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Creating a Safer and Healthier World by Advancing the Science of Toxicology

Undergraduate Educator Network Webinar Series

Sponsored by

Undergraduate Education Subcommittee
SOT Education Committee

April 8, 2015
12:00 Noon ET

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Welcome

Mindy Reynolds, PhD

Chair, Undergraduate Subcommittee

Washington College

Joshua Gray, PhD

Chair, Webinar Series

US Coast Guard Academy

Associate Professor

Undergraduate Educator Webinar

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Evidence-Based Instructional Practices in Undergraduate Science Courses

Bethany Bowling, PhD
Associate Professor
Northern Kentucky University,
Highland Heights, KY

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Facilitator Background

- Interdisciplinary Ph.D. - Biology Education
- Northern Kentucky University since 2007
  - Large, introductory biology
  - Mid-size, sophomore-level genetics
- PI for an NSF STEP Type 1A project
- American Society of Human Genetics
  - Information & Education Committee
  - Undergraduate Faculty Workshop

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Webinar Structure

- Overview of characteristics of evidence-based teaching practices
- Discussion of Teaching Practices Inventory and reflection on our own teaching
- Two examples
  - problem-based team learning in an introductory biology course
  - course-based research involving bioinformatics in a mid-level genetics course

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Learning Outcomes

Participants will be able to:

- list qualities of evidence-based instructional practices
- measure their use of evidence-based instructional practices
- identify areas within their teaching to incorporate evidence-based instructional practices
- find resources for incorporating evidenced-based instructional practices

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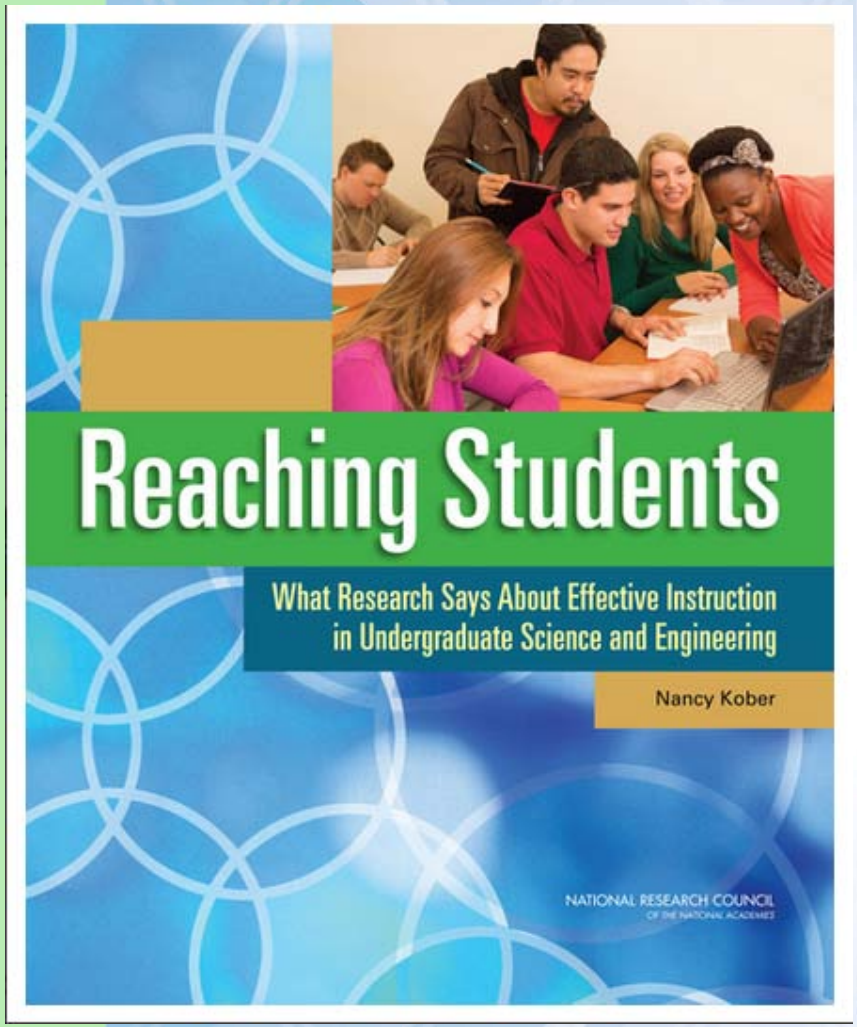

"The students who work hard do well in your courses, and your evaluations are good, perhaps outstanding. While there are certainly things you could tweak, the other demands on your time—including, in many cases, your own research agenda—may make you hesitant to tamper with a solid course."

"So why take time to investigate effective approaches to teaching and learning? Why make the effort to redesign a course or program that on the whole seems to be working well?

