Course Design Overview

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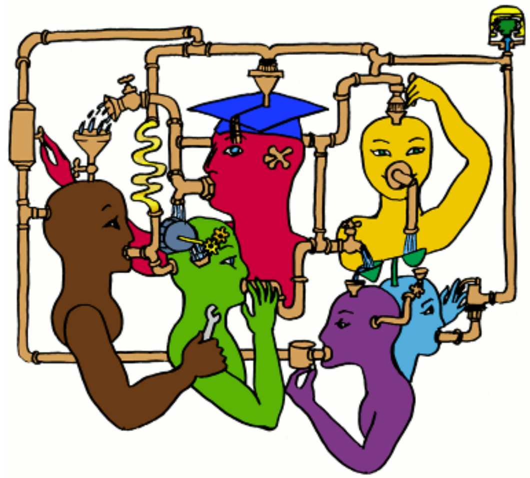
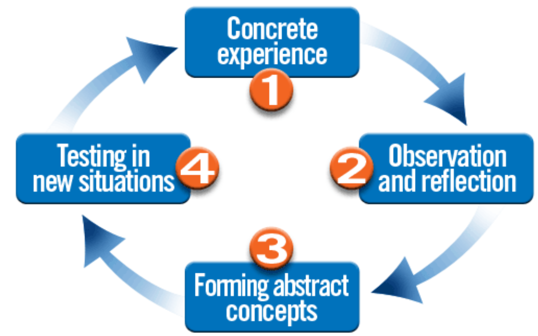
Assertion: Systematic approaches to course design are needed to incorporate findings from research on design, learning, and teaching.

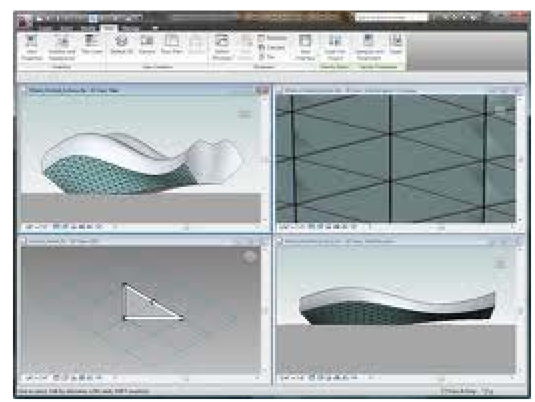
At least 3 research areas contribute to course design.



Learning



Design



I would like to highlight some findings from research on learning.

- Metacognition
- Motivation
- Cognition

Metacognition

$$\int \frac{x}{x^2 - 9} dx$$

Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A. H. Schoenfeld (Ed.), *Cognitive Science and Mathematics Education (pp. 189-215). Hillsdale, NJ: Erlbaum.*

Metacognition

- Your knowledge of your own thought processes
- Monitoring, control, and regulation
- Beliefs about a subject
  - Example: Stereotype threat (Claude Steele)

Steele, C. M. (1997). A threat in the air: How stereotypes shape intellectual identity and performance. *American Psychologist, 52(6), 613-629.*

Motivation

- Autonomy: choice, voice
  - Daniel Pink, Surprising Science of Motivation, TED Talk (http://www.ted.com/talks/dan_pink_on_motivation.html)
  - External incentives (e.g., money) hinder performance on cognitively challenging tasks
- Purpose
- Mastery
  - Fixed mindset vs. growth mindset (Dweck)
  - http://www.youtube.com/watch?v=MTsF2TaEaJA

- Svinicki, M. D. (2005). *Idea Paper #41: Student goal orientation, motivation, and learning.* Manhattan, KS: The IDEA Center, http://www.theideacenter.org/category/helpful-resources/knowledge-base/idea-papers
- Svinicki, M. D. (2004). *Learning and Motivation in the Postsecondary Classroom*. Bolton, MA: Anker Publishing Company.
- Dweck, C. S. (2007). *Mindset: The New Psychology of Success*: Ballantine Books.

External incentives (e.g., money, carrots, sticks) **hinder** performance on cognitively challenging tasks!

One finding from research on cognition is that it is important to envision and communicate the cognitive task.

- Example: physics mechanics
- Example: trick problem
- Bloom’s Taxonomy

Revised Bloom's Taxonomy - Cognitive Domain

	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual						
Conceptual						
Procedural						
Metacognitive						

Think – Pair – Share

What ideas do you have to incorporate findings from research on learning into the design of your courses?

