

# Facilitating Change in Undergraduate Science Instruction: Synthesis of Change Strategies across Disciplines

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# Collaborators

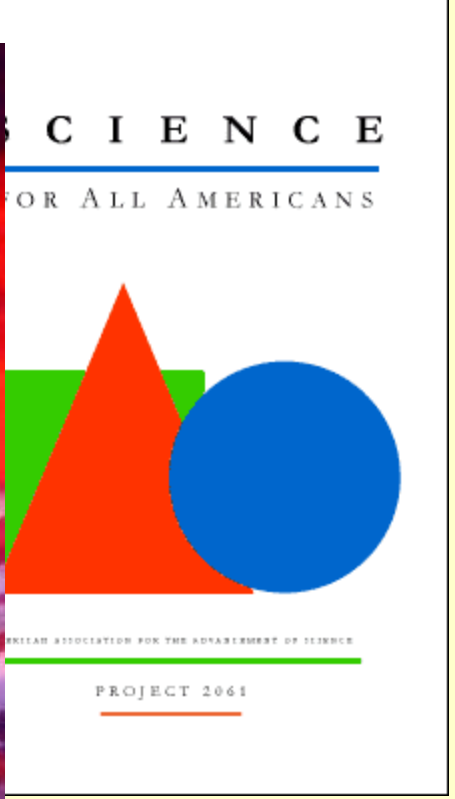
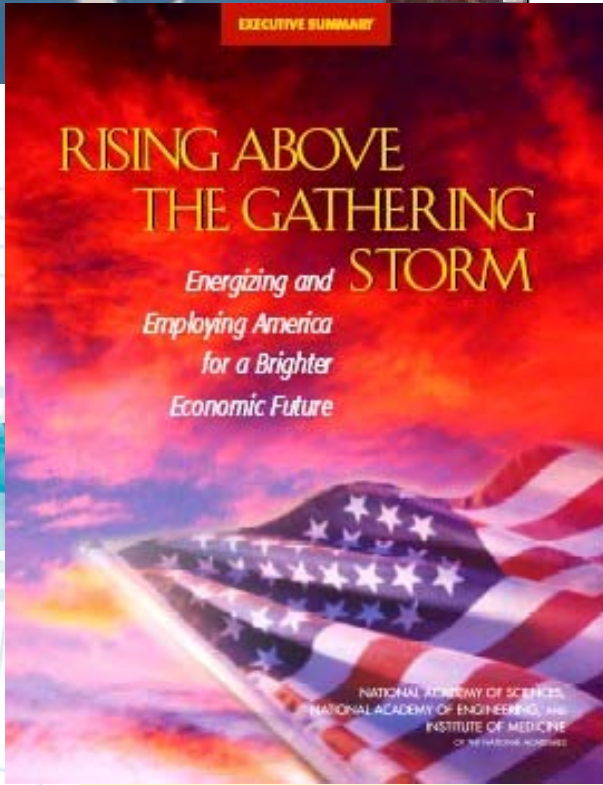
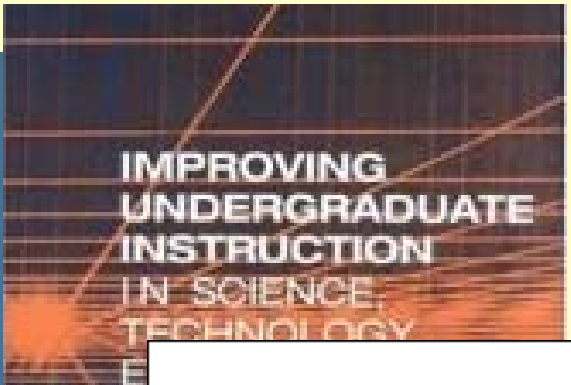


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# What's The Problem?



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Committee on Undergraduate Education  
 Center for Science, Mathematics, and Technology  
 National Research Council of the National Academies



THE NEED FOR CHANGES IN TEACHING AND LEARNING TO MEET GLOBAL CHALLENGES

NATIONAL RESEARCH COUNCIL ON SCIENCE AND TECHNOLOGY  
 WASHINGTON, D.C.



