Barriers and Promises in STEM Reform
Part 2: The Study and Improvement of STEM Change Strategies

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Another Perspective – Published Literature Relevant to College-Level STEM Reform

Main Points
• STEM change agents primarily use a development and dissemination change model
• Change agents from other disciplines use other change models
• STEM change agents do not treat the improvement of change models and strategies as a scientific problem to be solved:
  • Most articles do not reference any change literature
  • Most articles do not document the success (or failure) of change efforts

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.
Three Recent Literature Reviews

Disciplinary Science Education Researchers (SER)

Faculty Development Researchers (FDR)

Higher Education Researchers (HER)

Three Groups - One Common Goal
Transform undergraduate education from the instruction paradigm to the learning paradigm*

<table>
<thead>
<tr>
<th>The Instruction Paradigm</th>
<th>The Learning Paradigm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Physics class</td>
<td>Clicker use at UC Riverside</td>
</tr>
<tr>
<td>Workshop Physics Classroom at Dickinson College</td>
<td>White boards at Western Michigan University</td>
</tr>
<tr>
<td>SCALE-UP Physics class at Clemson University</td>
<td></td>
</tr>
</tbody>
</table>

Three Groups – No Communication

<table>
<thead>
<tr>
<th>Field</th>
<th>Article</th>
<th>Number of References</th>
</tr>
</thead>
<tbody>
<tr>
<td>[SER]</td>
<td>Seymour (2001)</td>
<td>77</td>
</tr>
<tr>
<td>[FDR]</td>
<td>Emerson &amp; Mosteller (2000)</td>
<td>34</td>
</tr>
</tbody>
</table>

No overlap in references! → No communication between groups

A Larger Literature Review: Preliminary Results*

Current Status:
- **Literature Search**
  - ~400 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)

*Supported by NSF DRL-0723699
Categories of Change Strategies Based on Two Dimensions

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

Focus on Changing Environment/Structures

Emergent Final Condition
- Encourage/support individuals to develop new teaching conceptions and/or practices. e.g., reflective practice, (FDR), action research (FDR), curriculum development (FDR, SER)
- Empower collective development of environmental features that support new teaching conceptions and/or practices. e.g., institutional transformation (HER), learning organizations (HER)

Each Type of Strategy has a Unique Emphasis

Focus on Changing Individuals

Prescribed Final Condition
- DEVELOPING Curriculum & Pedagogy
- DEVELOPING Policy

Emergent Final Condition
- DEVELOPING Reflective Teachers
- DEVELOPING Shared Vision

Focus on Changing Environment/Structures
Each Type of Strategy has a Unique Change Agent Role

Focus on Changing Individuals

- Teach/ Tell
- Encourage

Focus on Changing Environment/Structures

- Direct/ Manage
- Empower/ Catalyze

Prescribed Final Condition

Emergent Final Condition

Most STEM Change Agents Operate in the Disseminating Curriculum & Pedagogy Category

- Papers with only STEM author(s) (N=17)
- Papers with at least one STEM author (N=27)
- Papers with no STEM authors (N=76)
Relationship to Change Literature

Many articles made no connection with any change literature (despite a very liberal definition of “change literature”)

<table>
<thead>
<tr>
<th>Articles Making A Connection to Change Literature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Articles with at least one STEM author</td>
<td>5/12 = 42%</td>
</tr>
<tr>
<td>Articles without a STEM author</td>
<td>16/31 = 52%</td>
</tr>
</tbody>
</table>

Evidence of Success*

Many articles present little or no evidence of the success (or failure) of the change strategy implemented.

<table>
<thead>
<tr>
<th>Articles that Present at Least Moderate Evidence of the Success (or failure) of the change strategy</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Articles with at least one STEM author</td>
<td>2/7 = 29%</td>
</tr>
<tr>
<td>Articles without a STEM author</td>
<td>10/23 = 43%</td>
</tr>
</tbody>
</table>

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

Each has a different and important perspective.

There is little interaction between groups and minimal interaction within groups
(Based on a citation analysis within the complete set of articles.)

Each change strategy sees areas of influence of other strategies as outside of their control

Focus on Changing in Individuals

Prescribed Final Condition

Curriculum & Pedagogy

Most faculty do not have the skills to develop effective curricula.

Few rewards for curricular innovation and institutional infrastructure does not support innovative teaching.

Focus on Changing in Environment/Structures

Emergent Final Condition

Departmental colleagues teach very traditionally and are skeptical of innovation.
Summary

• STEM change agents frequently:
  • operate within the change category of disseminating curriculum and pedagogy.
  • do not attempt to test the effectiveness of their change strategies.
  • do not build their change strategies on the work of other STEM change agents or on knowledge of change strategies/models from other disciplines.

Recommendations

STEM Change Agents Should:
• Develop change strategies/models that span categories by drawing from other research communities.
• Collect and use data to test and improve change strategies/models.
• Publish the results of the above.