Thanks to our research team members
Amber D. Dumford, Alexander C. McCormick, & Louis M. Rocconi, IU Center for Postsecondary Research and,
AAC&U and Project Kaleidoscope for collaboration & support for this research!
Context for Examining STEM Education Reform
National Context for STEM Education Reform

- Produce 1 million more STEM degrees in next decade
- Improve undergraduate STEM education – focus on teaching
- Expand gender, racial-ethnic diversity in STEM graduates and workforce
What’s been done to reform STEM education?

1. Increase support culture in STEM departments
2. Fund faculty innovations, faculty development
3. Redress gender, racial-ethnic gaps
4. Develop network efforts for innovation
5. ABET, NSF, NAS pressure to improve learning
6. Support for enriching undergraduate research, applied learning, meaningful internships
7. Improve classroom instruction - use of student-centered, evidence-based, active & collaborative learning pedagogy
What Has Your Campus Done?
Literature on STEM Reform

- Focuses on improving teaching, learning, and student learning productivity (Drew, 2011; Fairweather, 2009).

- Emphasizes that active and collaborative learning & fostering climate where women & minorities feel welcome, positively affects outcomes (Drew, 2011; Fisher, Zeligman, & Fairweather, 2005; Seymour & Hewitt, 1997)

- “Poor teaching” main reason students leave STEM; also “weed out” method, competitive and unsupportive environments, and poor interactions with faculty and TA’s (Seymour & Hewitt, 1997).
STEM Reform: Project Kaleidoscope

- Project Kaleidoscope (PKAL): Leading advocate for transforming undergraduate STEM teaching and learning. Empowering network of faculty and administrators committed to integrative STEM education for all students.

- PKAL Goals:
  - Empower STEM faculty to graduate more students in STEM who are competitively trained and liberally educated
  - Develop scientifically literate citizenry
  - Advocate for reform in STEM teaching and learning
A New Opportunity to Study STEM Reform

- Could NSSE data collected over time be used to study change in student engagement in effective education practice in STEM fields?
- Does change differ among STEM disciplines?
NSSE Data as an Opportunity to Examine Trends

Similar approach to our Spencer-funded project, Learning to Improve, which examined institution-level trends
From Institution to Discipline

- Aggregate across institutions
- Examine trends
  - Between STEM & non-STEM
  - Within STEM fields
    - Astronomy & physics
    - Biology
    - Chemistry
    - Computer science
    - Earth Science
    - Engineering
    - Math & Statistics
    - Psychology
Data

### Criteria for including institutions

- At least one major in 2005, 2006, or 2007
- At least one major in 2010, 2011, or 2012
- At least four years with the major, 2005-12

<table>
<thead>
<tr>
<th>Field</th>
<th>Min</th>
<th>Max</th>
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<tr>
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# Measures Examined, 2005-2012

## Index Measures

- Higher-Order Learning (course emphasis)
- Reflective Learning
- Integrative Learning
- Course Challenge
- Active Learning
- Collaborative Learning
- Student-Faculty Interaction
- Supportive Campus Environment

## Single Items

**Participation in High-Impact Practices:**
- Learning Community (FY)
- Research with Faculty (Sr)
- Internship (Sr)
- Culminating Senior Experience (Sr)
What Qualifies as a Trend?

- **Criteria for determining a trend**
  - Significant and meaningful difference (effect size of at least .20) between 2005 & 2012
  - Good linear fit (R-square >= .70)
  - Example...

The graph shows a linear trend line with the equation:

\[ y = 0.4249x + 34.174 \]

and an R-squared value of 0.72197.
### STEM and Non-STEM

Where we found trends, for STEM & Non-STEM by class level

<table>
<thead>
<tr>
<th>Measure</th>
<th>STEM</th>
<th>NS</th>
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Where do we expect to see trends? More for First-years or more for Seniors?
## STEM and Non-STEM

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There were no instances of negative trends
But STEM is a diverse set of fields. What if we unpack it?
## STEM Fields

### Number of positive trends by STEM field and class level

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### STEM Fields

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There were no instances of negative trends
What do the Trends Look Like?

Engineering First-year Collaborative Learning

\[ y = 0.5752x + 48.016 \]

\[ R^2 = 0.82308 \]
Astronomy & Physics (FY)

Course Challenge

Active Learning

Supportive Campus Envt.

y = 0.6672x + 60.286
R² = 0.78388

y = 0.7121x + 34.963
R² = 0.73726

y = 0.8413x + 59.709
R² = 0.74503

National Survey of Student Engagement nsse.iub.edu
**Biology (FY)**

**Higher-Order Learning**

- Years: 2005 to 2012
- Initial Value: 68.3
- Final Value: 72.9
- Trendline: $y = 0.6514x + 67.641$
- $R^2 = 0.96985$

**Course Challenge**

- Years: 2005 to 2012
- Initial Value: 66.0
- Final Value: 69.1
- Trendline: $y = 0.4255x + 65.429$
- $R^2 = 0.91894$

**Supportive Campus Envt.**

- Years: 2005 to 2012
- Initial Value: 61.9
- Final Value: 65.7
- Trendline: $y = 0.5052x + 61.496$
- $R^2 = 0.88742$
Higher-Order Learning

$y = 0.8895x + 61.371$

$R^2 = 0.93451$

Reflective Learning

$y = 0.7425x + 52.321$

$R^2 = 0.84394$

Integrative Learning

$y = 0.5682x + 48.443$

$R^2 = 0.92402$

Supportive Campus Envt.

$y = 0.5297x + 58.756$

$R^2 = 0.84319$
Engineering (Sr)

Higher-Order Learning

\[ y = 0.5339x + 70.541 \]

\[ R^2 = 0.86847 \]

Supportive Campus Envt.

\[ y = 0.5607x + 53.582 \]

\[ R^2 = 0.72391 \]
Math & Stat (FY); Psych (FY)

Math & Stats
Higher-Order Learning

\[ y = 0.6098x + 64.907 \]

\[ R^2 = 0.80788 \]

Psychology
Course Challenge

\[ y = 0.5164x + 61.078 \]

\[ R^2 = 0.96047 \]
Most Common Gains

First-year students
3-way tie (4 instances):
• Higher-Order Learning
• Course Challenge
• Supportive Campus Environment

Seniors
2-way tie (2 instances):
• Higher-Order Learning
• Supportive Campus Environment
Discussion
STEM Trends

- Overall picture is positive, but maybe not as positive as we hypothesized
- STEM fields not the only ones working on improvement (other fields and institutions involved)
- What would it take to see more dramatic trends within STEM fields?
First-Years v. Seniors

- Most trends appear for FY
- Why?
  - Focus on FYE programs
  - Focus on gateway courses
- Do we need to turn our attention to other class years?
Narrow Focus

- Two areas stand out as areas where improvement is most likely to happen
  - Supportive Campus Environment
  - Higher-Order Learning

- Makes sense in light of
  - Push for more inclusive, welcoming environments
  - Push for critical thinking

- Is it time to push harder, differently in other areas? Which areas?
STEM Reform

- Some evidence that reform overall has had some effect
- One field (engineering) stands out; accreditation may be a key lever
- Teasing STEM reform apart from institutional reform a challenge
- Looking field by field is important
- What next?
Questions