

Transforming Institutions: 21st-Century Undergraduate STEM Education

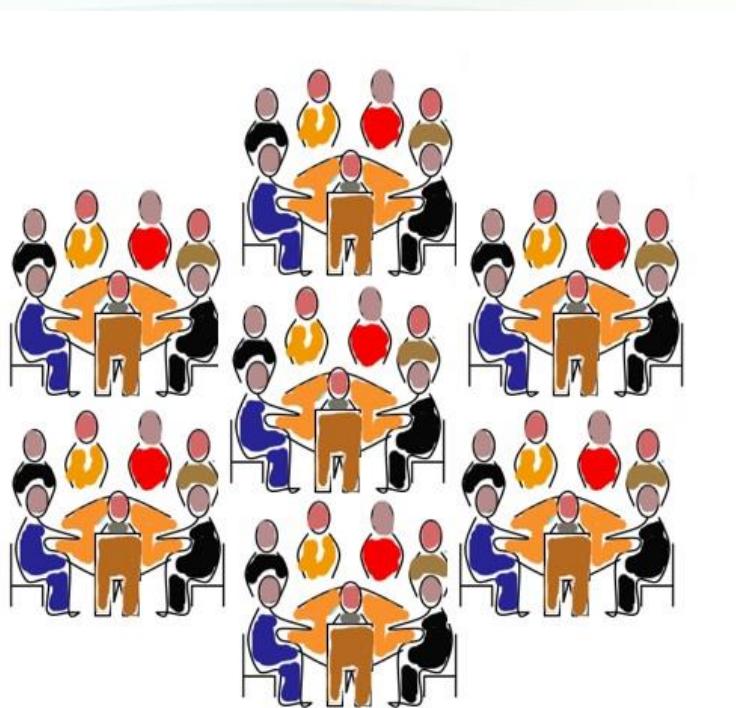
Workshop 4

James Lehman and Wilella Burgess, Purdue University

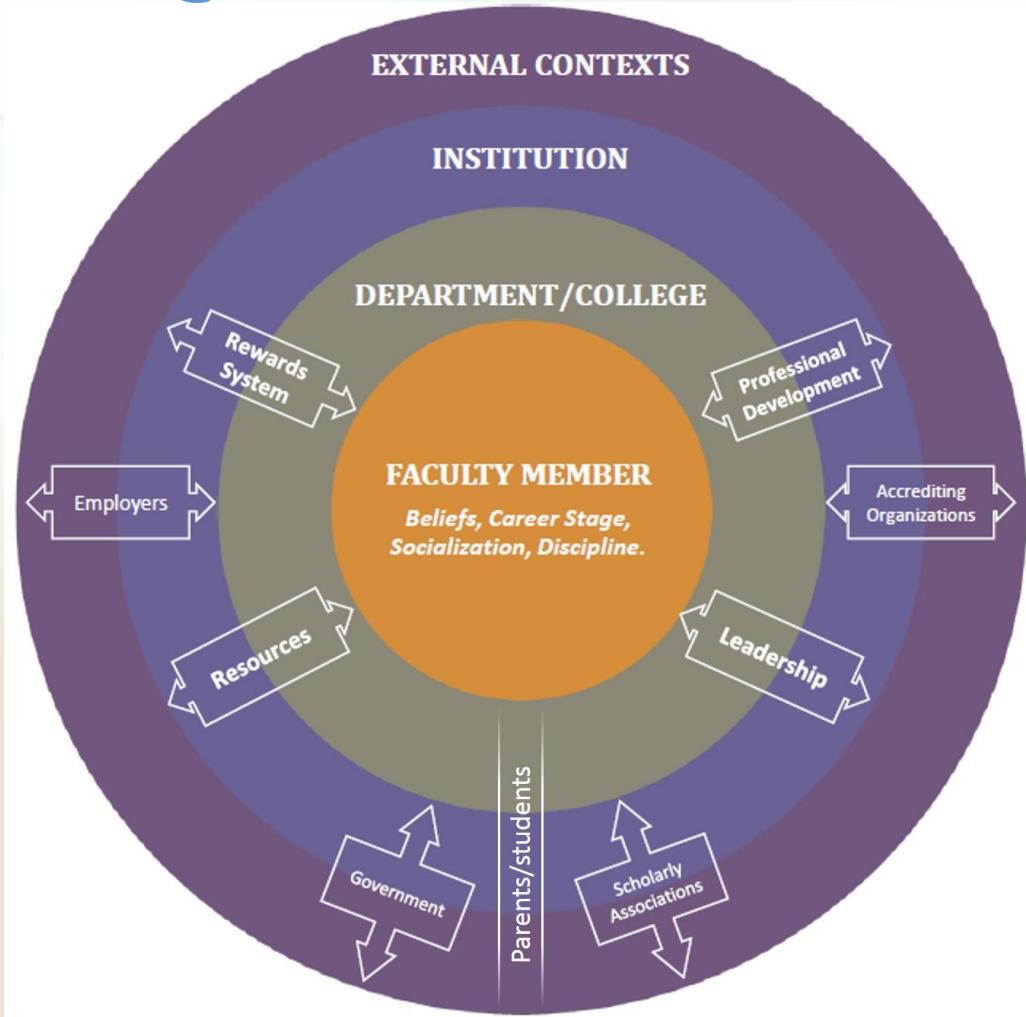
Gabriela Weaver and Linda Slakey, University of
Massachusetts-Amherst



Introduction to Workshop



Why engage in institution-level thinking in STEM educational reform?