Teaching

- Curse of Knowledge
- Promising Practices (Froyd, 2008)

Promising Practices (Froyd, 2008)

- Prepare a Set of Learning Outcomes
- Organize Students in Small Groups
- Organize Students in Learning Communities
- Scenario-based Content Organization
- Providing Students Feedback through Systematic Formative Assessment
- Designing In-class Activities to Actively Engage Students
- Undergraduate Research
- Faculty-initiated Approaches to Student-faculty Interactions

Froyd, J. E. (2008). *White paper on promising practices in undergraduate STEM education. Paper presented at the Workshop on Evidence on Promising Practices in Undergraduate Science, Technology, Engineering, and Mathematics (STEM) Education. Retrieved March 24, 2009, from* [*http://www7.nationalacademies.org/bose/PP_Froyd_STEM%20White%20Paper.pdf*](http://www7.nationalacademies.org/bose/PP_Froyd_STEM%20White%20Paper.pdf)

Think – Pair – Share

What ideas do you have to incorporate findings from research on teaching into the design of your courses?

What are the more influential stages in the design process?

Need Analysis

Requirements Design

Conceptual Design

Embodiment Design

Detailed Design

What are analogies between design process and course design?

Need Analysis

Requirements Design

?

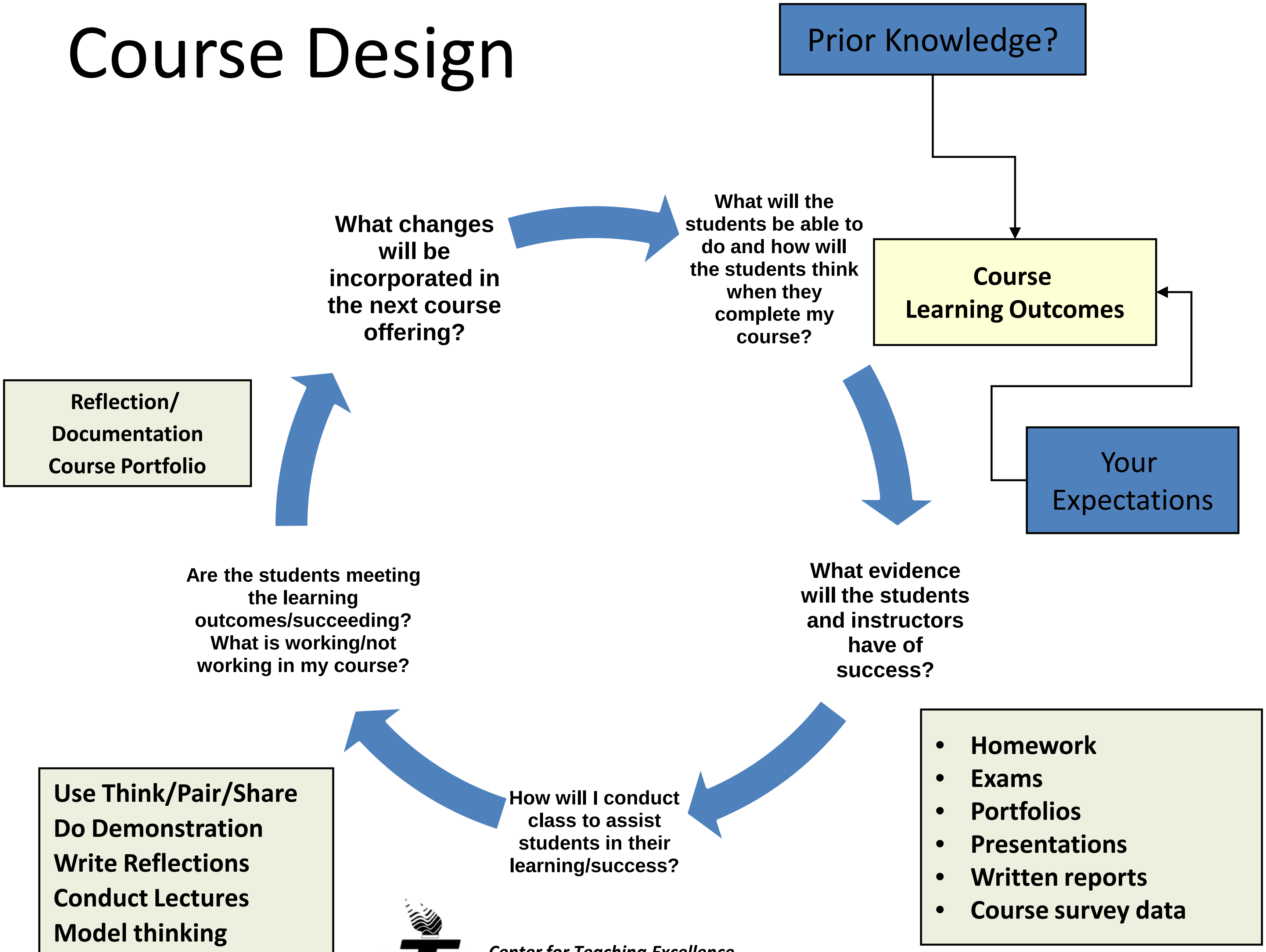
Conceptual Design

?

Embodiment Design

Detailed Design

Course Design



Center for Teaching Excellence at Texas A&M University

Questions?

Promising Practices in Undergraduate STEM Education

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Course Development Decisions

- **Expectations Decision:** How will I articulate and communicate my expectations for student learning?
  - **Traditional Approach: Prepare a list of topics**
- **Student Organization Decision:** How will students be organized as they participate in learning activities?
  - **Traditional Approach: Students work on activities individually**
- **Content Organization Decision:** How will I organize the content for my course? What overarching ideas will I use?
  - **Traditional Approach: Organize topics in a prerequisite chain**
- **Feedback Decision:** How will I provide feedback to my students on their performance and growth?
  - **Traditional Approach: Provide feedback by returning homework and exams**

Course Development Decisions

- **Gathering Evidence for Grading Decision:** How will I collect evidence on which I will base the grades I assign?
  - **Traditional Approach: Exams, writing assignments (e.g., lab reports, project reports), oral presentations, homework**
- **In-classroom Learning Activities Decision:** In what learning activities will students engage in during class?
  - **Traditional Approach: Lecture**
- **Out-of-classroom Learning Activities Decision:** In what learning activities will students engage outside of class?
  - **Traditional Approach: Individual homework**
- **Student-faculty Interaction Decision:** How will I promote student-faculty interaction?
