The Challenges of Spreading and Sustaining Research-Based Instruction in Undergraduate STEM

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Outline

• Development and Dissemination Change Model

• Impact of Development and Dissemination (D&D)
  – Typical D&D is good at promoting awareness and interest, but bad at supporting successful use
  – Communicating about innovations is difficult
  – Faculty perceptions of innovations are different at different stages in the innovation-decision process

• Improving Development and Dissemination
Development and Dissemination
Change Model

D&D
The Development and Dissemination Change Model

• New instructional strategies developed and tested by ‘experts’.
• Strategies are then widely scattered (talks, workshops, publications) in the hopes that they will take root.

• Communication is in one direction.
Physics has a History of D&D

Research-Based Instructional Strategies
for college-level introductory quantitative physics

UMN Online archive of context-rich problems:
http://groups.physics.umn.edu/physed
General Features of Dissemination
(within physics)

Talks – Papers – Workshops – Books

1) Generally done by the curriculum developers.
2) Aimed at changing individual instructors.
3) Transmission-oriented with five 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...)
   5. Often implementation of strategy is supported with curricular materials, books, etc.
An Example

Confessions of a converted lecturer

Mazur has given over 301 talks about Peer Instruction (Mazur, 2009, Winter AAPT).

From: http://mazur-www.harvard.edu/
Significant Materials Available

• 253 page book with detailed implementation recommendations and disk with ready-to-go materials:
  – In-class questions
  – Reading quizzes
  – Exam questions

• Publisher has distributed book for free to large numbers of US physics faculty.*
  – 18,700 copies shipped since 1996
  – 12,700 free

*From Mazur, 2009 AAPT Winter Meeting
Impact of Development and Dissemination on Physics Faculty
Data Collection

Web Survey

– Administered by American Institute of Physics Statistical Research Center, Fall 2008

– Random sample:
  • 1) two year colleges
  • 2) four year colleges with a physics B.A.
  • 3) four year colleges with a physics graduate degree

– 722 useable responses (response rate 50.3%)

– Questions about knowledge and use of 24 Research-Based Instructional Strategies (RBIS)


Where do Faculty Exit

The Innovation Decision Process*

Knowledge

Persuasion

Decision

Implementation

Confirmation

Know about 1 or more RBIS

Have tried 1 or more RBIS

Currently use 1 or more RBIS

*Rogers, Diffusion of Innovations
Impact of Development and Dissemination on Undergraduate Physics Instruction

Development and Dissemination Strategies:
• Are effective at helping faculty develop knowledge about new instructional strategies and motivating faculty to try.
• Are poor at supporting faculty during use – leading to high levels of discontinuation.

ECE & ChE Faculty

Know about 3 or more RBIS

Tried 3 or more RBIS

Currently use 1 or more

High users (5+ RBIS)

26%

Discontinued use of all

35%

Tried 2 or fewer RBIS

11%

Low users (1-4 RBIS)

24%

Know about 2 or fewer RBIS

3%

Who try, Discontinue

41%

Discontinuation For Individual Strategies

• In Physics:
  – Between 27% and 80% discontinuation for individual strategies.

• In Engineering:
  – Between 18% and 71% discontinuation for individual strategies.
## Correlated Variables†

<table>
<thead>
<tr>
<th>Variable</th>
<th>Know</th>
<th>Tried</th>
<th>Continue</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>READ (teaching-related journals)</td>
<td>*</td>
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<tr>
<td>NFW (Physics New Faculty Workshop)</td>
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<tr>
<td>ATND (talks/workshops)</td>
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<tr>
<td>MORE (interest in using more RBIS)</td>
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<td>GEN (gender)</td>
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<tr>
<td>SATF (satisfied with meeting goals)</td>
<td>*</td>
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<tr>
<td>PSTN (full-time, permanent vs. other)</td>
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<tr>
<td>RSH2 (research publications)</td>
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<td>*</td>
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<tr>
<td>SIZE (class size)</td>
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<tr>
<td>INST (type of institution)</td>
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<tr>
<td>CRSE (alg- or calc-based course)</td>
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<td>DGRE (highest degree)</td>
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<td>ENC (departmental encouragement for teaching)</td>
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<tr>
<td>GOAL (instructional goals)</td>
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<tr>
<td>JOB (% of job related to teaching)</td>
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<tr>
<td>PEER (frequency of talk w/ peers about teaching)</td>
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<tr>
<td>RANK (academic rank)</td>
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<tr>
<td>RSH1 (research presentations)</td>
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<td>RSH3 (research grants)</td>
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<tr>
<td>YEAR (years of teaching experience)</td>
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</tbody>
</table>

†Controlling for other study variables using a logistic regression model. *Strength of effect is based on size of odds ratios (each * ~ odds ratio of 2).
Conclusions (so far)

• Discontinuation after trying is the largest loss of faculty in the innovation-decision process
  – 1/3 of faculty who have tried at least one RBIS no longer use any RBIS
  – Discontinuation of individual RBIS range from 27%-80%

• Typical dissemination (talks, workshops, reading) is good at developing knowledge and motivation to try, but do not support continued use.

