

**“Build it and they will come”,
and other myths about
science education reform**

Charles Henderson
Western Michigan University
<http://homepages.wmich.edu/~chenders/>

Melissa H. Dancy
University of North Carolina - Charlotte

Abstract

Reform-minded science educators have focused much energy developing high quality curricular materials with the expectation that science instructors will recognize the superiority of these materials and adopt them. Adoption is assumed to be an unproblematic process and the expectation is that the number of faculty using these materials will naturally expand, eventually leading to a critical mass of instructors teaching in a fundamentally new way. Unfortunately, current and historical evidence does not indicate promise for this approach to reform. This talk will focus on the importance of understanding college science instructors and the contexts within which they work when planning instructional reforms. Specific examples will be given from several empirical studies of college physics faculty.

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.

3

Found Solutions!

Replace lecture with hands-on, inquiry based activities.
Encourage and support cooperative learning.
Explicitly teach problem solving.



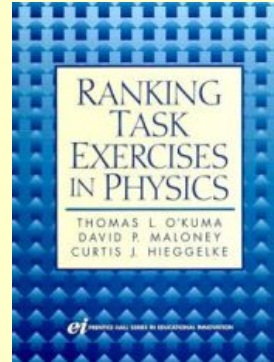
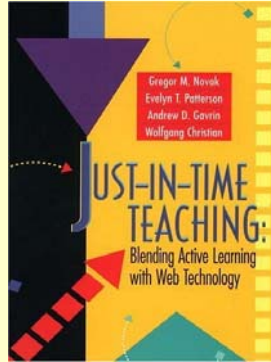
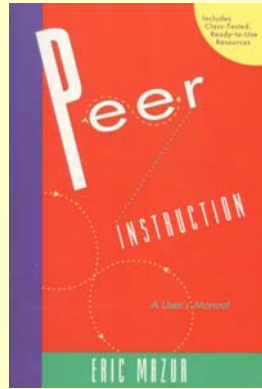
Traditional Physics class at University of Rochester



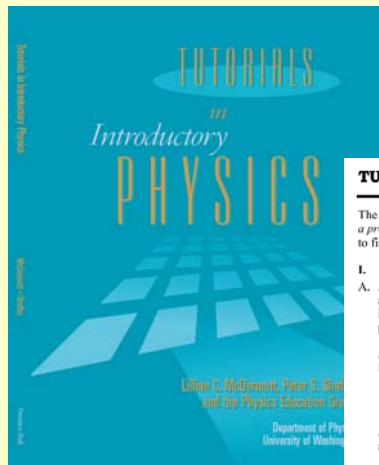
SCALE-UP Physics class at Clemson University

4

Classroom-Tested, Ready-to-Use Materials and Strategies



Research-Based Tutorials



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.

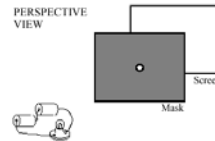
I. Light

- 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 you see on the screen. Explain.

Perform the experiments and check your predictions. If any of your predictions were incorrect, resolve the inconsistency.

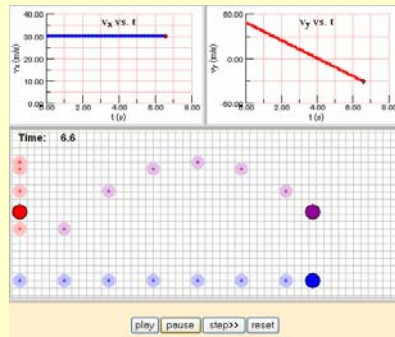


Technology



Classroom Response Systems

Java Applets



Research-Based Nationally-Normed Assessments

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, although not explicit, we do have a number of other conditions you have indicated. None of these tests are to be incorporated into a web-based system delivery system without adequate security to prevent printing or other unauthorized access by students. Contact the author in those cases.

If you have any questions, please contact phone 919-515-5236 or e-mail John.D.Bohrer@ncsu.edu (The Physics Department)

TC2 is Bohrer's Test of Understanding Graphs in Electricity is available in English, Spanish, French, German, Finnish, and Portuguese by sending e-mail to John.D.Bohrer@ncsu.edu. A discussion of the test is in S. Bohrer, "Creating a Student's Test of Understanding Graphs in Electricity" *Am. J. Phys.* 65, 750-762 (1994).