A short answer comes from the experiences of many instructors around the country—successful by standard criteria—who reviewed the research on learning, reflected on their teaching, and found it wanting."

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I was using active learning but…

- Questioning prior knowledge
- Class discussion
- Personal response system (clickers)
- Small group activities
- Students arriving late and leaving early
- Attendance ~75%
- Class and small group discussion engaged only portion of the students

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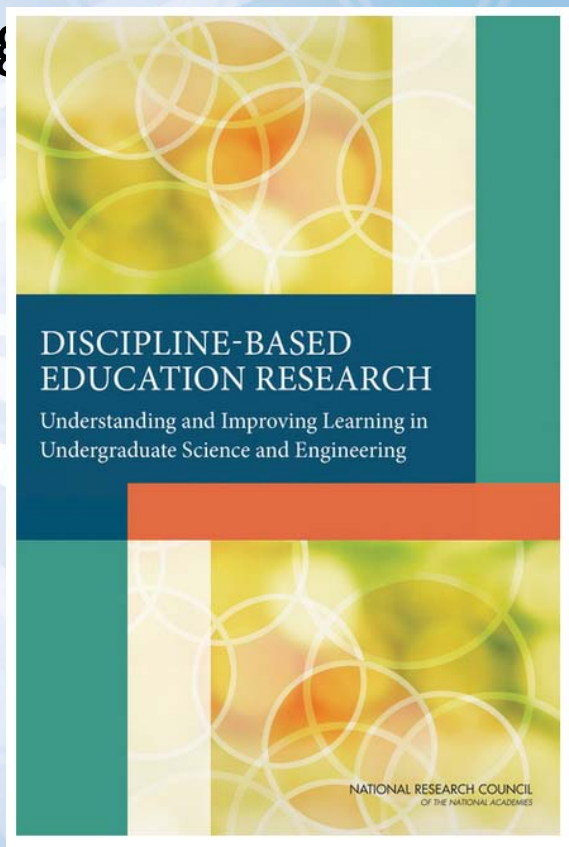
Evidence-Based Instructional Practices

Discipline-Based Education Research

- Investigates learning and teaching in a discipline using a range of methods with deep grounding in that discipline's priorities worldview, knowledge, and practices
- Informed by and complementary to general research on human learning and cognition



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What is DBER?

	Action Research	SoTL	DBER
Subject of research	▪ K-12 class	▪ College course	▪ Post-secondary education specific to a discipline
Researcher	▪ Teacher of the class	▪ Instructor of the course	▪ Usu. not the instructor
Scope of findings	▪ Specific to the class	▪ Specific to the course	▪ Generalizable
Audience for findings	▪ Researcher	▪ Researcher and Public	▪ Public
Governing research questions	▪ How can I improve my own teaching? ▪ How can I improve the learning of students' in my K-12 class?	▪ How can I improve my own teaching? ▪ How can I improve the learning of students in my college course?	▪ How do undergraduate students learn a specific discipline? ▪ What are the best methods for achieving understanding within that discipline?
Motivation behind research	▪ Teachers (actors) should study their own teaching (action). ▪ Understand one's own teaching and students, to improve learning in your own personal teaching context and class.	▪ Systematically reflect on one's own teaching and students, to improve learning in teacher-researcher's own personal teaching context and course. ▪ Bring same level of rigor in one's scholarly research to one's teaching.	▪ Understand disciplinary-level impediments to student learning and interventions to enhance student learning. ▪ Research is broadly applicable beyond a single course.

http://www.unl.edu/dber/action-research-sotl-dber

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Fundamentals of Human Learning & Cognition

- Students generate their own understanding and form meaning as a result of their experiences and ideas
- Students' prior knowledge may hinder or promote learning
  - Students have misunderstandings about a wide range of fundamental concepts
- Students enrich their understanding by interacting with others

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Evidence-Based Instructional Practices

Discipline-based education research typically compares:

- Student-centered vs teacher-centered
- Active learning vs passive learning

Comparison of Teacher-centered and Learner-centered paradigms

(Learner-Centered Assessment on College Campuses by Huba and Freed 2000)

Teacher-Centered Paradigm	Learner-Centered Paradigm
Knowledge is transmitted from professor to students	Students construct knowledge through gathering and synthesizing information and integrating it with the general skills of inquiry, communication, critical thinking, problem solving and so on
Students passively receive information	Students are actively involved
Emphasis is on acquisition of knowledge outside the context in which it will be used	Emphasis is on using and communicating knowledge effectively to address enduring and emerging issues and problems in real-life contexts
Professor's role is to be primary information giver and primary evaluator	Professor's role is to coach and facilitate Professor and students evaluate learning together
Teaching and assessing are separate	**Teaching and assessing are intertwined**
Assessment is used to monitor learning	**Assessment is used to promote and diagnose learning**
Emphasis is on right answers	Emphasis is on generating better questions and learning from errors
Desired learning is assessed indirectly through the use of objectively scored tests	**Desired learning is assessed directly through papers, projects, performances, portfolios, and the like**
Focus is on a single discipline	Approach is compatible with interdisciplinary investigation
Culture is competitive and individualistic	Culture is cooperative, collaborative, and supportive
Only students are viewed as learners	Professor and students learn together