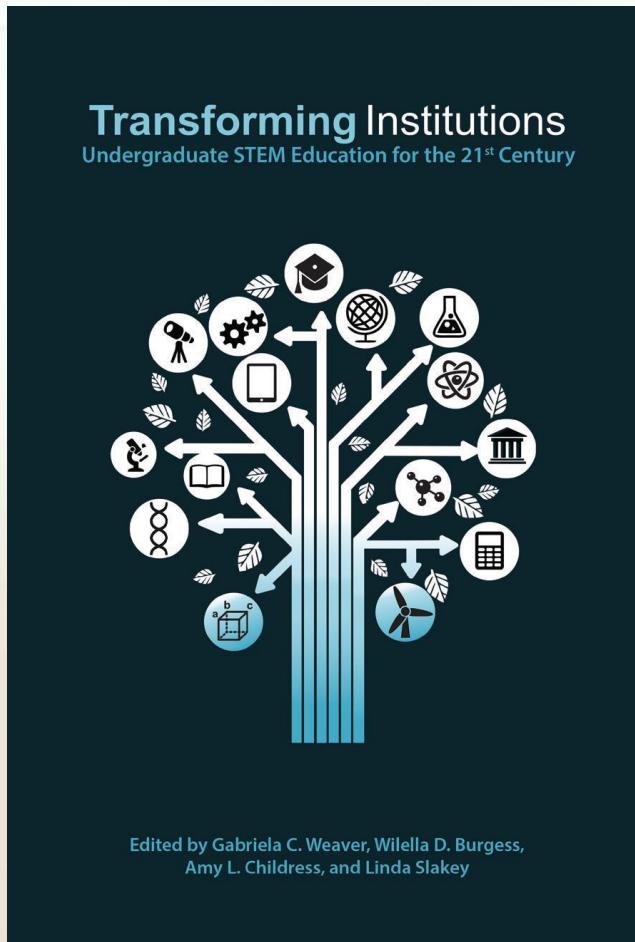
The National Context: Opportunities, Needs and Pressures

- Reports and studies from NRC, PCAST, NSF, AAAS, NAS/NAE/IM,
 - STEM-based jobs vs. STEM major production
 - “Majority minority” demographic shifts
- Increasing corporatization of higher education
 - Decreased state funding
 - Decreased research funding
 - Higher enrollments
 - Concerns about student debt



The Conferences and Outcomes

- *TI* conferences – 2011 and 2014



Reflection: Your Context

- What is your personal goal regarding institutional transformation around undergraduate STEM education and where do you intend for this to happen? State in 3 sentences or less.

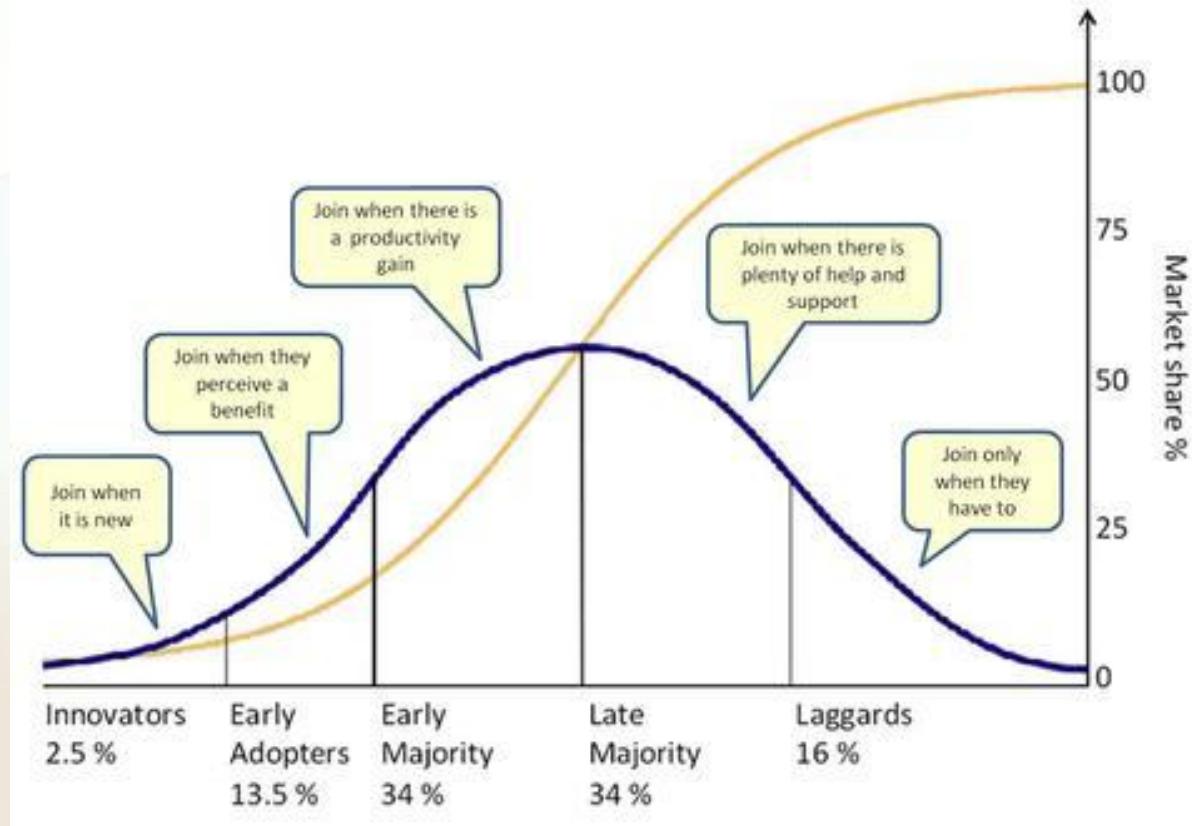
*Write a personal reflection on this question
in your handout.*