Davidoff & Bohrer's Test of Measurement Uncertainty Concept can be requested from John.D.Bohrer@ncsu.edu

SEMI Chabay & Sherwood's Semi-Conceptual Assessment Strategy to assess that students have about the most basic and central concepts of the calculus-based introductory SEM courses. It is comprehensive, covering topics from the Coulomb force law to magnetic induction, but nothing related beyond it. It is not common for the sake of content not to get far. It has been used by various instructors in various settings and has been judged an appropriate and fair assessment of introductory SEM by physics experienced in teaching SEM at various levels. It is not aimed at any particular curriculum but is consistent with those elements common to all calculus-based introductory courses. The PDF and the corresponding test items special grading was designed to make a more accurate assessment, and a spreadsheet is available from <http://www.phy.ncsu.edu/~jchabay/semconcepts> but please note these adjustments. Details about the test can be found in L. Ding, S. Chabay, in "Research and Practice: <http://www.phy.ncsu.edu/~jchabay/semconcepts>" *Phys. Rev. ST Phys. Educ. Res.* 5, 010101 (2009)

CEEM The Maloney, van Heesbeen, Haggard, and O'Keefe Conceptual Theory in Electricity and Magnetism (along with a separate test on electricity and another on magnetism) is available from <http://www.phy.ncsu.edu>. More info can be found at the Two-Year College Physics <http://www.phy.ncsu.edu/~maloney> and from B. Maloney, T. O'Keefe, C. Haggard, and A. Van Heesbeen, "Research and Practice: <http://www.phy.ncsu.edu/~maloney>" *Am. J. Phys.* 69, 812 (2001)

SEEM Maloney and Wilson have developed an E & M test that is available by contacting JEFF Maloney at maloney@phy.ncsu.edu

DSPECT L.J. D'Agostino & Bohrer's test of simple resistive electrical circuit concepts is available in English, Spanish, and French by sending a request to John.D.Bohrer@ncsu.edu. More details are in P. Haggard, and S. Bohrer, "Physics: <http://www.phy.ncsu.edu/~maloney>" *Am. J. Phys.* 75, 361-375 (2007)

ECCE The Electric Circuits Conceptual Evaluation is available from the Workshop Physics <http://www.phy.ncsu.edu>. You'll need a password.

EMCT Bohrer has created an instrument to assess learning in upper division E & M courses, the Electromagnetic Concept Inventory. Contact him at John.D.Bohrer@ncsu.edu or visit the www.phy.ncsu.edu

RSMT Two parallel versions of Albert A. Bohrer's Real and Pseudo-Test are available by sending e-mail to John.D.Bohrer@ncsu.edu

FCI The Force Concept Inventory by Heston, Halla, Minner, and Hossen is available from <http://www.phy.ncsu.edu/~fcicomp/FCI.asp>. You'll need to request a password to open the file. Several articles describing the test are at the above page.

MP7 The Modern Physics Test by Heston and Wells is available from <http://www.phy.ncsu.edu/~fcicomp/MP7.asp>. You'll need a password to open the file. An article describing the test is available at above page.

PMCE The Force and Motion Conceptual Evaluation was developed by Eric Thorngren & David Sokoloff. Information can be seen at: Thorngren, and Sokoloff, "Assessing Student Learning of Physics: The Force and Motion Conceptual Evaluation and the Evaluation of Active Learning Laboratory and Lecture Concept" *Am. J. Phys.* 66, Issue 4, 330-332 (1998).

MCCE The Heat and Temperature Conceptual Evaluation is available from the Workshop Physics <http://www.phy.ncsu.edu>. You'll need a password.

TC1 Maloff created an upper division engineering thermodynamics concept test. Contact John.D.Bohrer@ncsu.edu or visit the www.phy.ncsu.edu

Lightened Optics Bohrer has a test a light & optics test in the works from the Workshop Physics <http://www.phy.ncsu.edu>

MC: Dan has also working on a general optics test.

EC3 The Energy Concepts Survey looks at concepts in energy and momentum, contact Chankhalidha Singh, 309 Allen Hall, Department of Physics, University of Pittsburgh, PA 15260 chankhalidha@pitt.edu 412-624-0945

QMCT The Quantum Mechanics Visualization Instrument by Robert is available at <http://www.phy.ncsu.edu>

ASST John Zetlin and others have developed an astronomy dependent test. It is available from Mike Zetlin, zsetlin@ncsu.edu. (You can copy a directly from a <http://www.phy.ncsu.edu/~zsetlin> file.) A collection of classroom assessment instruments can be found <http://www.phy.ncsu.edu/~zsetlin>

LCPT Richard L. Millis has created the Lower Physics Concept Inventory, which is available from us.

WCT Tom Blundell and Ben Brundell have written a Waves Concept Inventory appropriate for upper division students.

The Student & Public <http://www.phy.ncsu.edu/~bohrer> is available on the web <http://www.phy.ncsu.edu/~bohrer> giving many details on the Public & Student Learning Style Model is also available.

Lorenson's Theorem Test of Scientific Reasoning is available from Anthony Lorenson by John.D.Bohrer@ncsu.edu. This already has already been used.

MDCE The Mathematical Modeling Conceptual Evaluation is available from the Workshop Physics <http://www.phy.ncsu.edu>. You'll need a password.