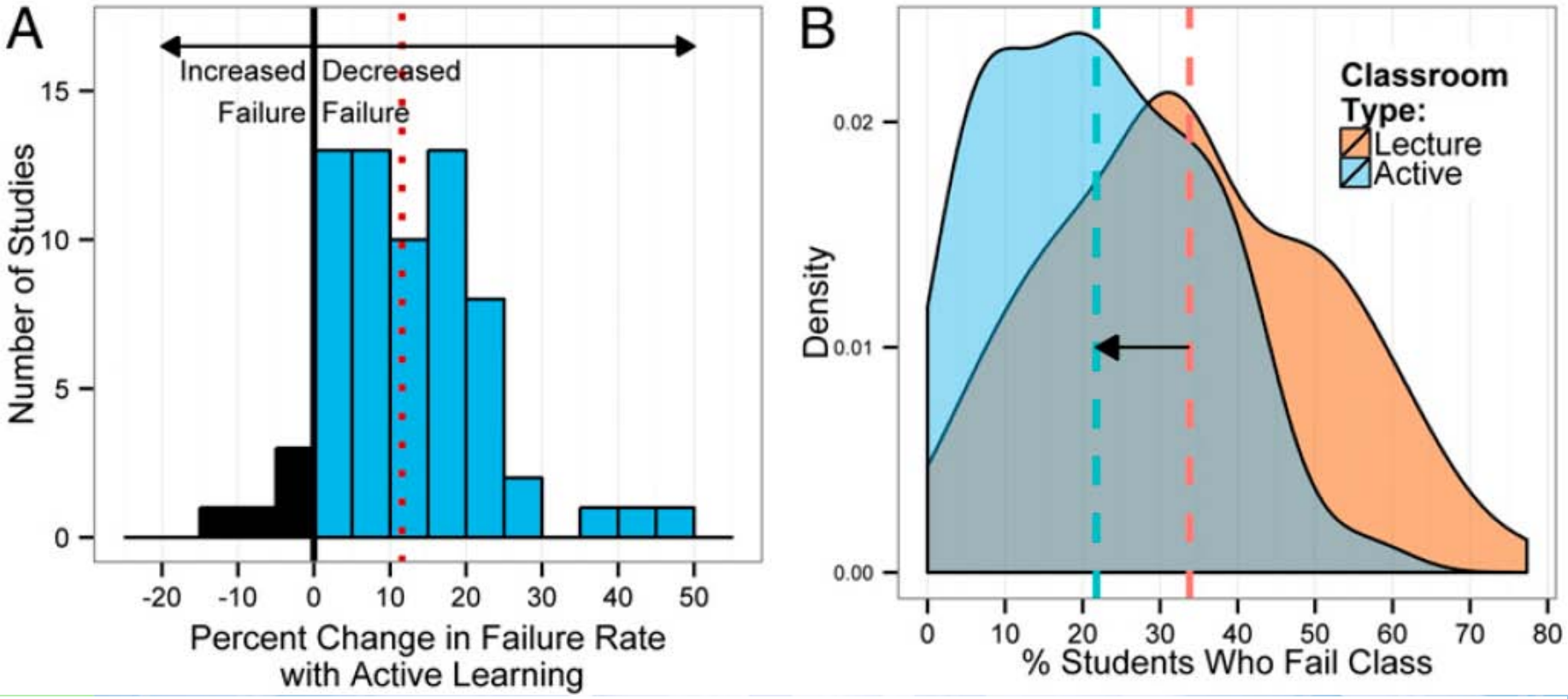

Fig. 1. Changes in failure rate. (*A*) Data plotted as percent change in failure rate in the same course, under active learning versus lecturing. The mean change (12%) is indicated by the dashed vertical line. (*B*) Kernel density plots of failure rates under active learning and under lecturing. The mean failure rates under each classroom type (21.8% and 33.8%) are shown by dashed vertical lines.

Freeman, Scott, et al. "Active learning increases student performance in science, engineering, and mathematics." *Proceedings of the National Academy of Sciences* 111.23 (2014): 8410-8415.

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Evidence-Based Instructional Practices

1. Activates ways of thinking that can help novices integrate or replace their prior knowledge with new information to construct more expert-like understanding
2. Allows learners to build understanding by applying the methods and principles of a discipline (actively engaging students in meaningful individual and/or group tasks)
3. Frequent formative assessment

Expert vs. Novices

Novice **Expert**

- Experts possess schemas (organizational frameworks) that guide perception and problem-solving
- Novices do not always connect the relevant knowledge they do have to new tasks
- Novices may focus on aspects of a problem, such as superficial details, that make it more difficult rather than easier to solve

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Questions regarding overview of characteristics of EBIPs?