# Starting Point: Current State of Knowledge

- **We know a lot about:**
  - **effective teaching and learning of STEM subjects**
  - **how to apply this knowledge in individual classrooms**
- **A significant problem is finding ways to scale these effective practices so that all undergraduate students experience them.**

# Three Groups Focused on Change in Undergraduate STEM Instruction

## **Disciplinary STEM Education Researchers (SER)**

**Housed in the STEM disciplines in College of Arts and Sciences or Engineering, Sometimes in College of Education**

## **Faculty Development Researchers (FDR)**

**Housed in Center for Teaching and Learning**

## **Higher Education Researchers (HER)**

**Housed in College of Education or Administration**

Each group has their own professional societies, conferences, journals, etc.

# This Project

- **In this research project, we critically review, integrate, and align the research literatures and perspectives of the SER, FDR, and HER communities to identify the change strategies that have the most promise for future work.**

# Research Questions

- **What core strategies to promote changes in instructional practices are used in undergraduate STEM education?**
- **What evidence is available to support the effectiveness of these strategies?**
- **What common ideas about instructional change are evident in the literature?**
- **How is the broader change literature (e.g., individual and organizational change theories) used by authors to frame their use or study of change strategies?**

# A Larger Literature Review: Preliminary Results\*

## Current Status:

- **Literature Search**
  - ~300 relevant journal articles identified
- **Preliminary Analysis**
  - Use 130 articles (randomly selected) to develop four categories of change strategies
  - Use 43 articles (subset of the 130) to identify subcategories and analyze i) strength of data presented and ii) connection to change literature
- **Ongoing Analysis (target completion date – Feb 2009)**
  - Complete analysis of remaining articles – modifying categories and coding criteria as necessary
- **Next Steps (Winter and Spring 2009)**
  - DELPHI (distilling knowledge from a group of experts)
  - Validity check (comparison of articles to grant reports)

# Literature Search

- **Primary Databases: Web of Science, ERIC**
- **Search Terms: change, improvement, reform, teaching, instruction, higher education, college, university, tertiary**
- **Dates: 1995-present**
- **Use Title and Abstract to determine inclusion**

Category	Codes
Discipline (which disciplinary audience is being spoken to, as defined by the journal)	HER FDR SER --biology, chemistry, engineering, geosciences, math, physics, technology OTHER
Author affiliation	HER FDR SER --biology, chemistry, engineering, geosciences, math, physics, technology

### Change Intervention Details

Source of Change Intervention Details	Specific intervention studied
Unit of Change Intervention (individual to environment)	Aspects of change intervention(s) inferred Individual or groups of individuals Department (or subgroup of department) Institution Extra-Institutional
Change Agency (refers to the unit of change above)	Internal                      External – Voluntary                      External -- Involuntary
Objective of Change Intervention (refers to unit of change above)	Observable actions Ways of thinking
Directedness of Objective (refers to unit of change above)	prescribed (directed) emergent
Duration of Intervention	One-time Short: one day or less One-time Long: between one and six days Ongoing: longer than six days

**Develop  
categorization  
scheme of change  
strategies**

Sample Size	One number
Unit of Sample	Individual Department (or subgroup of department) Institution Extra-Institutional
Institution Type studied	Research Comprehensive Liberal Arts Community College Mixed Unknown/not applicable
<b>Findings</b>	
Significant Findings/Claims	Studying Change      Designing Change      Both      Neither
Studying Change – open	
Designing Change – open	
Quality (Claims Supported by Evidence)	Strongly supported      Mixed in support      Weakly supported
Short summary - open	
Keep/eliminate	Keep for further analysis      Eliminate from further analysis
Comments	Open

# Categorized along two Important Dimensions

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

<b>Individuals</b>	<b>Environments and Structures</b>
<p><b>The change intends to directly impact personal characteristics of single individuals, such as beliefs, knowledge, behaviors, etc.</b></p>	<p><b>The change intends to directly impact extra-individual characteristics of the system such as rules, physical characteristics of the environment, norms, etc.</b></p>
<p><b>Implicit Assumption: Individuals' actions are primarily influenced by their own volition</b></p>	<p><b>Implicit Assumption: Individuals' actions are primarily influenced by external environments</b></p>