MPET The Modified Preceptor Test can be found at <http://www.phy.ncsu.edu/~bohrer/MPET.html>

VSAS Views About Science Survey is available from <http://www.phy.ncsu.edu/~bohrer/VSAS.html>. You'll need to request a password to open the file.

CLAS Colorado Learning Attitudes about Science Survey and a scoring spreadsheet are available from <http://CLAS2010.umd.edu>. Additional information can be found in W. K. Adams, K. E. Perkins, N. S. Podolsky, M. DeBoer, N. D. Fieldhouse, and C. B. Wynn, "The assessment for assessing student beliefs about science and learning physics: The Colorado Learning Attitudes about Science Survey" *Phys. Rev. ST Phys. Educ. Res.* 2, 010001 (2006)

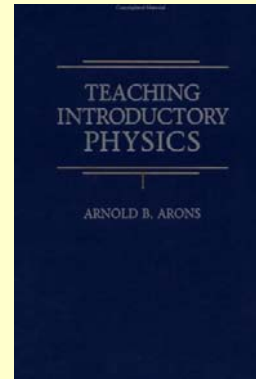
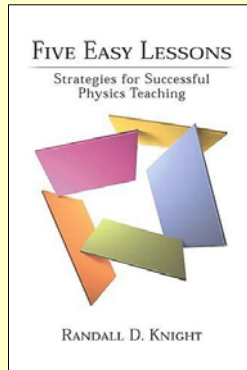
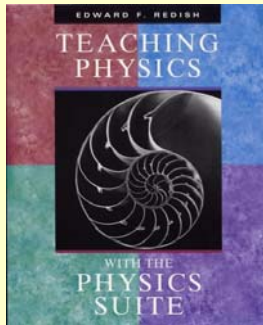
Two tests related to collaborative teams are available by contacting John.D.Bohrer@ncsu.edu. He <http://www.phy.ncsu.edu> has more information.

Some key findings test designers get for developing additional tests depends on viewing the findings agencies that the tests are useful, all of us would really appreciate hearing about how you are utilizing them. The NCST 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 agencies. P11007340, P11000009, DCE-0752313, DCE-0714246, DCE054250, EEC-0601067

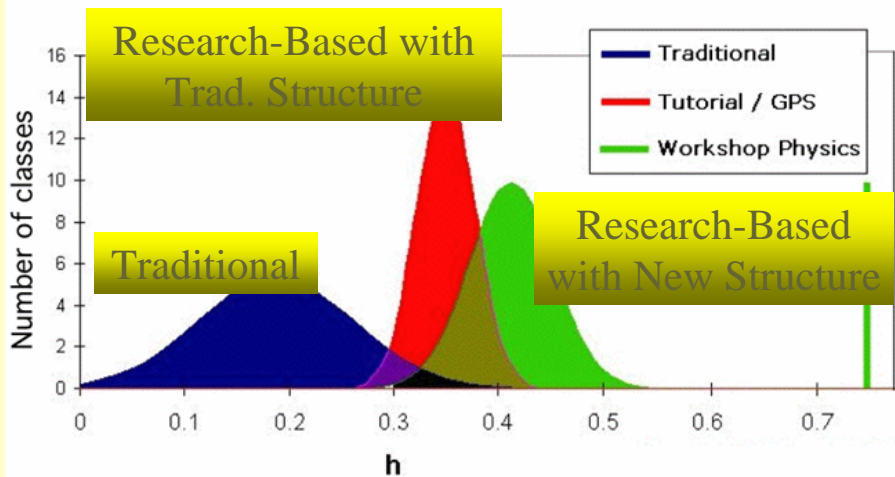
From: <http://www.ncsu.edu/per/TestInfo.html>



Books that summarize it all!



Evidence that Research-Based Reform Works!



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).

What's the problem?

Good research and development is only valuable if it is actually used.

Products of physics education appear to be only marginally incorporated in physics classrooms.

Why is research-based reform so slow and difficult?



A Very Brief History of Change in

Discourse on Reform of Science Education

1900's – Progressive Era

2000's – Structures are Important

Saturday, April 30, 1904

Good Ideas Travel Naturally

Modern field of Science Education Develops Science educators such as William James, Charles Ehot, and John Dewey argue against traditional science teaching, based on reading, recitation, and memorization. Schooling should be understood children's

Monday, September 14, 1959

Teacher-Proof Curricula Needed

A significant expansion of the field of science education. The U.S. began and teaching practice were self-explanatory and follo self-implementing. Once imp school

Tuesday, November 15, 1994

Teachers are Important

Although the basic one-way transfer model of educational change remained in place, it was augmented by other fields. Communication Diffusion of Innovations exemplified in the work of Everett Rogers. Identified conditions and processes for change. Cognitive Psychology. Cognitive learning theories had