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  - problem-based team learning in an introductory biology course

Teaching Practices Inventory

- Consists of eight sections reviewing:
  - Course information
  - Supporting materials
  - In-class activities
  - Assignments
  - Feedback and testing
  - Training and guidance of teaching assistants
  - Collaboration or sharing in teaching

http://www.cwsei.ubc.ca/resources/TeachingPracticesInventory.htm

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Reflecting on the TPI

- Did the questions align with your original qualities of effective teaching? Were there any questions that you found surprising? Why or why not?

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Reflecting on the TPI

- How does your teaching align with the practices asked about in the TPI? Can you identify areas of increasing your use of EBIPs?

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TPI Items

- Metacognition
- Learning Goals
- Affective Domain
- Collaborative Learning
- Assessment

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Metacognition

- "Thinking about thinking"
  - Monitoring progress as one learns
  - Making changes and adapting strategies
- Preassessments – what do they already know
- Encourage reflection on learning
  - Muddiest point
- Model the thinking process
- Feedback from students to instructor – midterm course evaluation

http://cft.vanderbilt.edu/guides-sub-pages/metacognition/

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Establishing Learning Goals

- Learning goals guide decisions about instruction
- Tell students explicitly what the learning goals are and remind them to reinforce what they need to study
- Reinforce metacognition

http://www.cwsei.ubc.ca/resources/learn_goals.htm

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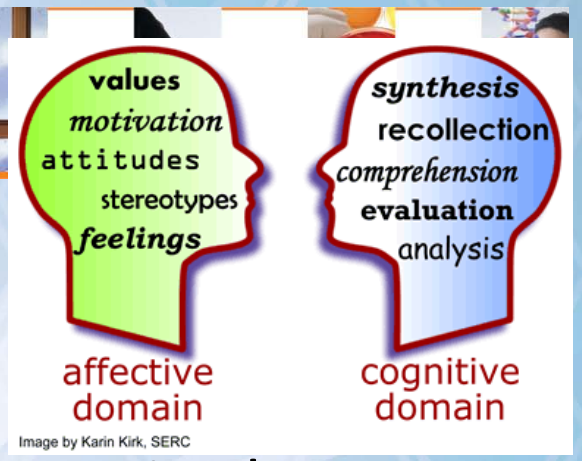

Affective Domain

- Improve student learning by engaging attitudes, motivation, believes, and other factors
  - Give frequent, early, positive feedback that supports students' beliefs that they can do well.
  - Ensure opportunities for students' success by assigning tasks that are neither too easy nor too difficult.
  - Help students find personal meaning and value in the material.
  - Create an atmosphere that is open and positive.
  - Help students feel that they are valued members of a learning community.

http://serc.carleton.edu/NAGTWorkshops/affective/index.html

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Assessment

- Formative vs. summative
- Frequent – inform student and instructor of progress
- How just as important as correct?
- Aligned with learning goals
- Assess the individual as well as the group (example)

http://www.nap.edu/catalog/18687/reaching-students-what-research-says-about-effective-instruction-in-undergraduate

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Collaborative Learning

- Collaborative activities enhance the effectiveness of student-centered learning
  - Establish a community, positive effect on motivation
  - Help each other solve problems, build on each other's knowledge
  - Challenge each other's thoughts and beliefs
- Can be accomplished with large classes (example)

http://www.cte.cornell.edu/teaching-ideas/engaging-students/collaborative-learning.html

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Questions regarding TPI?

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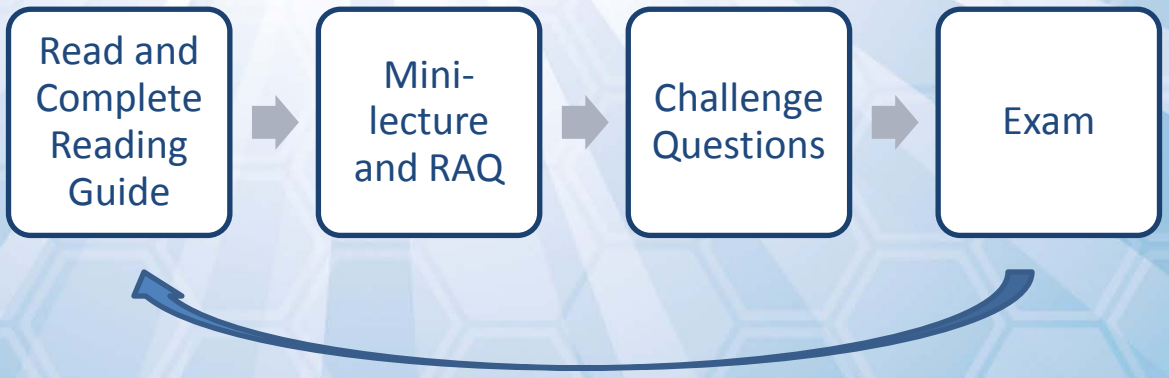
Problem-Based Team Learning in Introductory Biology Course