  - **Traditional Approach: Place responsibility for contacting faculty member on students**

Evaluation Standards

- Implementation Standards
  - Implementation standards characterize the extent to which faculty members must change to implement a promising practice.
- Student Performance Standards
  - Student performance standards characterize the extent to which research supports the efficacy (with respect to student learning) of a promising practice.

Implementation Standards

- **Relevance:** Is the option appropriate for the STEM course? For example, innovations in laboratory courses would not be appropriate for non-laboratory courses.
- **Resource Constraints:** Is the option feasible within the constraints of space, time, and instructional resources (e.g., teaching assistants)? Some options may be appropriate for classrooms with significant computer resources, but not applicable for classrooms without these resources.
- **Comfort Level:** To what extent will an option require a faculty member to make adjustments to approaches to teaching? Effort expended to adapt an option for a course might be placed in this or the preceding category.
- **Theoretical Foundation:** Is there theoretical support for an option?

Felder, R. M., Woods, D. R., Stice, J. E., & Rugarcia, A. (2000). The future of engineering education II: Teaching methods that work. *Chemical Engineering Education, 34*(2), 26-39.

Student Performance Standards

- **Comparison Studies:** Comparison of student performance and/or learning between a group of students using promising approach and a group of students using traditional approach
- **Implementation Studies:** Description of implementations in different disciplines at different institutions using promising approach with some student performance information
  - Note: Comparison studies are a more persuasive demonstration of the efficacy of the promising approach

Promising Practice No. 1
Learning Outcomes

- Prepare and use a list of learning outcomes
  - Implementation Standards
    - Strongly supported
  - Student Performance Standards
    - Many implementation studies, but no comparison studies
- Provides an alternative for:
  - **Expectations decision**

Promising Practice No. 1
Learning Outcomes

- Frequently mentioned desirable abilities for STEM graduates
  - Critical thinking
  - Self assessment (part of lifelong learning)
  - Integrative, interdisciplinary thinking
  - Creating/design
  - Systems thinking
  - …
- Challenge: Often these desirable abilities are only articulated in these poorly characterized terms

Promising Practice No. 1
Learning Outcomes

- Critical thinking
  - Susan Wolcott, http://www.wolcottlynch.com
- Self assessment
  - Alverno College, http://depts.alverno.edu/saal/selfassess.html
- Integrative, interdisciplinary thinking
  - (Boix Mansilla & Duraisingh, 2007)
- Creating/design
  - ?
- Systems thinking
  - ?