1970's – Teachers are Important

Teachers are Partners

Many national reports in mid 1980's: A Nation at Risk, the Neal Report. Similar to earlier reforms, focus less on terms and facts that students memorize and more on students' conceptual understanding and their ability to apply knowledge in novel contexts. In addition, also focus on the importance of developing a scientifically literate population in addition to preparing the next generation of scientists and engineers. Significant

The Chronicle

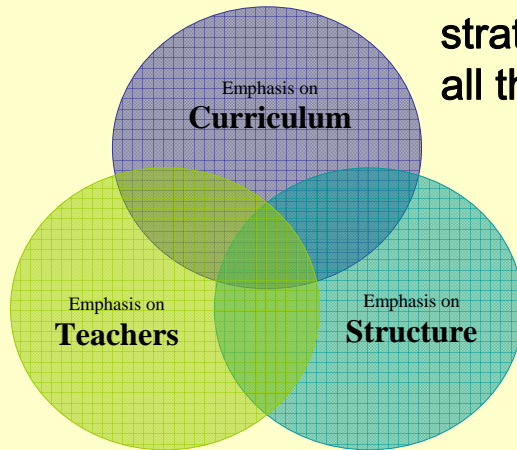
Monday, March 19, 2004

Structural Change is Needed

Pockets of change have been produced, but rewards and risks of instructional changes are often not well accepted that faculty have beliefs and values about teaching and learning as well as prior experiences that affect whether they decide to make instructional changes and, if so, how those changes are conceived and implemented. The overall problem is a systemic one.

1990's – Standards Era

Three Aspects of Educational Change

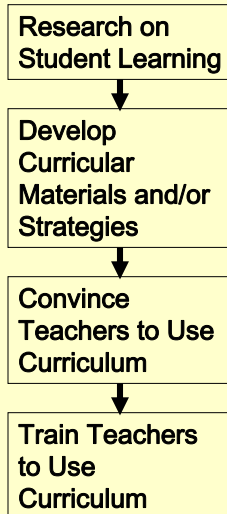


An appropriate change strategy should address all three aspects.

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.

Emphasis on Curriculum The Dissemination Model



This is the currently the most widely used model by educational researchers – often implicit – and has been since at least the 1950's.

Examples:

- Curricular materials and strategies disseminated by workshops, talks, papers, teacher guides, etc.

What Does the Dissemination Model Look Like?



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



Traditional Physics class at University of Rochester

Emphasis on Curriculum The Dissemination Model

Problems

Often Ignores Teacher Characteristics

- Assumes that fidelity of Implementation is desirable and possible.
- Makes incorrect assumptions about teachers.

Often Ignores Structural Characteristics

- Situational characteristics typically strongly favor traditional instruction
- It is assumed that if the developer can overcome situational factors, so can other instructors.

Myth #1: Curriculum is the most important aspect of educational change.

Reality: Curriculum is necessary, but not sufficient.

Emphasis on Teachers The Action Research Model

Continuous
Cycles of*:

Problem
Formulation

Data Collection

Data Analysis

Reporting of
Results

Action Planning

Main focus is on teacher ideas and teacher-directed inquiry, although some structural change is typically required since such inquiry is an unusual activity in most contexts.

Examples:

- Scholarship of Teaching and Learning
- Faculty Learning Communities
- Lesson Study

Problems:

- Often ignores strongly traditional structures (e.g., time spent on action research may not be recognized in tenure decisions)
- Often ignores curriculum -- without appropriate introduction to existing work, teachers may reinvent rather than build on good products.

Emphasis on Structure The Structural Change Model

This model is not well known to educational researchers. It is often used by politicians at K-12 level. In higher education changes can be made at the accrediting level, the institutional level, or the departmental level.

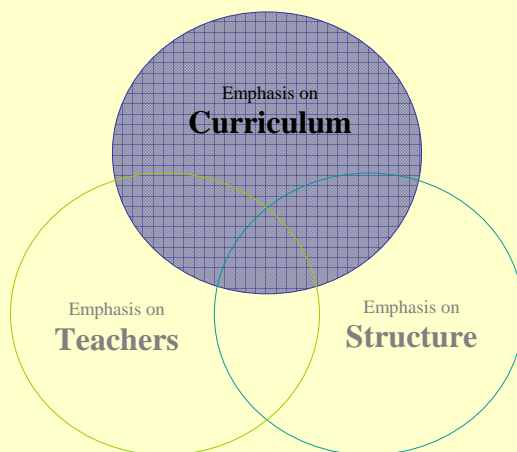
Examples:

- Engineering Education (ABET)
- Increasing institutional value on “good teaching” or recognition for scholarly work in teaching and learning
- Departmental changes in infrastructure to support “good” teaching – e.g., SCALE-UP room, clicker technology.