- ~100 students in teams of 5
- Two instructors and two undergraduate teaching assistants
- Explicit reading guides
- Frequent formative evaluation
- Brief mini-lectures (~15 min)
- Exams



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Frequent Formative Evaluation & Collaboration

- Readiness Assessment Quizzes (RAQs)
- Team Challenge Questions – application of concepts

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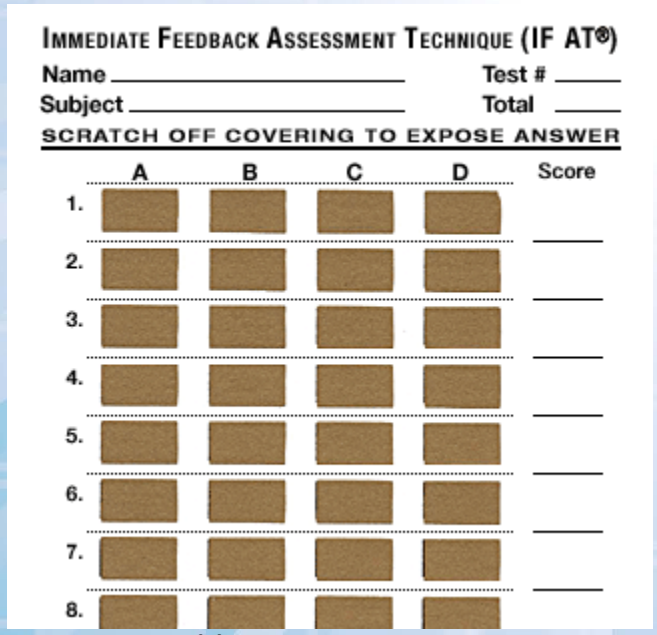
Frequent Formative Evaluation & Collaboration

- Personal response system ("clickers") individually
- IF-AT Forms for team responses



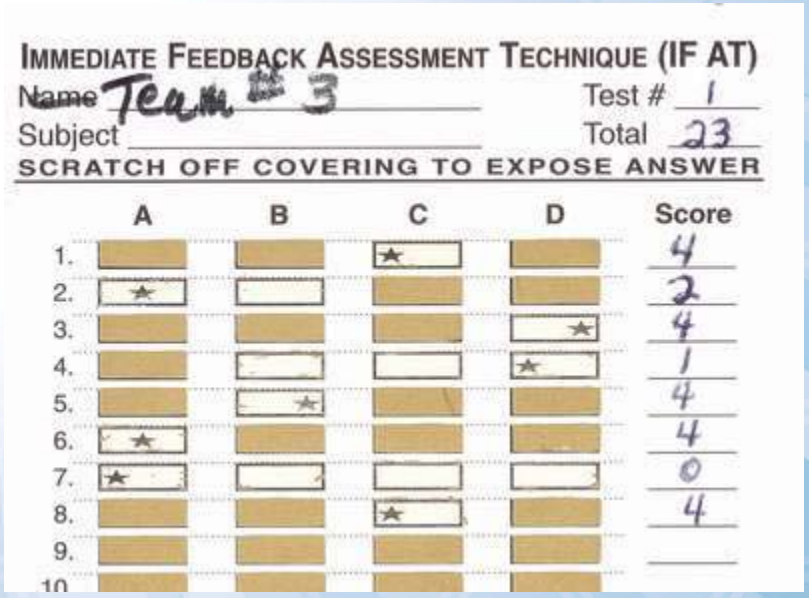
IMMEDIATE FEEDBACK ASSESSMENT TECHNIQUE (IF AT®)

Name _____ Test # _____

Subject _____ Total _____

SCRATCH OFF COVERING TO EXPOSE ANSWER

	A	B	C	D	Score
1.					
2.					
3.					
4.					
5.					
6.					
7.					
8.					



IMMEDIATE FEEDBACK ASSESSMENT TECHNIQUE (IF AT)

Name Team # 3 Test # 1

Subject _____ Total 23

SCRATCH OFF COVERING TO EXPOSE ANSWER

	A	B	C	D	Score
1.			★		4
2.	★				2
3.				★	4
4.				★	1
5.		★			4
6.	★				4
7.	★				0
8.			★		4
9.					
10					

http://www.epsteineducation.com/home/Default.aspx

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Frequent Formative Evaluation & Collaboration

- Team Challenge Questions

4. Which of the following statements are correct? Use the space below each statement to explain why it is either CORRECT or INCORRECT.

a. Proteins are so remarkably diverse because each is made from a mixture of amino acids that are linked in random order.

b. Lipid bilayers are macromolecules that are made up mostly of phospholipid subunits.

c. Nucleic acids contain sugar groups.

d. Many amino acids have hydrophobic side chains.

e. The hydrophobic tails of phospholipid molecules are repelled from water.

f. DNA contains the four bases A, G, U and C.

