight line. The first submarine travels at an average velocity of 20 km/hr for the first 500 km,
the next 500 km, 30 km/hr for the next 500 km and 50 km/hr for the final 500 km. In the plot, the
submarine is required to travel at a constant velocity, so the captain needs to determine the magnit
velocity.

2. It is a beautiful weekend day and, since winter will soon be here, you and four of your friends deci
outdoors. Two of your friends just want to relax while the other two want some exercise. You nee
time to study. To satisfy everyone, the group decides to spend the day on the river. Two people will put a canoe in the river and just drift downstream with the 1.5 mile per hour current. The second pair will begin at the same time as the first from 10 miles downstream. They will paddle upstream until the two canoes meet. Since you have been canoeing with these people before, you know that they will have an average velocity of 2.5 miles per hour relative to the shore when they go against this river current. When the two canoes meet, they will come to shore and you should be there to meet them with your van. You decide to go to that spot ahead of time so you can study while you wait for your friends. Where will you wait?

3. It's a sunny Sunday afternoon, about 65 °F, and you are walking around Lake Calhoun enjoying the last of the autumn color. The sidewalk is crowded with runners and walkers. You notice a runner approaching you wearing a tee-shirt with writing on it. You read the first two lines, but are unable to read the third and final line before he passes. You wonder, "Hmm, if he continues around the lake, I bet I'll see him again, but I should anticipate the time when we'll pass again." You look at your watch and it is 3:07 p.m. You recall the lake is 3.4 miles in circumference. You estimate your walking speed at 3 miles per hour and the runner's speed to be about 7 miles per hour.

UMN Online archive of context-rich problems:
http://groups.physics.umn.edu/physed

Evidence that Research-Based Reform Works!



Research-Based with Trad. Structure

Traditional

Research-Based with New Structure

Student learning gains on the Force Concept Inventory

From J. M. Saul and E. F. Redish, "Final Evaluation Report for FIPSE Grant #P116P50026: Evaluation of the Workshop Physics Dissemination Project," (University of Maryland, 1997).

PER Dissemination Activities

1. Talks
   a) Departmental Colloquia
   b) Professional Meetings (AAPT, APS, AAS)
2. Workshops
   a) Single-day (e.g., AAPT Workshops)
   b) Multi-day (e.g., New Faculty Workshop)
   c) 1-2 Weeks in summer (e.g., Workshop Physics)
3. Papers
   a) Specific articles (e.g., focused on a particular method)
   b) General articles (e.g., on learning theory, misconceptions, etc.)
4. Books
   a) Already discussed (often available for free from textbook publishers)

General Features of Dissemination

1. Aimed at changing individual instructors.
2. Transmission-oriented with four main segments:
   1. Problems with traditional instruction are identified and described
   2. An instructional strategy is introduced that can overcome these problems
   3. Evidence is presented to show that the new strategy is successful
   4. The presenter attempts to motivate the audience to try (e.g., it's not so hard…)

What Impact has PER dissemination activities had on Instruction?

Limited Data Exists

- Peer Instruction:
  - 353 self-described users of Peer Instruction[1]. "Most" teach physics.
- Just-in-Time Teaching (JiTT)
  - 71 United States physics instructors who use JiTT for introductory physics[2].
- There are ~11,360 physics faculty employed in two-year and four-year colleges in the United States[3,4].
  - Peer Instruction – 3.1% of faculty
  - JiTT – 0.6% of faculty

1. Fagen, A. P., Crouch, C. H. and Mazur, E. (2002) Peer instruction: Results from a range of classrooms. *The Physics Teacher* 40, 206-209.
2. Novak, G. M. (2004) JiTT impact and citations. Retrieved February 12, 2007, from Just-in-Time Teaching web site: http://webphysics.iupui.edu/jitt/impact.html.
3. Ivie, R., Stowe, K. and Nies, K. (2003) *2002 physics academic workforce report* (AIP Pub. Number R-392.5) American Institute of Physics.
4. McFarling, M. and Neuschatz, M. (2003) *Physics in the two-year colleges: 2001-02* (AIP Pub. Number R-436) American Institute of Physics.

Experts Consider Use of PER to Be Low

“Most introductory [science] courses rely on transmission-of-information lectures and cookbook laboratory exercises.”

J. Handelsman, D. Ebert-May, R. Beichner, P. Bruns, A. Chang, R. DeHaan, J. Gentile, S. Lauffer, J. Stewart, S. M. Tilghman and W. B. Wood, "Education: Scientific teaching," Science. 304 (5670), 521-522 (2004). http://scientificteaching.wisc.edu/ScientificTeaching/ScientificTeaching.pdf

In a web survey of 30 PER practitioners, 80% agreed or strongly agreed that “Physics faculty teach very traditionally.”