Problems:

- Often ignores teachers -- Teachers may subvert structural changes
- Often ignores curriculum -- Without appropriate introduction to existing work, faculty may reinvent rather than build on good products.

Three Aspects of Educational Change



An appropriate change strategy should address all three aspects.

Most strategies address only one – curriculum.

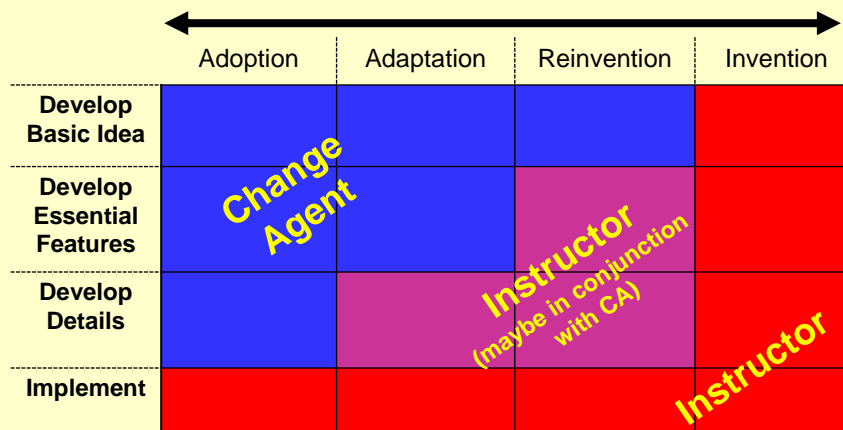
Myth #2: Curriculum should be designed to be used with fidelity

Problems:

- **Requires transfer of significant implicit knowledge**
fidelity only possible in an apprenticeship-based dissemination model
- **This is not what faculty want nor is it how they operate**
faculty want and do customize curricula.
- **Customization is typically necessary due to contextual differences**
- **Expecting fidelity is insulting to faculty because it devalues their knowledge and experience**

21

Adoption-Invention Continuum: Possible Relationships Between Change Agents and Faculty



22

Myth #3: Teachers teach traditionally because they have transmissionist learning theories

Problems:

- **Not true**
faculty interviewed have rejected transmissionist learning theories and indicate that they teach in a transmissionist way due to situational constraints
- **Insulting**
typical professional development starts by attacking transmissionist instruction and learning theories

Myth #4: Situational factors can be overcome - My own teaching is proof by example.

Problems:

- **Situational factors (e.g., large classes, content coverage expectations) do not usually prevent many recommended teaching styles**
they just make them more difficult for faculty to enact them
- **Situational factors do actually prevent some changes**
for example, a course with no grades

Empirical Support

Three Examples from Three Studies:

Example #1: Instructors may reinvent innovations based on minimal understanding.

Example #2: Faculty do not have transmissionist learning theories.

Example #3: Instructor attributes are often not the dominant factor preventing use of research-based instruction -- situational factors are.

Example 1: Instructors may reinvent innovations based on minimal understanding.

What: Semester-long case study of one physics instructor as he attempted to change his instruction

Publications:

•Henderson, C. (2005). [The challenges of instructional change under the best of circumstances: A case study of one college physics instructor](#). *American Journal of Physics (Physics Education Research Section)*, 73 (8), 778-786.

Assumptions of Typical Dissemination Strategies

1. Faculty first learn a lot about the innovation.
 - How it works
 - Why it works
2. Faculty then make a rational, informed decision
3. Faculty use the innovation “as is” first and then (maybe) modify for future use.

The Case - Dr. Holt

- Tenured, experienced, research university faculty
- Planning to change his instruction to improve student learning

Dr. Holt had Characteristics Necessary for Successful Change

- Dissatisfied with outcomes of previous instruction
- Learned about research-based alternatives
- Departmental Support

Data Sources

- **Weekly interviews** (15 interviews, 20-60 minutes each)
- **Daily class observations** (62 of 67 class days observed)
- **Materials distributed to students** (syllabus, exams, HW)

Example from Dr. Holt: Use of White Board Group Work

- Dr. Holt was dissatisfied with the level of student engagement in his course.
- He had heard about using white boards to promote small group discussion during class.
- He decided to implement use of white boards based only on this awareness knowledge. He developed implementation details on his own.
- Lack of knowledge led to problems:
 - **Groups were assigned, but assignments not enforced.**
 - **Student groups were not asked to share their solutions with other groups or with the class.**
 - **Student group work was not graded in any way.**
- **Many students were not engaged in group work.**

Important Differences Between Dr. Holt's Change Process and Typical Developer Assumptions

- Implementation decisions were made based on minimal knowledge.
Awareness knowledge, not knowledge of principles or details
- All innovations from external sources were changed significantly.
Ex: White board group work, problem solving procedure
- Innovations did not all come from external sources.
Ex: Reading Questions

Example #2: Faculty do not have transmissionist learning theories.