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Summative Feedback & Grading

- Traditional multiple choice exams – comparable to previous semesters
- Grading

Exams Semester Exams (4) + Comprehensive Final	= 50%
Semester Exams (4) = 33%	
Comprehensive Final = 17%	
RAQs and in-class activities	= 20%
Laboratory score	= 30%

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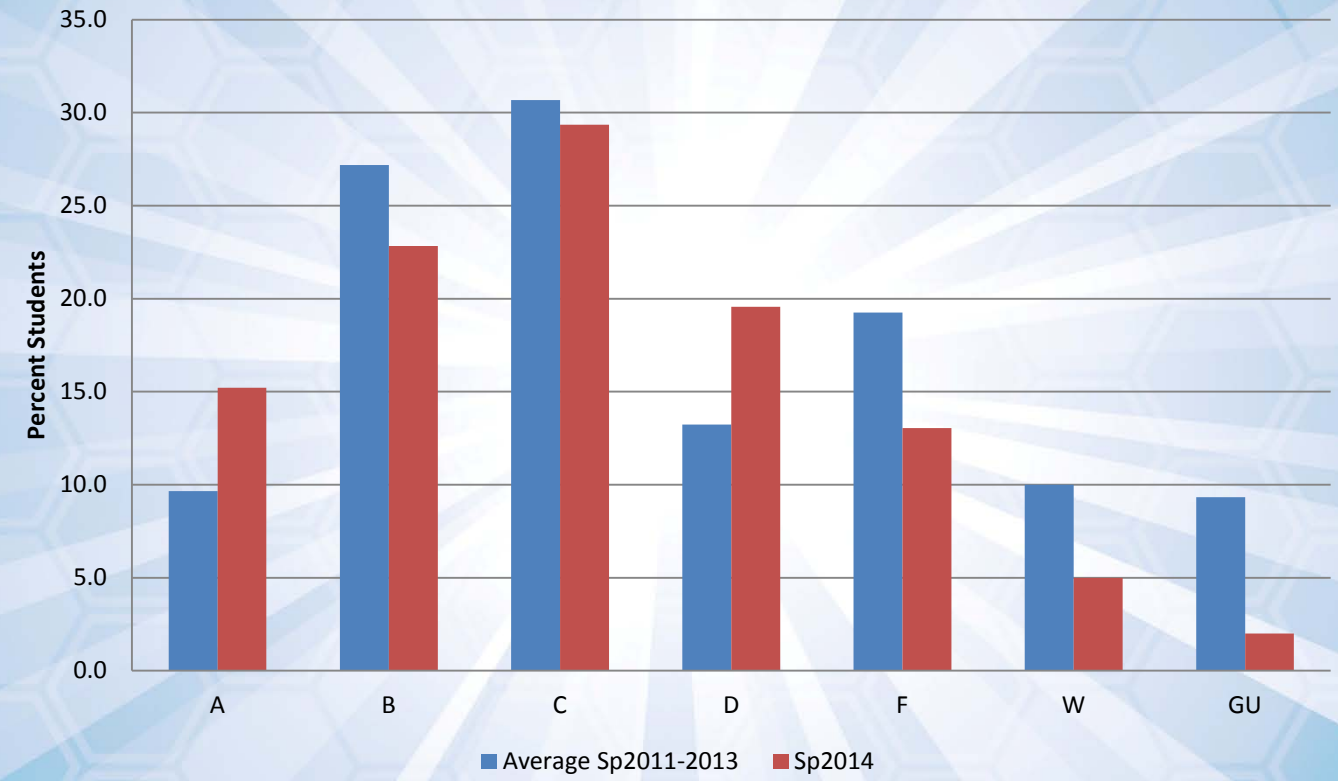
Comparison of grades from 2011-2013 and Spring 2014



- "GU" – give-up, stop coming to class
- Class attendance ~95%

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Course-Based Research in Genetics Laboratory

- Focus on the process of science, data interpretation, synthesis of data
- Authentic research using bioinformatics tools in a sophomore/junior-level genetics course
  - Annotate genes in *Pseudomonas fluorescens* R124, an isolate from a nutrient-limited cave environment (http://img.jgi.doe.gov/cgi-bin/edu/main.cgi)