C. Henderson and T. Stelzer, "The gap between PER and mainstream faculty: The PER perspective," (Poster presented at the Foundations and Frontiers in Physics Education Research Conference, Bar Harbor, Maine, August 16, 2005, 2005). http://homepages.wmich.edu/~chenders/Publications/FFPER05Poster.pdf

“A crucial question, then, is why introductory science courses in many colleges and universities still rely primarily on lectures and recipe-based laboratory sessions.”

National Research Council, Improving undergraduate instruction in science, technology, engineering, and mathematics: Report of a workshop (The National Academies Press, Washington, D.C., 2003).

The Dissemination Activities Commonly Used by PER have yet to prove their effectiveness

One Problem:

“In reform efforts, the theory or theories that underwrite the chosen forms of actions often remain unstated.”*

*E. Seymour, "Tracking the process of change in us undergraduate education in science, mathematics, engineering, and technology," Science Education. 86, 79-105 (2001), p. 90.

Why Reform Models are Important

Changing reform models of the Foundation Coalition*

Foundation Coalition:

- What: 6 institutions to develop and implement a new 4-year engineering curriculum
- When: First grant – 1993-1998 ($14M)

National Science Foundation
WHERE DISCOVERIES BEGIN

Award Number	Title	NSF Organization	Program(s)	Start Date	Principal Investigator	State	Organization	Awarded Amount to Date
9802942	Foundation Engineering Education Coalition	EEC	ENGINEERING EDUCATION	10/01/1998	Froyd, Jeffrey	TX	Texas Engineering Experiment Station	$14,191,167.00
9221460	The Foundation Coalition	EEC	ENGINEERING EDUCATION	10/01/1993	Frair, Karen	TX	Texas Engineering Experiment Station	$14,000,000.00

*C. M. Clark, J. Froyd, P. Merton and J. Richardson, "The evolution of curricular change models within the foundation coalition," Journal of Engineering Education. **93** (1), 37-47 (2004).

Elicitation Activity

What is your current model of reform?

Assuming that a goal of educational reform is to have a majority of physics faculty teach in a manner consistent with the general recommendations of PER, how do we get there?

Describe an activity or set of activities that can lead to reform. Be explicit about how the activities lead to the goal.

(If thinking about reform at the national level seems too big, perhaps consider just your institution or department.)

Group Discussion

Group Consensus Model of Reform

-Groups of 4-5

-Sit with people you do not know well and who are not from your institution

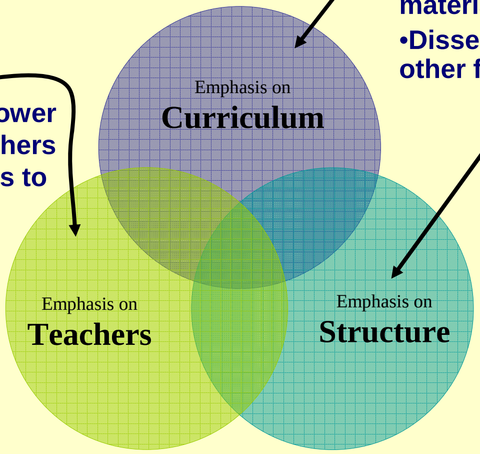
1. Introductions
2. Share Individual Models
3. Create Group Model

Your Task: Assuming that a goal of educational reform is to have a majority of physics faculty teach in a manner consistent with the general recommendations of PER, how do we get there?

Describe an activity or set of activities that can lead to reform. Be explicit about how the activities lead to the goal.

Tools for thinking about change activities and change models

Tool 1: Three Foci of Change Activities



(Curriculum)

- **Conduct research and develop curricular materials and strategies**
- **Disseminate these to other faculty**

(Teachers)

- **Motivate/empower individual teachers or small groups to focus on instructional improvement**

(Structures)

- **Study how institutional structures influence teacher practices and student learning**