What: Artifact-based structured interviews with 6 randomly-selected research university faculty.

Publications:

- Henderson, C., Yerushalmi, E., Kuo, V., Heller, P., & Heller, K. (2004). [Grading Student Problem Solutions: The Challenge of Sending a Consistent Message](#), *American Journal of Physics*, 72, 164-169.
- Yerushalmi, E., Henderson, C., Heller, K., & Heller, P., 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*.
- Henderson, C., Yerushalmi, E., Heller, K., & Heller, P., Kuo, V. (accepted). [Physics Faculty Beliefs and Values about the Teaching and Learning of Problem Solving Part II: Procedures for Measurement and Analysis](#), *Physical Review Special Topics: Physics Education Research*.

Interview Structure

1½ hour open-ended interview guided by instructional artifacts:

- 3 Instructor solutions
- 5 Student solutions
- 4 Problem types

All artifacts were based on **one problem** -- instructors were given the problem and asked to solve it on their own before the interview.

Example: Instructor Solution Artifacts and Interview Questions

- Q1:** In what situations are your students provided with examples of solved problems? Why?
- Q2:** How would you like your students to use the solved examples you give them?
- Q3:** How do these instructor solutions compare to your solutions?

Instructor solution I

The tension does no work
Conservation of energy between point A and B

$$mv_A^2/2 = mgh$$

$$v_B^2 = 2gh$$

At point A, Newton's 2nd Law gives us:

$$\vec{F} = m\vec{a}$$

$$T = w = mv_A^2/R$$

$$T = 16N + 2 \cdot 16N \cdot 25J / 65J = \boxed{1232N}$$

Instructor solution II

For a massless string $F_{net} = T_1 = T_2 = T_{tension}$ at bottom

Step 1) Find v_A needed to reach h

Conservation of energy for the stone-earth system since no external forces.

$$E_A = E_B$$

$$PE_{stone,A} + KE_{stone,A} = PE_{stone,B} + KE_{stone,B}$$

$$mgh + mv_A^2/2 = mgh + mv_B^2/2$$

Using 1 from above:

$$v_A^2 = 2gh$$

Step 2) Find v_B needed to have v_A at release

Conservation of energy for the stone-earth system since T is circular path, T does no work.

$$E_A = E_B$$

$$PE_{stone,A} + KE_{stone,A} = PE_{stone,B} + KE_{stone,B}$$

$$mgh + mv_A^2/2 = mgh + mv_B^2/2$$

Using 1 from above:

$$v_B^2 = 2gh$$

Step 3) Find T_1 , tension at bottom, needed for stone to have v_B at bottom

To make the forces to velocity we can look at the radial component, and use Av^2/R .

Using v_B from above:

$$T_1 = w + mgh/R$$

$$T_1 = w + 2w = 3w = 18 + 2 \cdot 18 = 54N = \boxed{1232N}$$

T_1 equals F , the force my hand exerts for a massless string

Instructor solution III

Approach:

I need to find F_{net} force exerted by me. I know one path is straight and level and v_A velocity at top

1) For a massless string $F_{net} = T_1 = T_2 = T_{tension}$ at bottom

2) I can relate T_1 to v_A (velocity at bottom) using the radial component of $\sum \vec{F} = m\vec{a}$ and radial acceleration Av^2/R , since stone is in circular path

3) I can relate v_A to v_B using either 1) energy, 2) Conservation and Kinematics

4) I can apply work energy theorem for stone. Path has 2 parts: linear - circular, starts and ends interacts with stone. vertical - vertical, starts interacts with stone. In both parts the only force that does work is weight, since in first part hand is not moving so $\vec{F}_{hand} \cdot \vec{v}_{stone}$ does no work.

5) I can apply work energy theorem for stone. Path has 2 parts: linear - circular, starts and ends interacts with stone. vertical - vertical, starts interacts with stone. In both parts the only force that does work is weight, since in first part hand is not moving so $\vec{F}_{hand} \cdot \vec{v}_{stone}$ does no work.