Models of Institutional Change and Major Initiatives



Thinking about the broad context for change: The motivations that prompt innovators and draw in early adopters are unlikely to work for the people in the center of the distribution!



This concept was first developed by Everett Rogers. See Rogers, Everett M., *Diffusion of Innovation*, 2003 Free Press, New York. It has been adopted in many settings, e.g., <http://www.informationweek.com/software/social/5-social-business-adopter-types-prepare-early/d/d-id/898950>, from which this figure is taken. I owe my awareness of the work to Charles Henderson.



Thinking about the broad context for change

- What kinds of approaches are being used to work with the campus as a system?
- What have we learned about how organizational change plays out in academic life?
- What tools and resources are available?

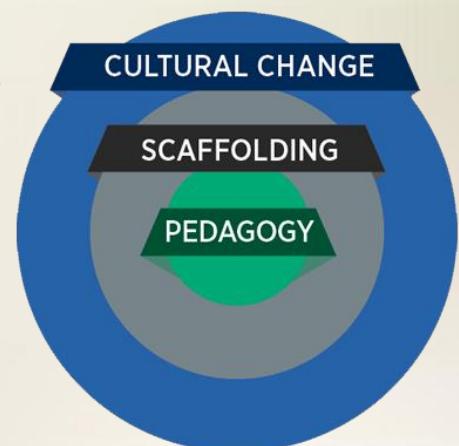


Thinking about the broad context for change

A **framework** can summarize the elements that need to be addressed to achieve a given outcome.

AAC&U's LEAP initiative is an example of a framework for excellence in undergraduate education.

The AAU STEM initiative is an example of a framework for institutional commitment to student-centered pedagogy.



Thinking about the broad context for change

A framework may also describe the process for bringing about change. (*Taken from the Keck/PKAL initiative*)

- Establish a vision
 - Examine the landscape and conduct capacity analysis
 - Identify and analyze challenges and opportunities
 - Choose strategies or interventions; leverage opportunities
 - Determine readiness for action
 - Begin implementation
 - Measure results
 - Plan next steps



Visions need practical descriptions of the desired outcome

Pedagogy (from the AAU STEM initiative framework)

- **Articulated learning goals**
 - Develop shared learning goals and outcome measures
 - Consider learning at all levels, from individual courses through programs and degrees
 - Make learning goals explicit to the students & connect assignments to learning goals throughout the course
- **Educational practices**
 - Engage students as active participants in learning
 - Implement evidence-based instructional strategies
 - Use data on student learning to refine practice
 - Use scenarios and real-world examples
 - Use technologies effectively
- **Assessments**
 - Develop and utilize instructor-independent tools to assess student learning
 - Teach for, and measure, long-term retention
- **Access**
 - Ensure that STEM courses are inclusive of all students
 - Implement practices known to enhance students' self-efficacy



Visions need practical descriptions of the desired outcome

Scaffolding (from the AAU STEM initiative framework)

- Provide faculty professional development
- Provide faculty with easily accessible resources
- Collect and share data on program performance
- Align facilities planning with modern instructional approaches.



Thinking about the broad context for change

Networks are playing an increasing role in supporting institutional change.

- PKAL as a network of mutual support for change.
- Professional societies as networks
- The networked improvement community as an agent of change – see the Bay View Alliance presentation, also some of the APLU initiatives
- The PULSE community network within the life sciences education community.
- The AAU initiative
- The APLU-led STEM Centers network
- CIRTL



What will work on your campus?

- Individual campus initiatives as models: see the case studies in *Transforming Institutions*.
- Who will be leading the change process?
- Where are the resources for supporting faculty?
 - The CWSEI model – the department as the key unit of change.
 - Centers for Teaching as the locus of support
 - Faculty Learning Communities
- Do the spaces for learning support student-centered pedagogy?



What have we learned about institutional change from the work in progress?