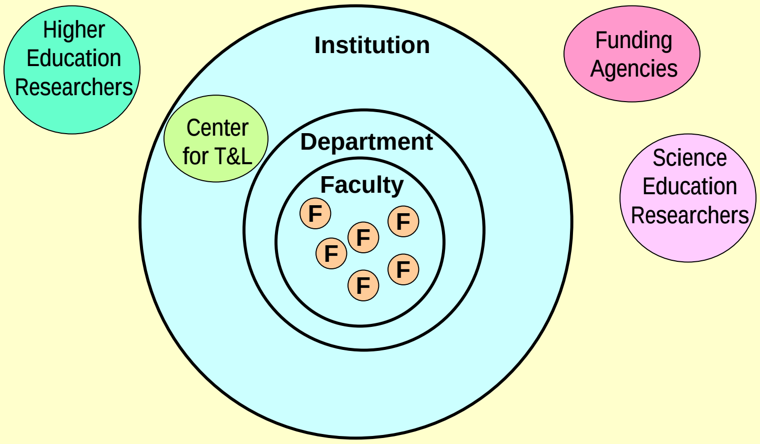
Three Foci

Most change strategies only focus on one area

Emphasizing only one of these areas is not likely to lead to widespread reform, but it can have some local impact -- there is a lot known about “best practices” within each area.

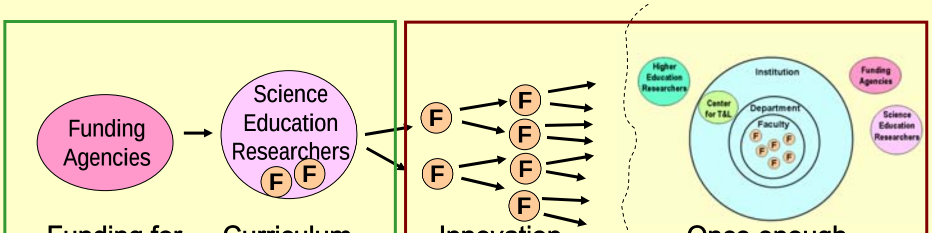
Common Strategies for Each Foci

Important parts of the System



(focus on curriculum)

Bottom-Up Change Models



Funding for specific curriculum development projects

Curriculum developers conduct research and develop/test innovations

Strong Evidence

Innovation spreads to other faculty and continues to spread

Once enough faculty use innovation it begins to influence other parts of the system

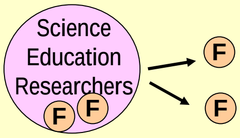
Little or No Evidence

(focus on curriculum)

Bottom-Up Change Models

A more modest agenda: Getting innovations used by other faculty

This typically involves dissemination to individual faculty.



Curriculum developers conduct research and develop/test innovations

Innovation spreads to other faculty

Dissemination to Individual Faculty

Activity	Problem	Reality
1. Identify problems with traditional instruction	Many faculty are already dissatisfied	Can be insulting and lead to defensiveness May not be necessary
2. Describe an instructional strategy that can overcome these problems	Supply information about only 1 curricula Not always explicit about critical pieces	Can be insulting and lead to defensiveness “they think their way is the only way” Instructors may not understand principles of curricula
3. Present evidence that the new strategy is successful		Instructors are not often persuaded by such evidence
4. Motivate audience to try (e.g., it’s not so hard…)	Ignores resistive situational factors Implementation success often requires significant implicit knowledge	Innovations may be given up after a brief trial (after situational factors are realized) Innovations typically not implemented with “fidelity”

Dissemination to Individual Faculty

Think individually, then discuss with group.

1. Do these problems and realities fit with your experiences?
2. Are there other problems/realities that you would include?

Tool 2: What types of Changes do we Expect?

Adoption-Invention Continuum:

Possible Relationships Between PER and Faculty

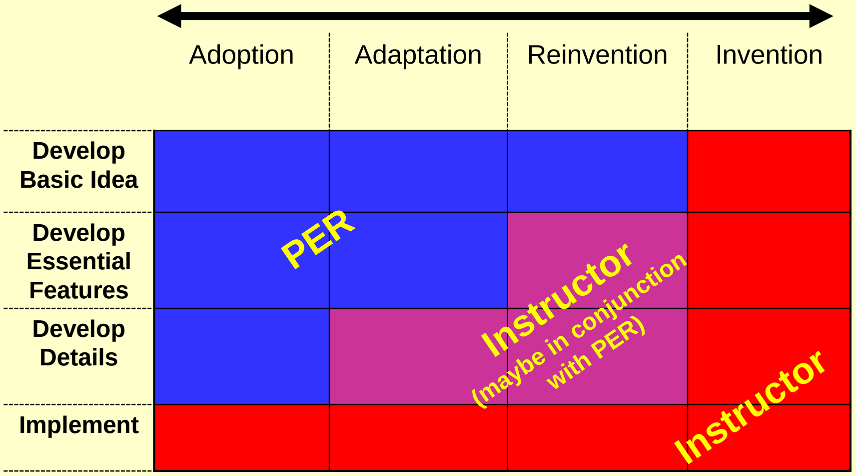
Adoption	Adaptation	Reinvention	Invention
The change agent develops all of the materials and procedures and gives them to the instructor to implement as is.	The change agent develops the materials and procedures and gives them to the instructor who changes them slightly before implementing.	Instructor uses the ideas of the change agent but significantly alters them or develops fundamentally new procedures based on the change agent ideas.	The instructor develops materials and procedures that are fundamentally based on his/her own ideas.