Boix Mansilla, V., and Duraisingh, E. D. (2007). Targeted Assessment of Students' Interdisciplinary Work: An Empirically Grounded Framework Proposed, *The Journal of Higher Education, 78*(2), 215–237

Promising Practice No. 2
Students Organized in Small Groups

- Students work on activities in small groups
  - Implementation Standards
    - Supported, requires new knowledge and skills for faculty
  - Student Performance Standards
    - Strong support via comparison studies, numerous implementation studies
- Provides an alternative for:
  - **Student organization decision**
  - **In-class activities decision**
  - **Out-of-class activities decision**

Promising Practice No. 2
Students Organized in Small Groups

- Springer, L., Stanne, M. E., and Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. Review of Educational Research, 69(1), 21–51.
- Wage, K. E., Buck, J. R., Wright, C. H. G., and Welch, T. B. (2005). The Signals and Systems Concept Inventory. IEEE Transactions on Education, 48(3), 448–461
- Buck, J. R., and Wage, K. E. (2005). Active and Cooperative Learning in Signal Processing Courses. IEEE Signal Processing Magazine, 22(2), 76–81
- Crouch, C.H., and Mazur, E. (2001). Peer Instruction: Ten years of experience and results. American Journal of Physics, 69(9), 970–977
- Wright, J.C., Millar, S.B., Kosciuk, S.A., Penberthy, D. L., Williams, P.H., and Wampold, B.E. (1998). A Novel Strategy for Assessing the Effects of Curriculum Reform on Student Competence. Journal of Chemical Education, 85(8), 986¬–992
- Prince, M. (2004). Does Active Learning Work? A Review of the Research. Journal of Engineering Education, 93(3), 223–231
- Johnson, D. W., Johnson, R. T., and Smith, K. A. (1998). Cooperative Learning Returns to College: What Evidence Is There That It Works? Change, 30(4), 26–35
- Bowen, C. W. (2000). A Quantitative Literature Review of Cooperative Learning Effects on High School and College Chemistry Achievement. Journal of Chemical Education, 77(1), 116–119
- Felder, R. M., Felder, G. N., and Dietz, E. J. (1998). A Longitudinal Study of Engineering Student Performance and Retention. V. Comparisons with Traditionally-Taught Students. Journal of Engineering Education, 98(4), 469–480
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- Bonsangue, M. (1994). An efficacy study of the calculus workshop model. CBMS Issues in Collegiate Mathematics Education, 4, Providence, RI: American Mathematical Society, 117–137
- Beichner, R. J., Saul, J. M., Abbott, D. S., Morse, J. J., Deardorff, D. L., Allain, R. J., Bonham, J. W., Dancy, M. H., and Risley, J. S. (2007). The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project. Retrieved August 27, 2007, from http://www.compadre.org/Repository/document/ServeFile.cfm?ID=4517&DocID=183
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- Born, W. K., Revelle, W., and Pinto, L. H. (2002). Improving Biology Performance with Workshop Groups. Journal of Science Education and Technology, 11(4), 347– 365

Promising Practice No. 3
Students Organized in Learning Communities

- Learning Communities: One or more structural (and pedagogical) mechanisms to help students relate and connect across multiple courses
  - Relate and connect concepts, ideas, skills, techniques…
  - Relate and connect socially
- "In higher education, curricular learning communities are classes that are linked or clustered during an academic term, often around an interdisciplinary theme, and enroll a common cohort of students. A variety of approaches are used to build these learning communities, with all intended to restructure the students' time, credit, and learning experiences to build community among students, between students and their teachers, and among faculty members and disciplines." (http://www.evergreen.edu/washcenter/lcfaq.htm)

Promising Practice No. 3

Students Organized in Learning Communities

- Organize students in learning communities
  - Implementation Criteria
    - Fair, requires department or inter-department cooperation, cannot be implemented by a single faculty member
  - Student Performance Criteria
    - Fair support via comparison studies, some implementation studies
- Provides alternatives for:
  - **Student organization decision**
  - **Content organization decision**
  - **In-class activities decision**
  - **Out-of-class activities decision**
  - **Student-faculty connection decision**

Promising Practice No. 3

Students Organized in Learning Communities

- Froyd, J., and Ohland, M. (2005). Integrated Engineering Curricula, *Journal of Engineering Education, 94*(1), 147–164.
- Smith, B. L., J. MacGregor, R. Matthews, and F. Gabelnick. 2004. *Learning Communities: Reforming Undergraduate Education*. San Francisco, CA: Jossey-Bass.