6) I can relate T_1 to v_A

7) I can relate T_1 to v_B

8) I can relate T_1 to v_B

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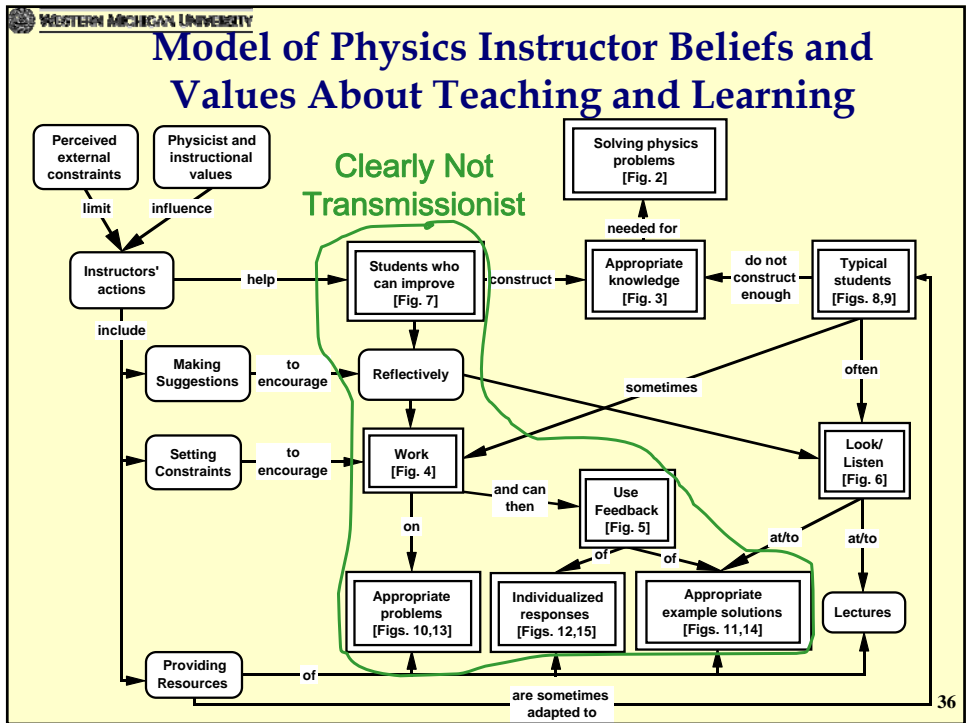
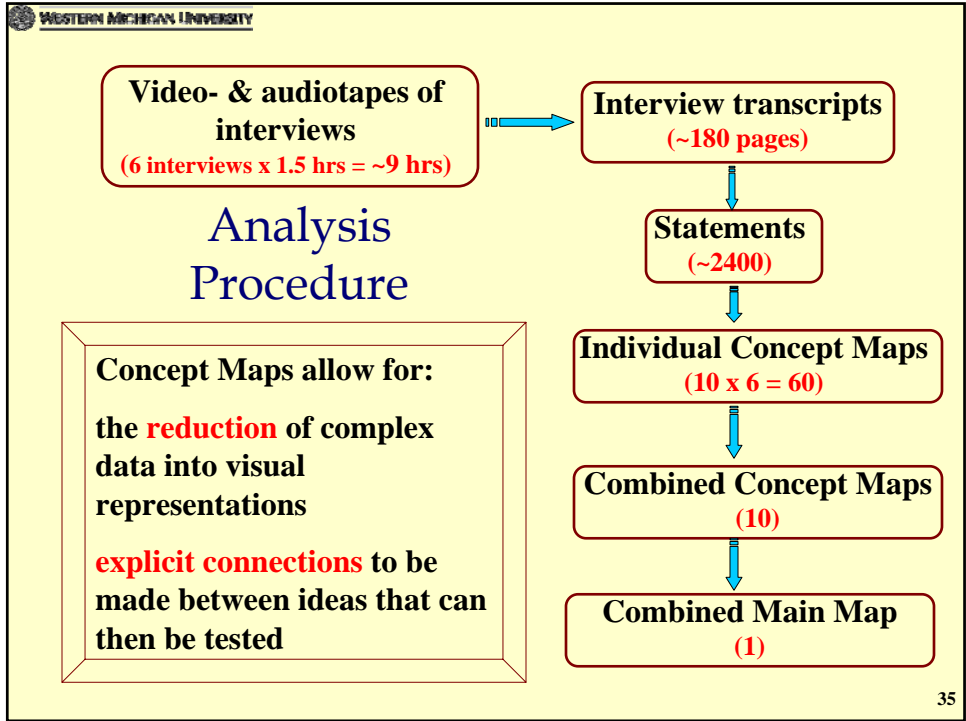
96) I can relate T_1 to v_B

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100) I can relate T_1 to v_B



Example #3: Instructor attributes are often not the dominant factor preventing use of research-based instruction -- situational factors are.

What: Interviews with 5 likely users of educational research

Publications:

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)*.

“Best Case” Faculty Project

Interviews with five physics faculty

- **4 institutions** (Research, Regional, Liberal Arts)
- **Senior and tenured**
- **Dedicated and highly regarded teachers**

In theory, this group should be likely to incorporate research-based methods

Asked about

- **Current practice**
- **Instructional Goals**
- **Beliefs**
- **Experiences with change**
- **Experiences with education research(ers)**

Findings

In general instructors...