Henderson, C. and Dancy, M. (submitted) Physics Faculty and Educational Researchers: Divergent Expectations as Barriers to the Diffusion of Innovations. Submitted April 2006 to *American Journal of Physics (Physics Education Research Section).*

Henderson, C., & Dancy, M. (2006). Physics Faculty and Educational Researchers: Divergent Expectations as Barriers to the Diffusion of Innovations. Proceedings of the 2005 AAPT Physics Education Research Conference (Salt Lake City, UT).

Adoption-Invention Continuum:

Possible Relationships Between PER and Faculty



Example – Peer Instruction (Mazur, 1997)

Basic Idea: Students are asked to respond to short conceptual questions during lecture to increase engagement and provide feedback to the instructor.

Essential Features:

- Reading assignment or quiz before lecture.
- Conceptual tests (CTs) are used to segment lecture.
- Peer-peer discussion of CTs.
- Conceptual questions on exams.

Details:

- Specific concept tests, reading quizzes, and exam questions
- Timing: 5-7 min lecture, CT, ~2 min discussion, CT
- Flash card or PRS system for managing student responses
- CTs characteristics: focus on common student difficulties, 35%-70% of students should initially answer incorrectly
- Coverage is same, but not all material is presented in class

Example – Peer Instruction

Adoption: Use “as is”

- Take Mazur’s book, follow recommendations and use available materials.

Adaptation: Change some details to suit individual situation

- Instead of multiple choice CTs, use free response questions.

Reinvention: Take basic idea, but drastically change or eliminate at least one essential feature

- Have one CT at end of class
- Eliminate student-student discussion

Invention: Do something completely different

Using the Adoption-Invention Continuum: An Example*

Open-Ended Interviews

- **Five instructors, four institutions**
- **Tenured**
- **No formal connections with PER**
- **Thoughtful, reflective, well-respected**

➔This type of instructor is highly likely to be interested in educational research

*Henderson, C. and Dancy, M. (submitted) Physics Faculty and Educational Researchers: Divergent Expectations as Barriers to the Diffusion of Innovations. Submitted April 2006 to *American Journal of Physics (Physics Education Research Section)*.

*Henderson, C., & Dancy, M. (2006). Physics Faculty and Educational Researchers: Divergent Expectations as Barriers to the Diffusion of Innovations. Proceedings of the 2005 AAPT Physics Education Research Conference (Salt Lake City, UT).

Faculty aware of Problems and Solutions

PER and faculty agree on many problems

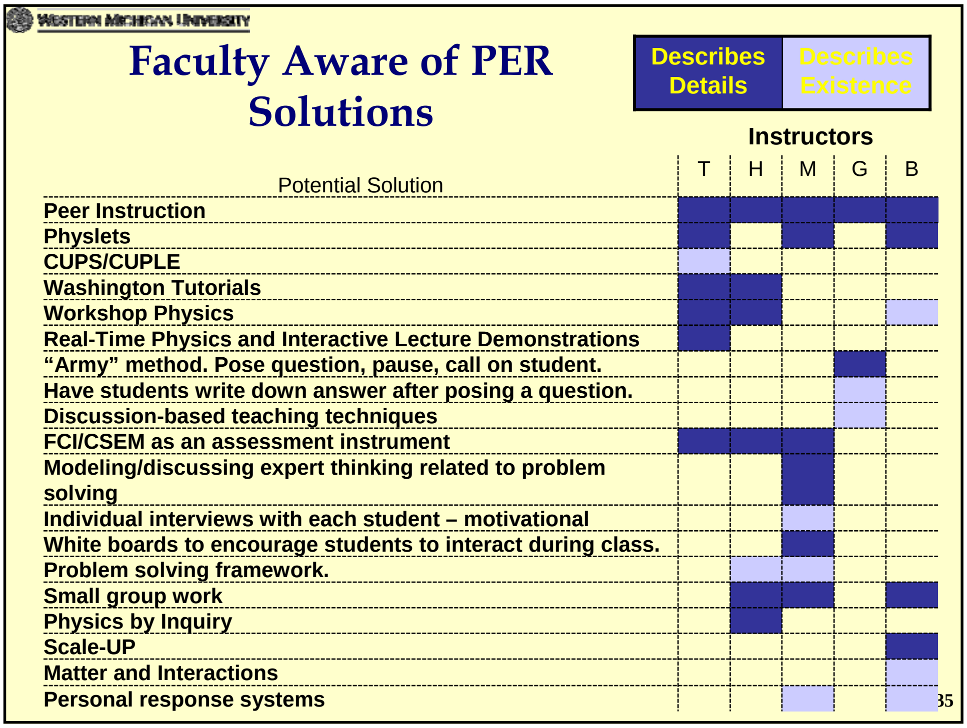
- **e.g., All five faculty stated (without prompting) that traditional lecture is largely ineffective.**