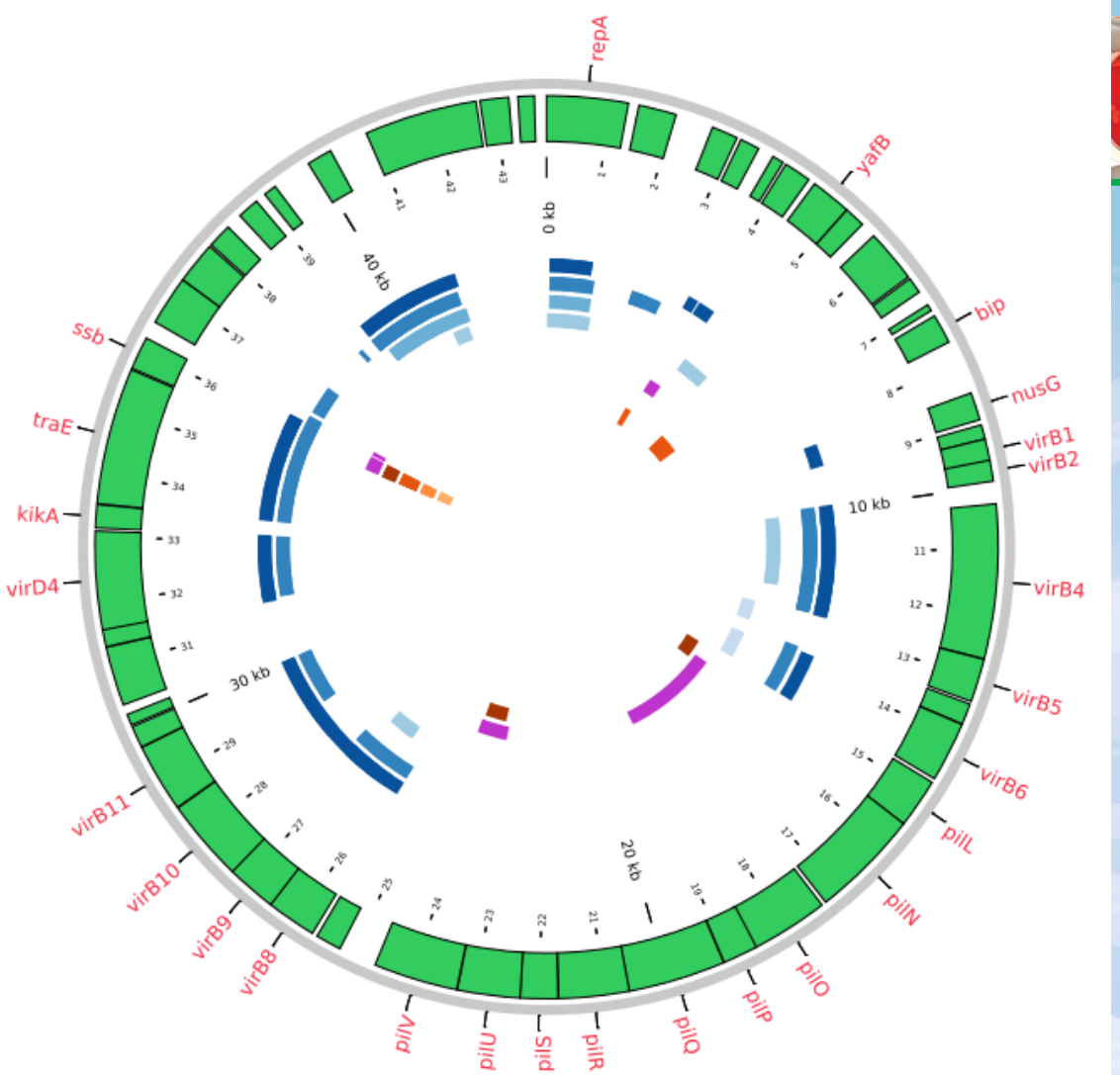

FIG 5 Map of *P. fluorescens* pMP-R124 plasmid. Genes are shown in the green outer track and labeled using sequence similarity to database sequences where possible. Inner tracks show regions of similarity to reference sequences and are color coded by type: the blue tracks represent plasmid sequences from *Pseudomonas syringae*, the purple track shows alignment to the *P. aeruginosa* PA07 genome (52), and the orange tracks represent alignments to *P. fluorescens* genomes. Amino acid identity to reference genes can be found in Table S9 in the supplemental material. The accession numbers used to generate the alignment tracks are, from outer to inner, as follows: AY603979.1, CP000060.1, AY603980.1, CP000059.1, AY603982.1, CP000744.1, CP000076.1, CP000094.2, AM181176.4, and AY887963.3.

Barton, Michael D., et al. "The genome of Pseudomonas fluorescens strain R124 demonstrates phenotypic adaptation to the mineral environment." *Journal of bacteriology* 195.21 (2013): 4793-4803.