- Saw a need for change
- Knew about alternatives
- Had tried or seriously considered many of the alternatives
- Taught mostly traditionally

Blamed restrictive situational factors for lack of change

Self-Identified Restrictive Situational Factors

Institutions are set up for traditional instruction.



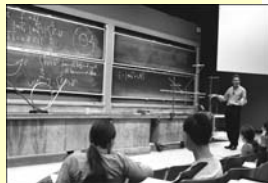
Physical Infrastructure

MAE-CAPE
Course and Professor Evaluation
 (Please use Scantron Form #88 1-ES and a #2 pencil, giving only your Section Number)

COURSE: _____
 PROFESSOR: _____

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

Departmental Norms



Institutional Expectations

Self-Identified Restrictive Situational Factors



Content Coverage Expectations

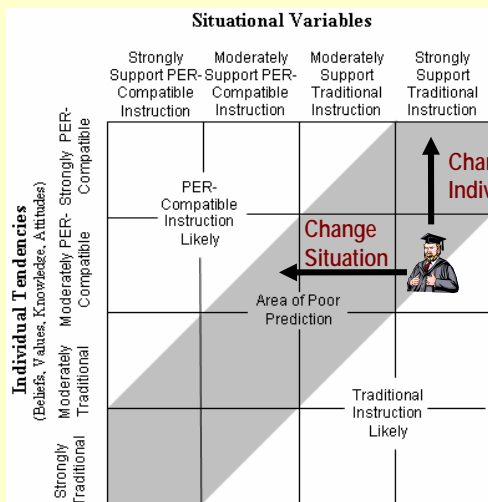
Common 1st Semester Introductory Physics Topics

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



Student Expectations (the hidden contract)

Role of Situational Factors



Promoting change in individual faculty is not enough to promote widespread change given the current strongly traditional situational variables

Model for predicting behavior based on beliefs and context adapted from L. G. Warner and M. L. DeFleur, "Attitude as an interactional concept: Social constraint and social distance as intervening variables between attitude and action," *American Sociological Review* 34 (2), 153-169 (1969).

Summary

Educational researchers have made significant progress in:

- Understanding Student Learning
- Designing effective curriculum based on this understanding

This emphasis on curriculum has:

1. not produced widespread change
2. led to several myths that minimize focus on the important areas of **teacher** and **situation**

Summary - Myths

Myth #1: Curriculum is the most important aspect of educational change.

Reality: Curriculum is necessary, but not sufficient.

Myth #2: Curriculum should be designed to be used with fidelity

Reality: Fidelity is not practical and does not match with faculty expectations.

Myth #3: Teachers teach traditionally because they have transmissionist learning theories

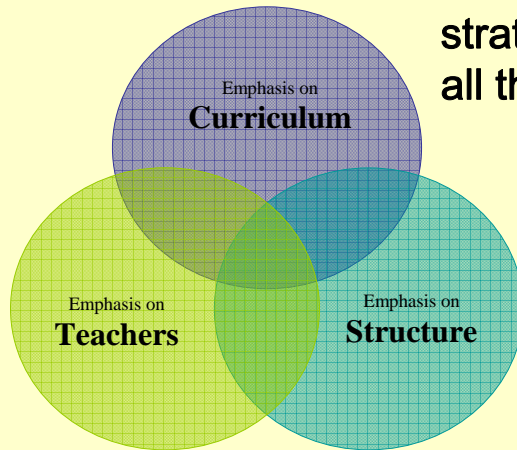
Reality: Traditional teaching results from a complicated interaction between teacher and situational characteristics.

Myth #4: Situational factors can be overcome – my own teaching is proof by example.

Reality: With strong enough teacher characteristics many situational barriers can be overcome, yet such changes require significant teacher effort and are not likely to be maintained.

Implications

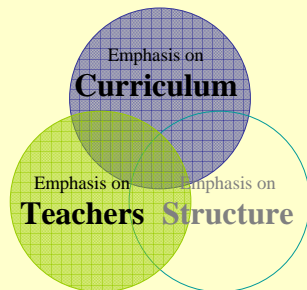
An appropriate change strategy should address all three aspects.



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.

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:

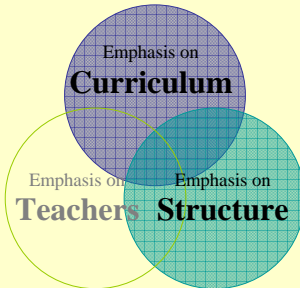
- Weizmann Institute (Israel) – Ongoing teacher workshops focused on promoting student self-monitoring in problem solving

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/CCL/index.html>

Another Promising Approach: Department-Level Structural Change



Change departmental structures and curriculum. Ensure that changes do not conflict deeply with faculty 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>]

The End

Questions/Comments

I will post a copy of this talk on my web page:
<http://homepages.wmich.edu/~chenders/>