Faculty aware of many possible solutions

- **Knew names and basic practices of many PER curricula.**

PER and Faculty Agree on Many Problems

	Instructors				
Instructional Problem	T	H	M	G	B
Students don't get much from traditional lecture.	■	■	■	■	■
Different kinds of students learn differently.	■			■	■
Students have misconceptions that are not simple to change.	■	■		■	
Many students have poor problem solving skills		■	■	■	
Assessment difficulties – getting the right answer does not mean that a student understands			■		■
It is helpful to tailor explanations to individual students, but this is difficult/impossible in a large class		■			
Students have great difficulty learning the basic concepts of physics		■			

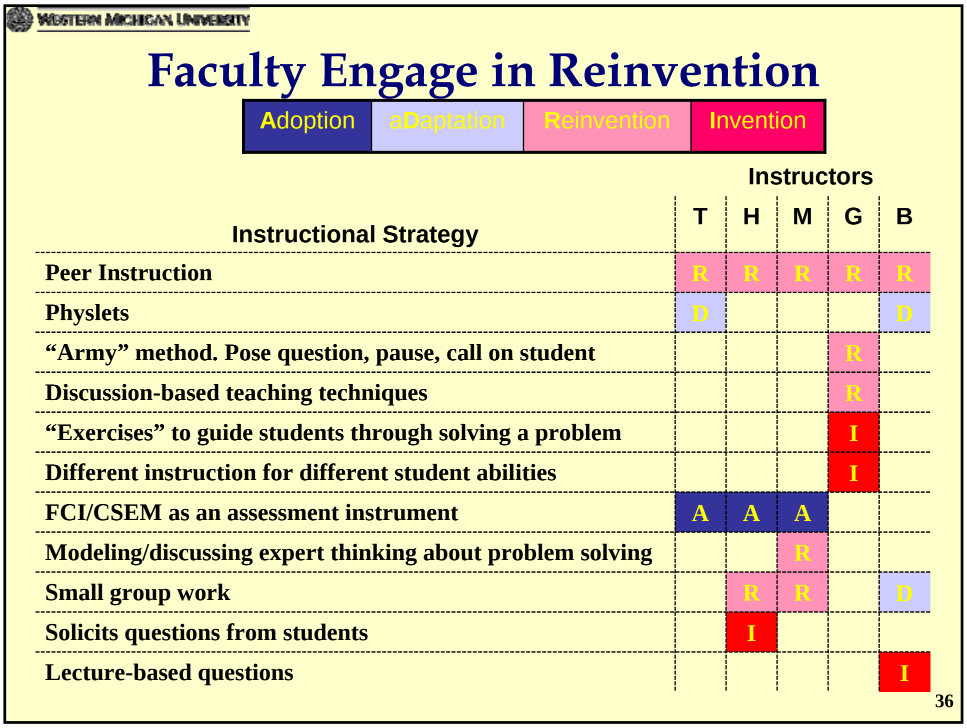


Western Michigan University

Faculty Aware of PER Solutions

■ Describes Details | □ Describes Existence

Potential Solution	T	H	M	G	B
	Instructors				
Peer Instruction	■	■	■	■	■
Physlets	■		■		■
CUPS/CUPLE	□				
Washington Tutorials	■	■			
Workshop Physics	■	■			□
Real-Time Physics and Interactive Lecture Demonstrations	■				
"Army" method. Pose question, pause, call on student.				■	
Have students write down answer after posing a question.				□	
Discussion-based teaching techniques				□	
FCI/CSEM as an assessment instrument	■	■	■		
Modeling/discussing expert thinking related to problem solving			■		
Individual interviews with each student – motivational			□		
White boards to encourage students to interact during class.			■		
Problem solving framework.		□	□		
Small group work		■	■		■
Physics by Inquiry		■			
Scale-UP					■
Matter and Interactions					□
Personal response systems			□		□