- All the parts of the process matter!
- Change is more likely to be accepted and lasting if both the leadership and the grass roots are engaged.
- It's important to understand the driving forces at each level of the system.
- Networking begins at home – are the various initiatives on campus staying in touch to realize synergies?



What have we learned about institutional change from the work in progress?

How will you work with the NIH (Not Invented Here) problem:

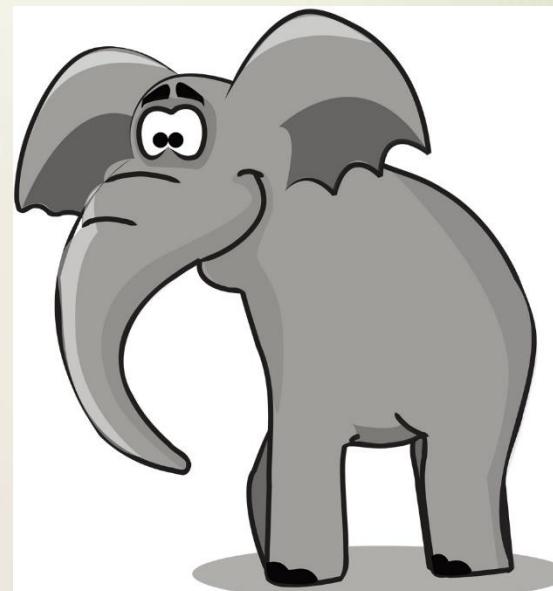
- On the one hand, much is known now about what is needed in the classroom and in support services, to facilitate success for all students.
- On the other hand, faculty buy in may depend heavily on their owning the process by designing it themselves.



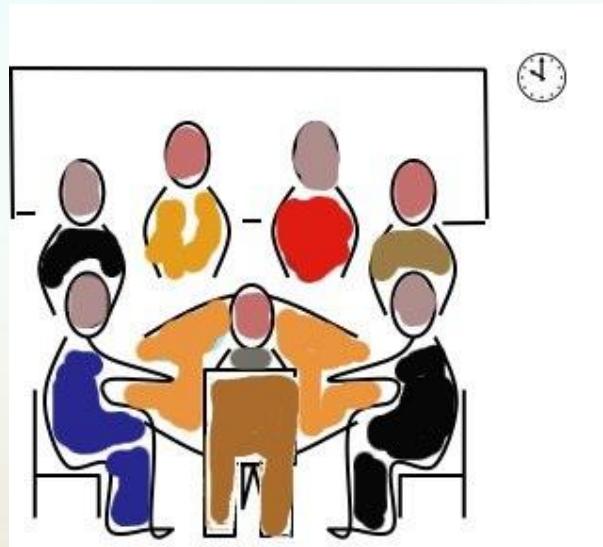
What have we learned about institutional change from the work in progress?

And finally, the elephant in the room:

How do we judge teaching, and do the reward systems align with what is known about effective teaching?



Discussion



Discussion Questions

- What elements of existing reform initiatives might be applicable in your situation?
- How could these models and theories contribute to you reaching your institutional transformation goal?



Issues Related to Faculty and Faculty Development



Faculty Development

- Honor versus Remediation
- Learning Communities
- Fundamentals
 - PCK
 - Backward Design
 - Student-Centered Pedagogies
 - Peer Instruction
- Inclusive Pedagogies
- Evaluation and Reward Structures