• A lot of factors that we think of as barriers to innovative teaching are not:
  – Research productivity
  – Class size
  – Age
Why So Much Discontinuation?

• When describing their RBIS (via talks, workshops, publications) developers often present an overly rosy picture.
  – Implementing faculty face obstacles that they are unprepared for:
    • student complaints
    • an inability to cover the amount of content that they feel is appropriate
    • weaker than promised student outcomes
• Faculty implementers usually do not follow or even necessarily learn about all of the details of innovation use. Instead, they invent or reinvent these details for themselves*.
• Thus, traditional dissemination (talks, workshops, publications) should be careful to articulate potential problems, reasonable expectations, and essential features of RBIS use. This is not commonly done.

What Can We Learn By Talking to Faculty?

35 Interviews related to Peer Instruction

- Knowledge
- Persuasion
- Decision
- Implementation
- Confirmation

14 Knowledgeable non-users
6 Former Users
15 Current Users

*Rogers, Diffusion of Innovations*
Interview Results: Problems Communicating about Innovations

- Names of innovations mean very different things to different people
- Innovations are commonly modified during implementation
  - Few faculty (between 6% and 47%)* use a RBIS innovation as described by the developer.
  - In many cases faculty are not aware of these differences.

* Based on Peer Instruction. Range depends on how you define and measure use of an innovation.
## From Web Survey – Use of ‘Essential Features’ of Peer Instruction

<table>
<thead>
<tr>
<th>Features of Peer Instruction (measured on survey)</th>
<th>Self-Described Users of Peer Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Lecture (for nearly every class or multiple times every class)</td>
<td>55%</td>
</tr>
<tr>
<td>Students discuss ideas in small groups (multiple times every class)</td>
<td>27%</td>
</tr>
<tr>
<td>Students solve/discuss qualitative/conceptual problem (multiple times every class)</td>
<td>27%</td>
</tr>
<tr>
<td>Whole class voting (multiple times every class)</td>
<td>38%</td>
</tr>
<tr>
<td>Conceptual questions (used on all tests)</td>
<td>64%</td>
</tr>
</tbody>
</table>

| Uses all 5 components | 6% |
| Uses 4 or more of the 5 components | 21% |
| Uses 3 of more of the 5 components | 35% |

Use of ‘essential features’ was even lower for Cooperative Group Problem Solving.
### Engineering Results – Use of ‘Essential Features’ of Peer Instruction

<table>
<thead>
<tr>
<th>Features of Peer Instruction (measured on survey)</th>
<th>Self-Described Users of Peer Instruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Lecture (&gt; 25% of class time)</td>
<td>85%</td>
</tr>
<tr>
<td>Students discuss ideas in small groups (&gt; 25% of class time)</td>
<td>49%</td>
</tr>
<tr>
<td>Students must answer before class proceeds (&gt; 25% of class time)</td>
<td>36%</td>
</tr>
<tr>
<td>Whole class voting (&gt; 25% of class time)</td>
<td>7%</td>
</tr>
<tr>
<td>Conceptual questions (&gt; 25% of class time)</td>
<td>23%</td>
</tr>
<tr>
<td>Uses all 5 components</td>
<td>3%</td>
</tr>
<tr>
<td>Uses 4 or more of the 5 components</td>
<td>11%</td>
</tr>
<tr>
<td>Uses 3 of more of the 5 components</td>
<td>28%</td>
</tr>
</tbody>
</table>
Engineering Results - Interviews

“The place where I’ve used peer instruction is when I have a significant number of students who have failed the class and are taking it for a second time. I have sometimes had a TA take those students and have them do the homework ahead of the lecture material...”

-ChE Full Professor, large public institution
From Telephone Interviews (N=35)

Relationship between self-described user status and Use of Peer Instruction Features

Number of Peer Instruction features used by self-described users, former users, and knowledgeable non-users.

7/15 (47%) self-described users use at least 7 PI features.
Interviewee’s Relationship with Peer Instruction

Self-Described User Status

- Non-User: N=14
  - Knows about Peer Instruction: 9
  - Non-User: N=10
  - Former User: N=6
  - User: N=15
  - High User: N=7

Researchers Described User Status

- Non-User: N=10
  - Knows about Peer Instruction: 5
  - Mixed User: N=18
  - High User: N=7
How Do Faculty Perceive PI?