Western Michigan University

Faculty Engage in Reinvention

Adoption | a**D**aptation | **R**einvention | **I**nvention

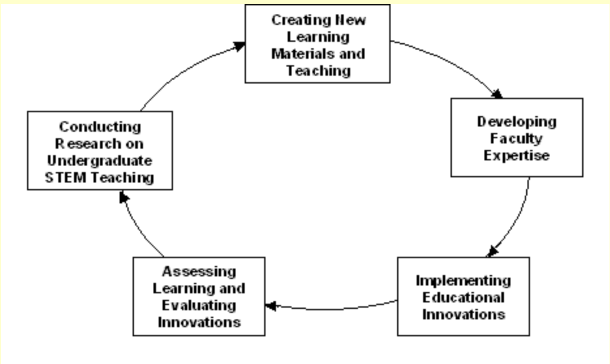
Instructional Strategy	T	H	M	G	B
	Instructors				
Peer Instruction	R	R	R	R	R
Physlets	D				D
"Army" method. Pose question, pause, call on student				R	
Discussion-based teaching techniques				R	
"Exercises" to guide students through solving a problem				I	
Different instruction for different student abilities				I	
FCI/CSEM as an assessment instrument	A	A	A		
Modeling/discussing expert thinking about problem solving			R		
Small group work		R	R		D
Solicits questions from students		I			
Lecture-based questions					I

Why Reinvention?

Faculty do not believe an externally developed curricula can match their unique style, preferences, skills, and teaching situation

- “M*any* [PER Curricula] *don’t transport very well out of the environment in which they were developed because they were developed for certain set of teachers in a certain educational environment with a certain set of students*.” (Terry)
- “*I mean a lot of things I won’t even bother trying because I know I’m not the right person to do it*.” (Harry)

PER Expects Adoption/Adaptation



Cyclic model for knowledge production and improvement of practice in undergraduate STEM education

From 2005 NSF-CCLI Solicitation

Divergent Expectations → Problems

From Faculty Perspective

- Each PER practitioner is selling a particular curricula and not interested in them or their students
- PER does not recognize/value faculty skill and experience

From PER Perspective

- Faculty are not interested in our work and, thus, must not care about teaching
- Faculty inappropriately modify our curricula

What do Faculty Want?

PER and faculty work together

- *"I've spent my life doing this* [teaching] *and part of my teaching is in fact to be aware of all of the things that are going on, but I want it to be useful and meaningful to that discourse."* (Terry)

PER to develop more theory than packaged curricula

- *"I have a good feel for the conditions under which [optical phenomena] occurs . . .I don't have an intellectual framework around which to organize innovations in teaching. . . . If I had a framework like that then I could answer my own questions [about teaching]."* (Harry)

PER to communicate openly/honestly

- "*It's really frustrating if somebody just falls behind a smokescreen and will start using jargon and will start talking about papers that you don't know what's in the paper.*" (Mary)

Summary – Some Incorrect Assumptions

About faculty:

- These faculty were aware of many problem with traditional instruction and many of the available PER instructional strategies.

About the change process:

- Change agents operate with adoption/adaptation in mind, but these faculty operated with reinvention/invention in mind
- Divergent expectations contributed to the lack of meaningful change in many cases

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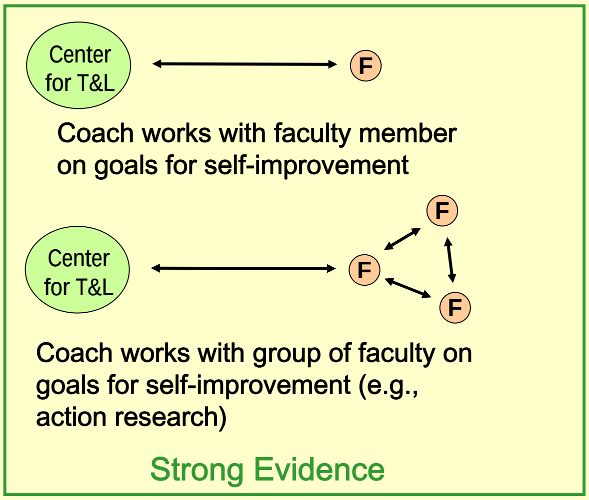
(focus on teachers)

Faculty-Directed Change Models

Interventions can be effective when they are*:

1. Collegial
2. Exist over an extended time
3. Focus on specific goals

No Evidence that this strategy can promote widespread change



Coach works with faculty member on goals for self-improvement

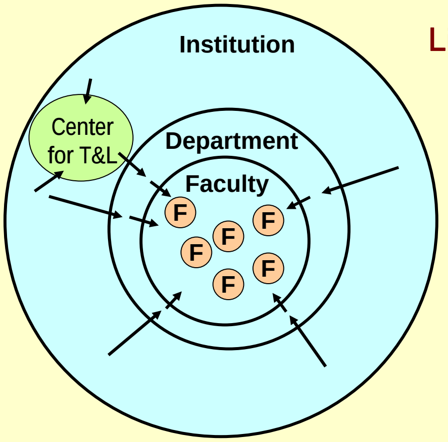
Coach works with group of faculty on goals for self-improvement (e.g., action research)

Strong Evidence

*Emerson & Mosteller, 2000

(focus on structures)

Top-Down Planned Change Models



Little or No Evidence

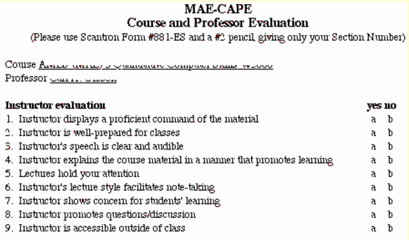
Significant evidence that institutional structures can prevent change, but no evidence that changing structures alone is enough to cause change.

Change institutional reward system to reward faculty for developing and using innovative instruction. Faculty change behavior because of this change in reward system.

Restrictive Structures

Institutions are set up for traditional instruction.

Physical Infrastructure



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

Course [illegible]
Professor [illegible]

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

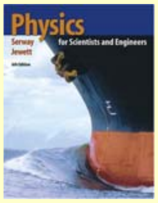
Institutional Expectations

Departmental Norms

Henderson, C. and Dancy, M. (submitted) Barriers to the Use of Research-Based Instructional Strategies: The Dual Role of Individual and Situational Characteristics. Submitted October 2006 to *Physical Review Special Topics: Physics Education Research*.

Dancy, M., & Henderson, C. (2005). Beyond the Individual Instructor: Systemic Constraints in the Implementation of Research-Informed Practices. Proceedings of the 2004 AAPT Physics Education Research Conference (Sacramento, CA).

Restrictive Structures



Content Coverage Expectations

Common 1st Semester Introductory Physics Topics

1. Vectors
2. Units
3. Motion in One Dimension
4. Motion in Two Dimensions
5. Newton's Laws
6. Work and Energy
7. Systems of Particles
8. Conservation of Momentum
9. Rotation
10. Static Equilibrium
11. Gravity
12. Elastic Properties of Solids
13. Mechanics of Fluids
14. Ideal Gas Law
15. First Law of Thermodynamics
16. Second Law of Thermodynamics
17. Oscillations
18. Waves on a String
19. Sound

For the New Teacher

Patricia Blanton, Column Editor

When Is a Good Day Teaching a Bad Thing?

Timothy F. Slater

Student Expectations

(the *hidden contract*)

(focus on structures)

Top-Down Planned Change Models

Problem:

Assumption of rational decision-making

“The individual’s choice to change is not often made based on a review of fact-based data; instead, people are found to consider the implication of the change on the future of the division (political), or based on intuition, or how this change relates to emotional commitments they have made.” (Kezar, 2001, p. 122)

Change models based on rational decision-making that work in business settings may not work well in academic settings due to the unique characteristics of higher education (e.g., disciplinary cultures outside institutions, outputs are ambiguously defined and difficult to measure). (Kezar, 2001)

A. J. Kezar, "Understanding and facilitating organizational change in the 21st century: Recent research and conceptualizations," ASHE-ERIC Higher Education Report. 28 (4), 1-162 (2001). http://dx.doi.org/10.1002/aehe.2804

Strengths and Weaknesses

	Curriculum	Teachers	Structures
Strengths	-Developing good curricula is beyond the skills and available time of most faculty	-Treats faculty as professionals -Customization of curricula is typically necessary -Much implicit knowledge is used in teaching and is difficult to transmit	-Traditional structures are barriers to change -Structural change is probably needed for lasting impact
Weaknesses	-Faculty may use curricula inappropriately (or not at all) -Most effective curricula conflict with traditional structures	-Faculty working in isolation may reinvent the wheel -Traditional structures do not reward faculty for a focus on teaching	-Faculty may subvert structural changes -External structures (e.g., disciplinary cultures) strongly shape faculty work