Faculty Development

- Honor versus Remediation



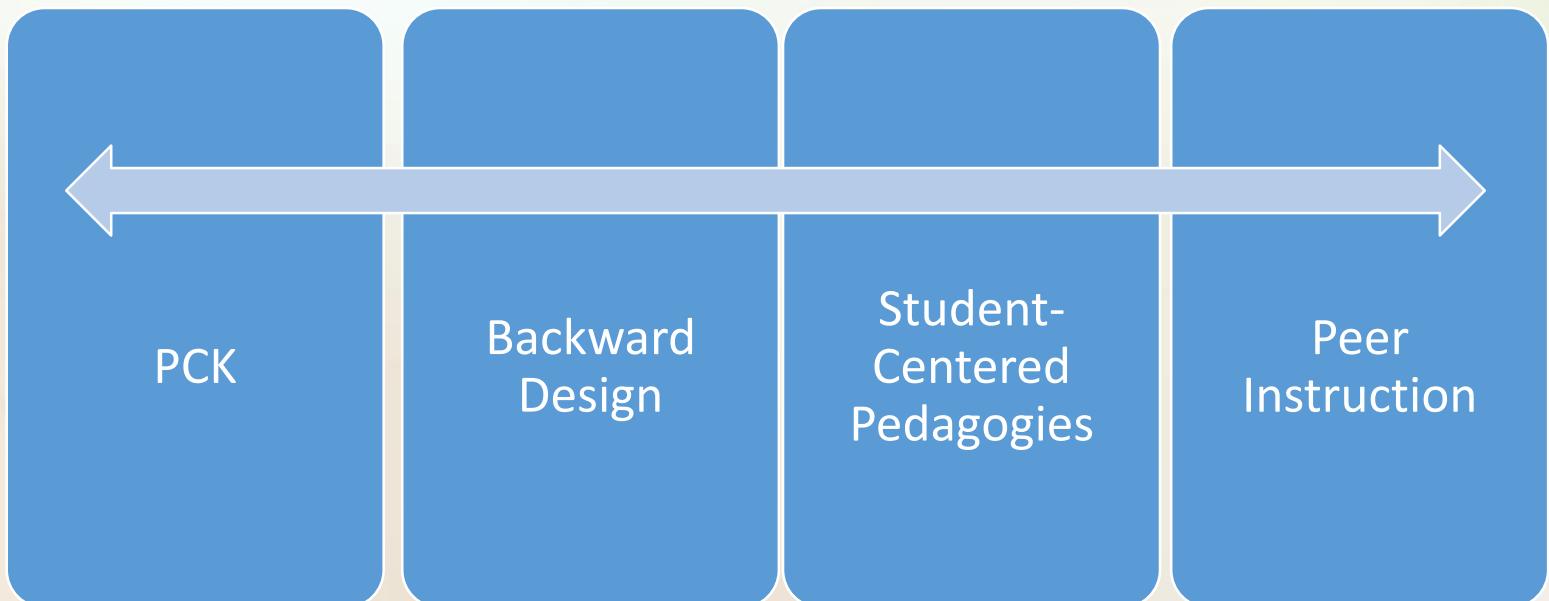
Faculty Development

- Honor versus Remediation
- Learning Communities



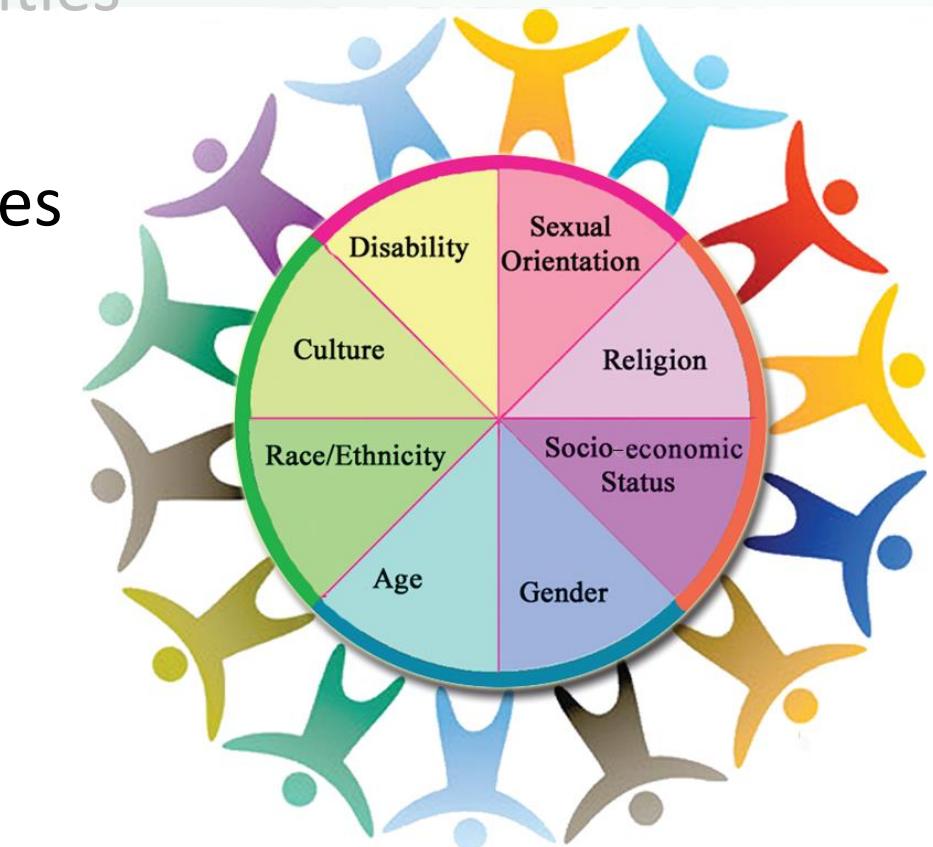
Faculty Development

- Honor versus Remediation
- Learning Communities
- Fundamentals



Faculty Development

- Honor versus Remediation
- Learning Communities
- Fundamentals
- Inclusive Pedagogies

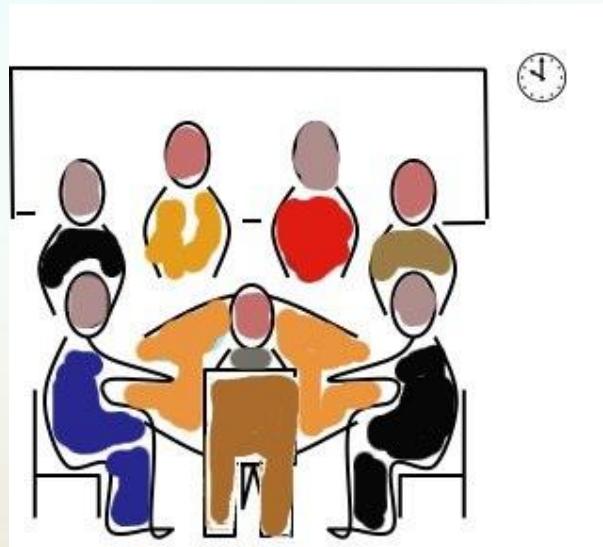


Faculty Development

- Honor versus Remediation
- Learning Communities
- Fundamentals
- Inclusive Pedagogies
- Evaluation and Reward Structures