## Categorized along two Important Dimensions

### 2. To what extent is the outcome prescribed in advance?

<b>Prescribed Final State</b>	<b>Emergent Final State</b>
<p>The desired final state for the individual or environment is known at the beginning of the change process.</p>	<p>The desired final state for the individual or environment is developed as part of the change process.</p>
<p><b>Implicit Assumption:</b> Important knowledge relevant to change outcome is known to a few people (e.g., experts). Therefore a small group should determine the intended outcome.</p>	<p><b>Implicit Assumption:</b> Important knowledge relevant to change outcome exists in individuals throughout the system. Therefore a variety of stakeholders should be involved in determining the intended outcome.</p>

# Four Categories of Change Strategies

Focus on Changing Individuals

Prescribed Final Condition

Tell/teach individuals about new teaching conceptions and/or practices.  
 e.g., dissemination (SER, FDR), focused conceptual change (FDR)

Encourage/support individuals to develop new teaching conceptions and/or practices.  
 e.g., reflective practice, (FDR), action research (FDR), curriculum development (SER)

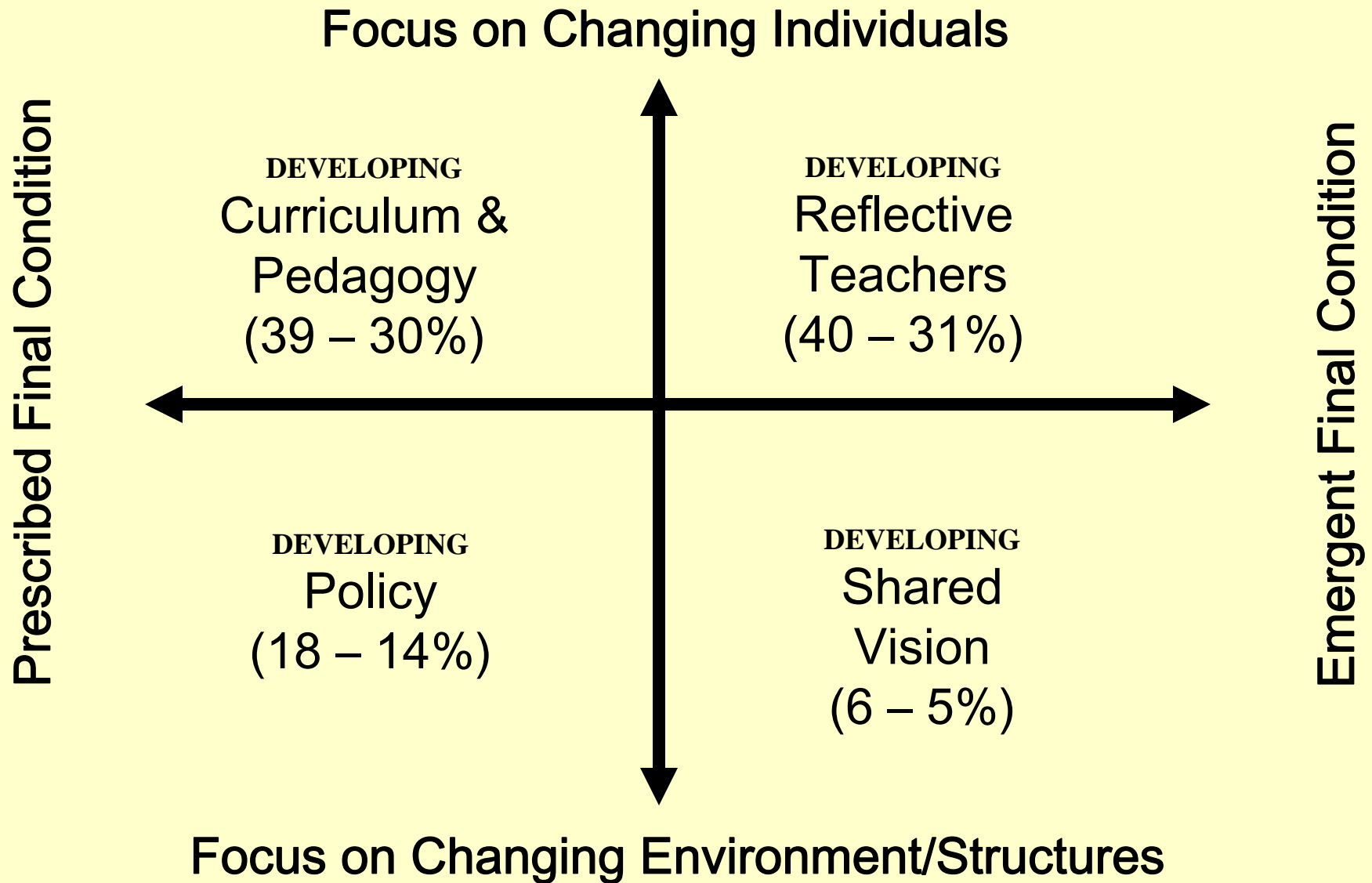
Emergent Final Condition

Develop new environmental features that require/encourage new teaching conceptions and/or practices.  
 e.g., policy change (HER), strategic planning (HER)