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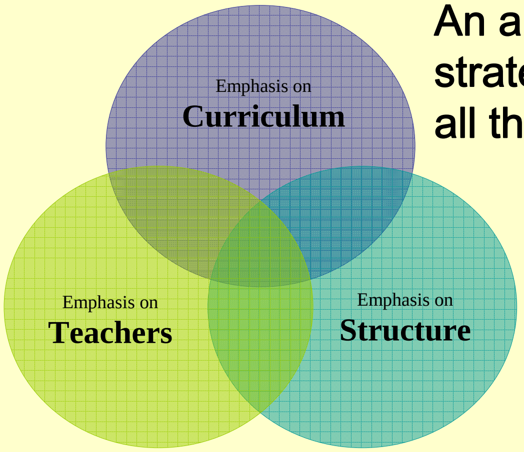
Strengths and Weaknesses

Think individually, then discuss with group.

1. Do these strengths and weaknesses fit with your experiences?
2. Are there other strengths and weaknesses that you would include?

Conclusion



An appropriate change strategy should address all three aspects.

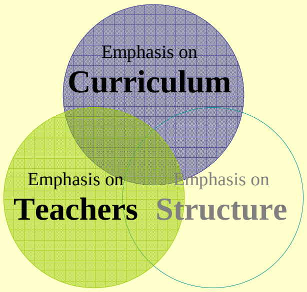
It should be explicit about:

•Which aspects are currently aligned with the proposed change and which will provide barriers.

•How to eliminate or work around the barriers.

Many change strategies focus on only one aspect and do not consider the others.

A Promising Approach:
Promote Teacher Customization



Explicitly accept current structural constraints, but provide teachers assistance in customizing research-based techniques to their own unique situations.

Examples:

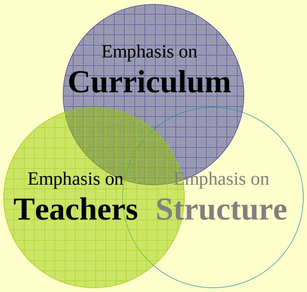
•Weizmann Institute (Israel) – Ongoing teacher workshops focused on promoting student self-monitoring in problem solving

E. Yerushalmi and B. Eylon, "Teachers' Approaches To Promoting Self-Monitoring In Physics Problem Solving By Their Students," Proceedings of the International GIREP Conference on Physics Teacher Education beyond 2000. (2001).

•University of Maryland – Open-source tutorials integrated with professional development materials

http://www2.physics.umd.edu/~elby/CCLI/index.html

Another Promising Approach: Co-Teaching



Emphasis on **Curriculum**

Emphasis on **Teachers**

Emphasis on **Structure**

An experienced teacher structures a course and teaches it jointly with a novice teacher. Novice teacher develops significant implicit knowledge about how to work effectively within the current structural constraints using a particular instructional style.

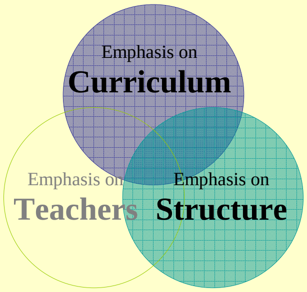
Examples:

•Western Michigan University

-Beach, A., Henderson, C., and Famiano, M. (Accepted) “Co-Teaching as a Faculty Development Model”, *To Improve the Academy*.

-Henderson, C., Beach, A., and Famiano, M. (Submitted) “Promoting Instructional Change via Co-Teaching”, Submitted August 2006 to *American Journal of Physics (Physics Education Research Section).*

Another Promising Approach: Department-Level Structural Change



Emphasis on **Curriculum**

Emphasis on **Teachers**

Emphasis on **Structure**

Change departmental structures and curriculum. Ensure that changes do not conflict deeply with faculty or disciplinary beliefs and that it is easier for faculty to go along with changes than to teach traditionally.

Example:

•University of Illinois, Urbana-Champaign – Recreating university physics to align with educational research

D. K. Campbell, C. M. Elliot and G. E. Gladding, "Parallel Parking an Aircraft Carrier: Revising the Calculus-Based Introductory Physics Sequence at Illinois," Forum on Education Newsletter of the American Physical Society. (Summer), 9-11 (1997). [http://www.aps.org/units/fed/newsletters/aug97/index.cfm#campbell]

Revisiting Change Models

Revisit your group change model

1. **Where does it fit on Tool 1: Adoption-Invention Continuum?**
2. **How many of the three foci (i.e., Tool 2) does it address?**
3. **How can your model be modified to focus on at least 2 of the three foci while explicitly accepting the third? Is it possible for a model to focus on changing all three?**

The End