Discussion



Discussion Questions

- How can development and support of faculty help you in achieving your institutional transformation goal?
- What challenges will you need to address in establishing faculty development efforts toward this goal
 - consider things that are already well addressed in your context versus those that are not yet – e.g. disciplinary differences, departmental/unit readiness, communication on campus, etc.



The Role of Assessment in STEM Education Reform



Assessments and Metrics

- Effective forms of assessment and metrics are essential to educational transformation efforts. We can think about these on at least two levels:
 - At the level of **students**:
 - In individual courses, assessments must align with the desired learning outcomes and pedagogical approaches (cognitive domain)
 - Assessments of transformation efforts should also examine impacts in the affective domain, i.e. students' feelings of belonging, connectedness, and self-efficacy;
 - At the level of **institutions** (and units within institutions), we must have effective tools for measuring progress toward transformational goals.



Student Assessments



Assessments in Courses

- Assessments in individual courses typically are designed to determine:
 - The extent to which students are making progress during instruction (**formative assessment**)
 - The extent to which students have achieved the desired learning outcomes after instruction (**summative assessment**)
- While focused on individual course content, of course these assessments also have implications for programs and institutions.



Traditional Assessments

- Traditional student assessments
 - Tests and quizzes
 - Summative, at end of unit and/or end of term
 - Multiple-choice or short answer format
 - Factual recall or solving particular problem types
 - Emphasize memorization for short-term recall
- Issues with traditional assessments
 - Limited effectiveness in assessing higher order thinking and problem-solving
 - Assess student knowledge largely out of context
 - Do not reflect how science is actually practiced
 - Align with a view of learning as knowledge *acquisition* rather than learning as the *construction* of understanding



Alternative Assessments

- As undergraduate courses adopt more active and learner-centered pedagogical approaches, there is increasing awareness of the need for new assessment approaches.
- Alternative assessment examples
 - Portfolios
 - Performance Assessments
 - Projects
 - Peer Assessments
 - Formative Assessments (e.g., clickers, minute papers, other in-class activities)
 - Rubrics
 - Measures of critical thinking, communication skills, etc.



Key Aspects of Student Assessments for Reform

- Align assessments with desired learning outcomes
- Use both formative and summative assessments
- Assess a range of learning outcomes
- Use multiple forms of assessment
- Assess higher order thinking
- Address real-world contexts

(Hanauer & Bauerle, 2012)



<https://www.aacu.org/publications-research/periodicals/facilitating-innovation-science-education-through-assessment>

Student Assessments – Affective Domain

- Only about 40 % of all students and 20% of underrepresented students admitted into a STEM major receive a bachelor's degree in a STEM discipline (Olsen & Riordan, 2012).
- Active learning strategies show promise for enhancing student success.
- Assessment strategies are needed to identify the mechanisms that explain the effectiveness of active learning strategies.



Key Components of Student Success in the Affective Domain

A growing body of evidence indicates that content instruction alone is no longer sufficient for student success. Students, particularly URM s and women, are more successful when they:

- Feel they are given choices and options about how to perform or present their work (**autonomy**);
- Believe they have mastered the material (**competence**) (Deci, Koestner, & Ryan, 1999; Deci & Ryan, 2000);
- Feel **connected** intellectually and emotionally to other students in the class and to their instructor;
- Find the course material **relevant**.



Measuring Student Success in the Affective Domain

- **Learning Climate Scale** (Black & Deci, 2000; Williams & Deci, 1996) – assesses the extent to which the environment is perceived to support autonomy
- **Basic Psychological Needs** – assesses the extent to which the needs for autonomy, competence, and relatedness are met in the learning environment
- **Classroom Experience Questionnaire (CEQ)** – indicators of student-centered instruction and engagement
- **Student Assessment of their Learning Gains (SALG)** (Seymour, 1997) – student feedback regarding the efficacy of course elements.
- **Focus groups and interviews**



Institutional Measures



Assessment in Institutions

- At an institutional level, assessments are often concerned with questions such as:
 - Is the program of study meeting the needs of students?
 - Are students meeting broad institutional learning outcomes?
 - Are students adequately prepared for future education, work, and life?
 - How cost effective is the educational experience?
 - These questions may not be addressable via typical in-course assessments.



Key Metrics

- Students
 - Graduation rates, retention rates, retention in major, degrees awarded, time to degree, DWF, learning outcomes, etc.
- Faculty
 - Scholarly productivity, external funding, teaching load, promotion/tenure, etc.
- Department/College/Institution
 - Employment outcomes, cost, faculty practices (e.g., learner-centered instruction), infrastructure (e.g., learning spaces), climate/policies (e.g., P&T), etc.