Empower collective development of environmental features that support new teaching conceptions and/or practices.  
 e.g., institutional transformation (HER), learning organizations (HER)

Focus on Changing Environment/Structures

# Each Strategy has a Unique Emphasis



# Subcategories

**More detailed analysis of selected articles within a category. Focus on:**

- **Core Change Strategy**
- **Relationship to Change Literature**
- **Ideas about Change**
- **Evidence of Success of Intervention**

**Each category completed initially by one researcher and then critiqued by another.**

# Subcategories

## Focus on Changing Individuals

Prescribed Final Condition

### CURRICULUM & PEDAGOGY

- 1) Disseminate Best Practices (N=7)
- 2) Modify Instructor Conceptions (N=4)
- 3) Provide Individualized Diagnosis and Support (N=1)

### REFLECTIVE TEACHERS

- 1) Faculty Curriculum Development (N=4)
- 2) Collaborative Action Research (N=3)
- 3) Provide information to help faculty make informed decisions (N=4)
- 4) Departmentally-Based Faculty Development Specialists (N=1)

### POLICY

- 1) System Synchronicity (N=6)
- 2) Institutionalization of quality assurance measures (N=4)
- 3) Directed Incentives (N=3)

### SHARED VISION

- 1) Institutional-Level Actions (N=3)
- 2) Externally initiated department level collaboration (N=2)
- 3) Internally initiated department level collaboration (N=1)

Emergent Final Condition

## Focus on Changing Environment/Structures

# Relationship to Change Literature

- Less than half had any connection with any change literature (despite a very liberal definition of “change literature”)
- Few commonalities across categories. Two exceptions:
  - Reflective practice (Reflective Teachers and Policy)
  - Departmental and Institutional Cultures (Policy and Shared Vision)

Curriculum & Pedagogy  <b>5/12 = 42%</b>	Reflective Teachers  <b>5/12 = 42%</b>
Policy  <b>7/13 = 54%</b>	Shared Vision  <b>4/6 = 67%</b>

## Evidence of Success\*

- Overall 12/30 (40%) presented at least moderate evidence of success/lack of success.

- Main weaknesses:

- Reflective Teachers. Often described collecting appropriate data, but reporting was very vague

- Policy. Often rely on anecdotal evidence

Curriculum & Pedagogy  <b>5/6 = 83%</b> (2 success; 3 No Success)	Reflective Teachers  <b>1/11 = 9%</b> (All success)
Policy  <b>3/9 = 33%</b> (1 success; 2 No Success)	Shared Vision  <b>3/4 = 75%</b> (All success)

\*13/43 articles did not present a specific change strategy and are not included in the counts on this slide.

# Categories of Change Strategies

**Two clear criteria allow for meaningful categorization of change strategies into four categories.**

- 1. What does the change effort intend to directly impact?**
- 2. To what extent is the outcome prescribed in advance?**

## Change Strategies are Often not Questioned

- It is often assumed that change strategies are successful (even though evidence is weak or anecdotal)
- If a change strategy does not produce evidence of success, it is often assumed that more time is required:
  - [Curriculum & Pedagogy] “The great ship of teaching and learning does not change direction quickly.”  
(Sharp & McLaughlin, 1997, p. 324)
  - [Reflective Teachers] “This study took place over the course of a year. This was not long enough.”  
(Schneider & Pickett, 2006, p. 264)

## Each Group Has Similar Weaknesses

### Poor Connection to Change Literature

- 21/43 (49%) had connections to change literature

### Little Evidence of Success

- 12/30 (40%) presented at least moderate evidence of success or failure of change strategies
- 7/30 (23%) success, 5/30 (17%) lack of success

# Recommendations

**We need researchers to:**

- **Develop change strategies that span categories and research communities**
- **Develop change theories that are empirically tested and detailed enough to inform action**