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Course-Based Research in Genetics Laboratory

- Annotate hypothetical genes in *Saccharomyces cerevisiae* genome (http://wiki.yeastgenome.org/index.php/Educational_Resources)
- Create knock-outs and phenotype testing

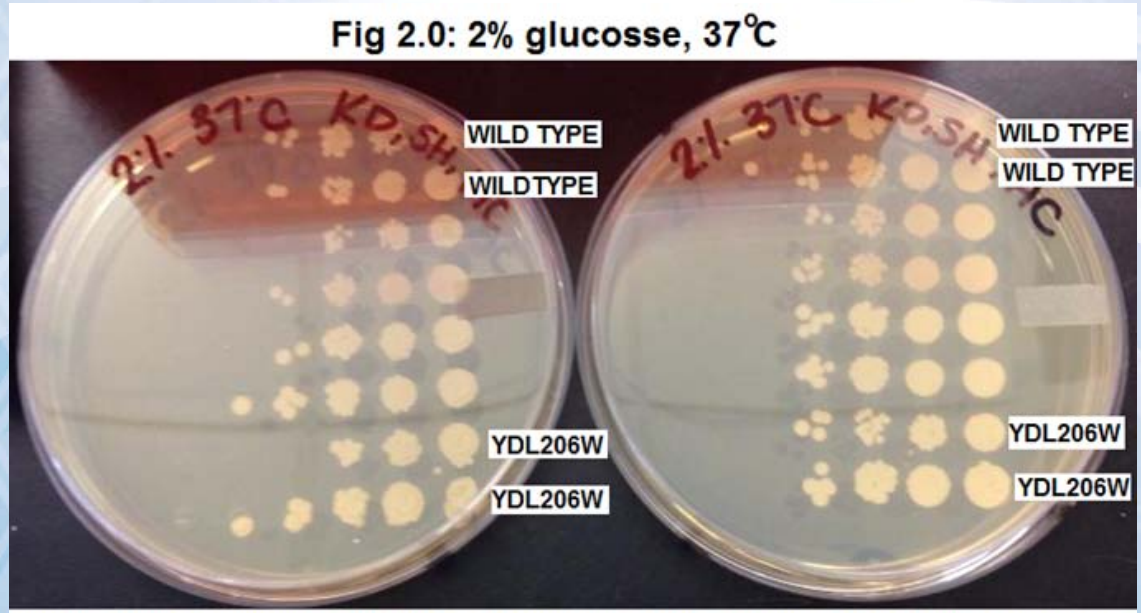

Fig 2.0: 6 rows, 6 columns. Rows 1 and 2 are wild type. Rows 7 and 8 are YDL206W deletion strain

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Course-Based Research in Genetics Laboratory

- Assessment
  - Student gains in knowledge
  - Gains in confidence regarding scientific investigations
  - Portion of students were overwhelmed, need to better prepare in introductory lab
- Implementation challenges
  - Enthusiastic instructors required

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Questions about examples?

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Making Real Change

- Take advantage of existing resources
- Participate in professional development
  - Research shows this needs to be significant - duration of four weeks or more
- Start small
- Know that you will encounter challenges
- Garner support from colleagues
  - Join a learning community
  - Co-teach a course

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Measuring Evidenced-Based Teaching

- Describing & Measuring Undergraduate STEM Teaching Practices from AAAS: http://ccliconference.org/files/2013/11/Measuring-STEM-Teaching-Practices.pdf
  - Teaching Practices Inventory (TPI) – self-report
  - Classroom Observation Protocol for Undergraduate STEM (COPUS) – observation
  - Reformed Teaching Observation Protocol (RTOP) - observation

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Resources

- PKAL (Project Kaleidoscope): http://www.aacu.org/pkal
- AAAS/NSF Vision & Change in Biology Education: http://visionandchange.org/
- Coursera – An Introduction to Evidence-Based Undergraduate STEM Teaching: https://www.coursera.org/course/stemteaching

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Resources

- Center for Peer-Led Team Learning: https://sites.google.com/site/quickpltl
- Process Oriented Guided Inquiry Learning (POGIL): https://pogil.org/
- Science Education Resource Center (SERC): http://serc.carleton.edu/sp/library/pedagogies.html
- Team-Based Learning Collaborative: http://www.teambasedlearning.org/
- Problem-Based Learning: http://www.udel.edu/inst/
- National Center for Case Study Teaching in Science: http://sciencecases.lib.buffalo.edu/cs/

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Resources

- National Research Council. *How People Learn: Brain, Mind, Experience, and School: Expanded Edition*. Washington, DC: The National Academies Press, 2000.

- National Research Council. *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. Washington, DC: The National Academies Press, 2012.

- Kober, N. (2015). *Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering*. Board on Science Education, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

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Questions and Concluding Comments

Undergraduate Educator Network Webinar Series

Thank you for participating today!