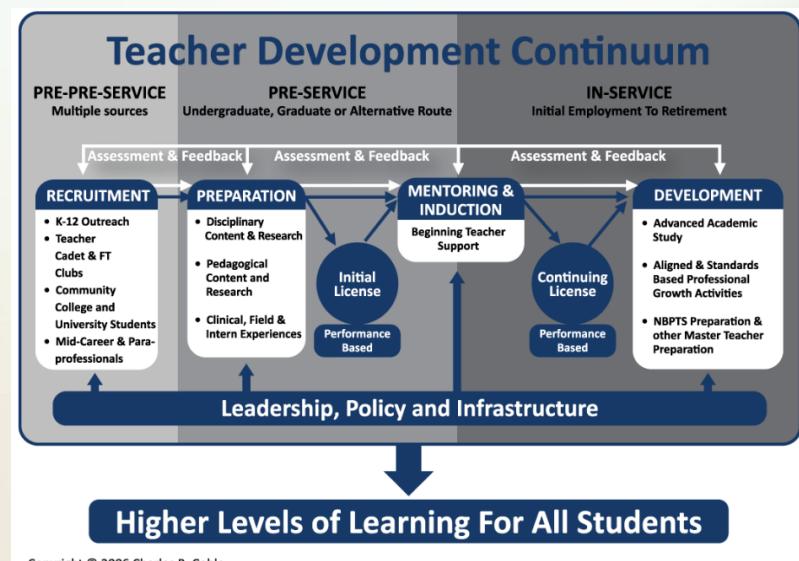
Significant Efforts

- APLU Science and Mathematics Teaching Imperative
 - Teacher Education Program Assessment (TEPA)
- AAC&U
 - Liberal Education and America's Promise (LEAP) Essential Learning Outcomes
 - Valid Assessment of Learning in Undergraduate Education (VALUE)
- AAU STEM Initiative
 - Framework for Systemic Change in Undergraduate STEM Teaching and Learning



APLU SMTI TEPA

- SMTI is focused on increasing the number of math and science teachers prepared each year.
- The Teacher Education Program Assessment (TEPA) was created to analyze and implement better teacher preparation programs. It is used to assess the components of teacher education programs.

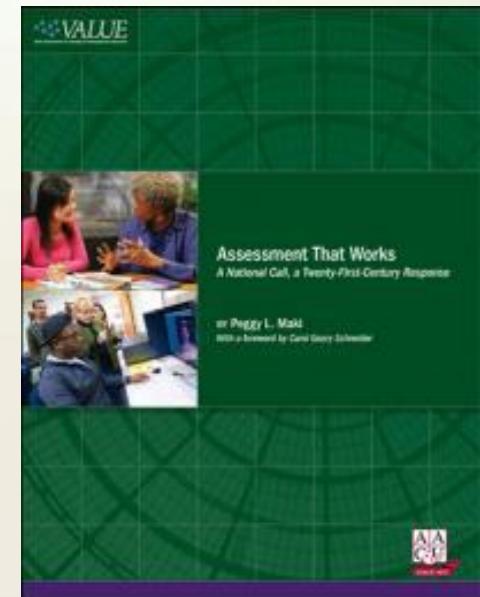


<http://www.aplu.org/projects-and-initiatives/stem-education/science-and-mathematics-teaching-imperative/>
http://www.aplu.org/projects-and-initiatives/stem-education/SMTI_Library/TEPA/file



AAC&U LEAP and VALUE

- LEAP defines essential learning outcomes and the VALUE rubrics are used to assess examples of student work developed in curricular/co-curricular contexts and saved in an e-portfolio.
- The sixteen rubrics align with the LEAP learning outcomes and are intended to bring expert judgment to bear on answering questions about student proficiencies and outcomes related to preparation of students for work and life.



<https://www.aacu.org/leap>
<https://www.aacu.org/value>



Valid Assessment of Learning in Undergraduate Education

ORAL COMMUNICATION VALUE RUBRIC

for more information, please contact value@aacu.org



Definition

Oral communication is a prepared, purposeful presentation designed to increase knowledge, to foster understanding, or to promote change in the listeners' attitudes, values, beliefs, or behaviors.

Evaluators are encouraged to assign a zero to any work sample or collection of work that does not meet benchmark (cell one) level performance.