- Perceived affordances of PI
- Perceived constraints of PI

<table>
<thead>
<tr>
<th>Researcher Assigned Implementation Group</th>
<th>Average # of Codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Use</td>
<td>8.0</td>
</tr>
<tr>
<td>Mixed Use</td>
<td>6.0</td>
</tr>
<tr>
<td>Non-Use</td>
<td>9.0</td>
</tr>
</tbody>
</table>
## Variations by Implementation Group

<table>
<thead>
<tr>
<th></th>
<th>Most Prevalent Affordances</th>
<th>Most Prevalent Constraints</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>HIGH (N=7)</strong></td>
<td>1. Dissatisfaction with traditional lecture (86%)</td>
<td>1. Difficulty of getting students engaged (100%)</td>
</tr>
<tr>
<td></td>
<td>2. Evidence of effectiveness, personal experience (71%)</td>
<td>2. Trouble finding good questions (57%)</td>
</tr>
<tr>
<td></td>
<td>3. Forces more students to participate (71%)</td>
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<tr>
<td></td>
<td>4. Evidence of effectiveness, data (57%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PI makes intuitive sense (57%)</td>
<td></td>
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<tr>
<td></td>
<td>Provides feedback to the instructor (57%)</td>
<td></td>
</tr>
<tr>
<td><strong>MIXED (N=18)</strong></td>
<td>1. Dissatisfaction with traditional lecture (78%)</td>
<td>1. Time and energy required to change (56%)</td>
</tr>
<tr>
<td></td>
<td>2. Gets students active in class (67%)</td>
<td>2. Personal commitment to content coverage (50%)</td>
</tr>
<tr>
<td></td>
<td>3. Evidence of effectiveness, personal experience (56%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Departmental support or encouragement (50%)</td>
<td></td>
</tr>
<tr>
<td><strong>NON (N=10)</strong></td>
<td>1. Evidence of effectiveness personal experience (50%,)</td>
<td>1. Time and energy required to change (90%)</td>
</tr>
<tr>
<td></td>
<td>2. Student deficiencies (60%)</td>
<td>2. Student deficiencies (60%)</td>
</tr>
<tr>
<td></td>
<td>3. Personal commitment to content coverage (50%)</td>
<td>3. Personal commitment to content coverage (50%)</td>
</tr>
<tr>
<td></td>
<td>Structural, Lack of resources (50%)</td>
<td>Structural, Lack of resources (50%)</td>
</tr>
<tr>
<td></td>
<td>Structural, Class size (50%)</td>
<td>Structural, Class size (50%)</td>
</tr>
<tr>
<td></td>
<td>Current practice effective (50%)</td>
<td>Current practice effective (50%)</td>
</tr>
<tr>
<td></td>
<td>External requirement of content coverage (50%)</td>
<td>External requirement of content coverage (50%)</td>
</tr>
</tbody>
</table>
Conclusions (so far)

• Faculty do not use instructional strategies as recommended by the developer.

• Users at different stages in the innovation-decision process see the innovation differently.
  – High users are concerned with student learning.
  – Non users are concerned mainly with perceived barriers.
What Can We Learn From the Literature?

Improving Dissemination and Moving Beyond Dissemination
Need to think about dissemination differently

Common D&D: Developers ‘distribute’ instruction to faculty
(developers complain about uninterested faculty and faculty complain about feeling attacked by evangelistic developers*)

VS.

Better D&D: Developers and faculty work together to improve instruction

Best Practices in Dissemination
(Results from an Interdisciplinary Literature Review)

To support implementation, successful dissemination strategies involve*:

• coordinated and focused efforts lasting over an extended period of time
• use of performance evaluation and feedback
• deliberate focus on changing faculty conceptions

• Communication is in multiple directions

There are other Change Models

1. What does the change effort intend to directly impact?

<table>
<thead>
<tr>
<th>Individuals</th>
<th>Environments and Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>The change intends to directly impact personal characteristics of single individuals, such as beliefs, knowledge, behaviors, etc.</td>
<td>The change intends to directly impact extra-individual characteristics of the system such as rules, physical characteristics of the environment, norms, etc.</td>
</tr>
</tbody>
</table>
2. To what extent is the outcome prescribed in advance?

<table>
<thead>
<tr>
<th>Prescribed Final State</th>
<th>Emergent Final State</th>
</tr>
</thead>
<tbody>
<tr>
<td>The desired final state for the individual or environment is known at the beginning of the change process.</td>
<td>The desired final state for the individual or environment is developed as part of the change process.</td>
</tr>
</tbody>
</table>
There are other Change Models

Focus on Changing Individuals

Focus on Changing Environment/Structures

Prescribed Final Condition

Emergent Final Condition

Old (Top Down) Leadership

New (Empowering) Leadership

DEVELOPING Policy

DEVELOPING Shared Vision

DISSEMINATING Curriculum & Pedagogy

DEVELOPING Reflective Teachers

Development and Dissemination

Faculty Self-Development

Implications from Other Change Models

• Need to change environments and structures
  – Poor teaching is a systemic problem that needs a systemic solution
  – Departments may be key levers for change.

• Need to allow for some degree of faculty autonomy and emergent outcomes
  – Disseminate ideas and easily modified materials (not polished curricula)
Take Away Message #1

Discontinuation after trial (and non-optimal use) are significant problems.

Typical dissemination focuses here

Faculty implementers need support here
Take Away Message #2
Communication about educational innovations is difficult.

My teaching is very interactive

*SCALE-UP classroom at U of MN
Take Away Message #3

We can learn from other change models.

- **Empower faculty**
- **Address situational constraints**
Thank You

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