Promising Practice No. 4

Scenario-based Content Organization

- Organize content around carefully posed scenarios
  - Implementation Criteria
    - Strongly supported
  - Student Performance Criteria
    - Good support via comparison studies, numerous implementation studies
- Provides an alternative for:
  - **Student organization decision (typically)**
  - **Content organization decision**
  - **In-class activities decision**
  - **Out-of-class activities decision**

Promising Practice No. 4

Scenario-based Content Organization

- Labels
  - Inquiry-based learning
  - Problem-based learning
  - Project-based learning
  - Challenge-based learning – VaNTH Engineering Research Center (Cordray, et al., 2003)
  - Model-eliciting activities
  - Question-directed instruction (Beatty, et al., 2008)

- Scenarios differ in:
  - Length of activity
  - Support offered during activity (Kirschner, Sweller, & Clark, 2006; Mayer, 2004)
  - Guidelines for developing scenarios

Cordray, D. S., Pion, G. M., Harris, A., & Norris, P. (2003). The value of the VaNTH Engineering Research Center: Assessing and evaluating the effects of educational innovations on large educational research projects in bioengineering. *IEEE Engineering in Medicine and Biology Magazine, 22*, 47–54.

Beatty, I. D., Leonard, W. J., Gerace, W. J., Dufresne (2006). Question Driven Instruction: Teaching Science (Well) with an Audience Response System. In Banks, D. A. (ed.) *Audience Response Systems in Higher Education: Applications and Cases*, Hershey, PA: Information Science Publishing.

Kirschner, P. A., Sweller, J, and Clark, R. E. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. Educational Psychologist, 41(2), 75–86.

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Promising Practice No. 4

Scenario-based Content Organization

- Prince, M. J., and Felder, R. M. (2006). Inductive Teaching and Learning Methods: Definitions, Comparisons, and Research Bases. *Journal of Engineering Education, 95*(2), 123–138.
- Prince, M., and Felder, R. (2007). The Many Faces of Inductive Teaching and Learning. *Journal of College Science Teaching, 36*(5), 14–20
- Dochy, F., Segers M., Van den Bossche, P., and Gijbels, D. (2003). Effects of Problem-Based Learning: A Meta-Analysis. *Learning and Instruction, 13*, 533–568
- Gijbels, D., Dochy, F., Van den Bossche, P., and Segers, M. (2005). Effects of Problem-Based Learning: A Meta-Analysis from the Angle of Assessment. *Review of Educational Research, 75*(1), 27–61
- Vernon, D. T. A., and Blake, R. L. (1993). Does Problem-Based Learning Work? A Meta-Analysis of Evaluative Research. *Academic Medicine, 68*, 550–563.
- Capon, N., and Kuhn, D. (2004). What's So Good About Problem-Based Learning? *Cognition and Instruction, 22*(1), 61–79
- Farrell, J. J., Moog, R. S., and Spencer, J. N. (1999). A Guided Inquiry General Chemistry Course. *Journal of Chemical Education, 74*(4), 570–574
- Lewis, S. E., and Lewis, J. E. (2005). Departing from Lectures: An Evaluation of a Peer-Led Guided Inquiry Alternative. *Journal of Chemical Education, 82*(1), 135–139
- Roselli, R. J., and Brophy, S. P. (2006). Effectiveness of Challenge-Based Instruction in Biomechanics. *Journal of Engineering Education, 95*(4), 311–324.

Promising Practice No. 5

Feedback through Systematic Formative Assessment

- Design a systematic plan for formative assessment activities primarily for the purpose of providing feedback to students about their learning
  - Implementation Criteria
    - Supported
  - Student Performance Criteria
    - Fair support via comparison studies, some implementation studies
- Provides an alternative for:
  - **Feedback decision**

Promising Practice No. 5

Feedback through Systematic Formative Assessment

- “A recent review (Black and William, 1998) revealed that classroom-based formative assessment, when appropriately used, can positively affect learning.....students learn more when they receive feedback about particular qualities of their work, along with advice on what they can do to improve” (National Research Council, 2001)

- National Research Council (2001). *Knowing What Students Know: The Science and Design of Educational Assessment.* Washington, DC: National Academies Press.
- Black, P., & Wiliam, D. (1998). Assessment and Classroom Learning. *Assessment in Education: Principles, Policy & Practice, 5*(1), 7–74.