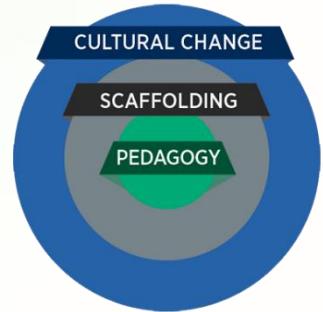
	Capstone 4	Milestones 3	Milestones 2	Benchmark 1
Organization	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is clearly and consistently observable and is skillful and makes the content of the presentation cohesive.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is clearly and consistently observable within the presentation.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is intermittently observable within the presentation.	Organizational pattern (specific introduction and conclusion, sequenced material within the body, and transitions) is not observable within the presentation.
Language	Language choices are imaginative, memorable, and compelling, and enhance the effectiveness of the presentation. Language in presentation is appropriate to audience.	Language choices are thoughtful and generally support the effectiveness of the presentation. Language in presentation is appropriate to audience.	Language choices are mundane and commonplace and partially support the effectiveness of the presentation. Language in presentation is appropriate to audience.	Language choices are unclear and minimally support the effectiveness of the presentation. Language in presentation is not appropriate to audience.
Delivery	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) make the presentation compelling, and speaker appears polished and confident.	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) make the presentation interesting, and speaker appears comfortable.	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) make the presentation understandable, and speaker appears tentative.	Delivery techniques (posture, gesture, eye contact, and vocal expressiveness) detract from the understandability of the presentation, and speaker appears uncomfortable.
Supporting Material	A variety of types of supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that significantly supports the presentation or establishes the presenter's credibility/ authority on the topic.	Supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that generally supports the presentation or establishes the presenter's credibility/ authority on the topic.	Supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make appropriate reference to information or analysis that partially supports the presentation or establishes the presenter's credibility/ authority on the topic.	Insufficient supporting materials (explanations, examples, illustrations, statistics, analogies, quotations from relevant authorities) make reference to information or analysis that minimally supports the presentation or establishes the presenter's credibility/ authority on the topic.
Central Message	Central message is compelling (precisely stated, appropriately repeated, memorable, and strongly supported.)	Central message is clear and consistent with the supporting material.	Central message is basically understandable but is not often repeated and is not memorable.	Central message can be deduced, but is not explicitly stated in the presentation.



See all rubrics at <https://www.aacu.org/value-rubrics>

AAU STEM Initiative

- Assessment goals include:
 - Develop instructor-independent tools to assess student learning
 - Use assessment instruments to measure hard-to-assess outcomes such as scientific thinking and problem-solving
 - Assess student retention
 - Measure achievement gaps and assess the impact of interventions on gaps
 - Develop measures of teaching effectiveness
 - Develop measures of unit commitment to evidence-based teaching
- Framework rubric under development



https://stemedhub.org/groups/aau/File:AAU_Framework_030114.pdf

Example Assessment Tools

- Partnership for Undergraduate Life Science Education (PULSE) Vision and Change Rubric
 - Rubric for assessing departmental transformation
 - <http://www.pulsecommunity.org/page/v-c-certification>
- Western Michigan WIDER Instruments
 - Teaching practices survey and climate survey
 - <https://app.box.com/s/5xbsr88ji7vmzn9aj006>
- Teaching Dimensions Observation Protocol
 - Customizable observation protocol for documenting teaching practices, especially active learning strategies
 - <http://tdop.wceruw.org>



Example Assessment Tools

- **Teaching Practices Inventory (TPI)**
(Wieman & Gilbert, 2014)
 - 10-15 min. self-report survey of teaching practices in a “lecture” course
 - <http://www.cwsei.ubc.ca/resources/TeachingPracticesInventory.htm>
- **Classroom Observation Protocol for Undergraduate STEM (COPUS)**
(Smith, Jones, Gilbert, & Wieman, 2013)
 - Observational protocol for characterizing how faculty and students spend time in the classroom
 - <http://www.cwsei.ubc.ca/resources/COPUS.htm>

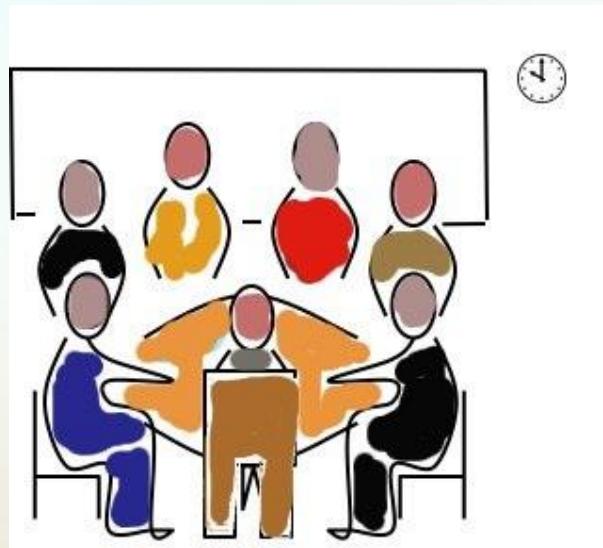


Example Assessment Tools

- National Survey of Student Engagement (NSSE)
<http://nsse.indiana.edu/>
- Student Experience in the Research University (SERU) survey
<http://www.seru.umn.edu/>
- Gallup Purdue Index
<https://www.luminafoundation.org/files/resources/galluppurdueindex-report-2014.pdf>



Discussion



Discussion Questions

- What types of data would help support you in your institutional transformation goal?
- What will you need to consider with respect to implementing assessment efforts to gather these data?



Wrapping Up



Closing Activity

- Write down 2-3 immediate actions to take upon returning to your campus. Consider something you will do on your first day back, something you will do in the first month, and something you will do within the first three months.

Be prepared to report out.



For Slides

- Visit: stemedhub.org