Promising Practice No. 5

Feedback through Systematic Formative Assessment

- Approaches for formative feedback
  - Classroom assessment techniques (Angelo & Cross, 1993)
    - Minute Paper (Stead, 2006)
  - Classroom response systems
    - Summary (Fies & Marshall, 2006)
    - Peer Instruction (Mazar, 1997; Crouch & Mazur, 2001)

- Angelo, T. A., & Cross, P. K. (1993). *Classroom Assessment Techniques: A Handbook for College Teachers* (Second ed.). San Francisco, CA: Jossey-Bass.
- Stead, D. R. (2005). A review of the one-minute paper. *Active Learning in Higher Education, 6(*2), 118–131.
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- Mazur, E. (1997). *Peer Instruction: A User's Manual*. Upper Saddle River, NJ: Prentice Hall
- Crouch, C.H., and Mazur, E. (2001). Peer Instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970–977

Promising Practice No. 6

Designing In-class Activities to Actively Engage Students

- Design in-class activities to actively and purposively engage students in a variety of challenging exercises that extend beyond listening
  - Implementation Criteria
    - Solidly supported
  - Student Performance Criteria
    - Strong support via comparison studies, numerous implementation studies
- Provides an alternative for:
  - **In-class activities decision**

Promising Practice No. 6

Designing In-class Activities to Actively Engage Students

- Crouch, C.H., and Mazur, E. (2001). Peer Instruction: Ten years of experience and results. *American Journal of Physics, 69*(9), 970–977.
- Burrowes, P. A. (2003). A Student-Centered Approach to Teaching General Biology That Really Works: Lord's Constructivist Model Put to a Test. *The American Biology Teacher, 65*(7), 491–502.
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- Hoellwarth, C., Moelter, M. J., and Knight, R. D. (2005). A direct comparison of conceptual learning and problem solving ability in traditional and studio style classrooms. *American Journal of Physics, 73*(5), 459–462.
- Michael, J. (2006). Where's the evidence that active learning works? *Advances in Physiology Education, 30*, 159–167.
- Knight, J. K., and Wood, W. B. (2005). Teaching More by Lecturing Less. *Cell Biology Education, 4*, 298–310.
- Freeman, S., O'Connor, E., Parks, J. W., Cunningham, M., Hurley, D., Haak, D., Dirks, C., and Wenderoth, M. P., (2007). Prescribed Active Learning Increases Performance in Introductory Biology. *Cell Biology Education, 6*, 132–139.

Promising Practice No. 7

Undergraduate Research

- Undergraduate research
  - Implementation Criteria
    - Significant resources to support one-to-one relationships, other models may offer opportunities for greater student participation
  - Student Performance Criteria
    - Some implementation studies, no known comparison studies
    - Supported via literature on the value student engagement with faculty
- Provides an alternative for:
  - **Multiple decisions**

Promising Practice No. 7

Undergraduate Research

- Seymour, E., Hunter, A.-B., Laursen, S. L., and Diatonic, T. (2004). Establishing the Benefits of Research Experiences for Undergraduates in the Sciences: First Findings from a Three-Year Study. *Science Education, 88*, 493–534.
- Lopatto, D. (2004). Survey of Undergraduate Research Experiences (SURE): First Findings. *Cell Biology Education, 3*, 270–277..
- Hunter, A.-B., Laursen, S. L., and Seymour, E. (2007). Becoming a Scientist: The Role of Undergraduate Research in Students' Cognitive, Personal, and Professional Development. *Science Education, 91*, 36–74.
- Russell, S. H., Hancock, M. P., and McCullough, J. (2007). Benefits of Undergraduate Research Experiences. *Science, 316*, 548–549.

Promising Practice No. 8

Faculty-initiated Approaches to Student-faculty Interactions

- Require students to make initial contact with faculty, use multiple communications channels to maintain contact
  - Implementation Standards
    - Easily adapted, with possible exception for large classes
  - Student Performance Standards
    - Some implementation studies, no known comparison studies
    - Supported via literature on the value student engagement with faculty
- Provides an alternative for:
  - **Student-faculty interaction decision**