Student-Centered Teaching: Designing your course methods, assignments and assessments to optimize the student’s opportunity to learn.

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Students Today: Sounds Familiar?

• _____ first-year students often struggle, even though they are academically strong
• Professors lament students’ ineffective study behaviors and poor performance
• Students’ history of success may be creating obstacles
• Not used to having to work hard to learn
• Resistant to adapting because high school strategies were so successful (though no longer)
Goals

• To argue that the implementation of best practices in teaching aids the success of students in college.

• To familiarize attendees with the concept of Scientific Teaching.
Learning Outcomes

• The Participants will be able to:
  – Define Scientific Teaching
  – Name at least two active learning techniques
  – Explain Bloom’s Taxonomy of Learning
  – Implement backward design in courses.
  – Name two forms of assessments
  – Begin assembling an action plan that leads to departmental and institutional transformation in pedagogy by using Scientific Teaching
I WANT TO RETURN MY DIPLOMA INSTEAD OF REPAYING MY STUDENT LOAN SINCE IT DIDN'T WORK.
The Skills Gap and the Seven Skill Sets that Employers Want: Building the Ideal New Hire

1. Teamwork
2. Communication, communication, communication
3. Quantitative and analytical skills/critical thinking
4. Creativity and problem solving in the real world
5. The ability to keep up in a rapidly changing world...
6. Time management
7. Diversity and cultural awareness
Think-Pair-Share and Student Response Systems
What is Think-Pair-Share?

Teacher poses a question, observation, or challenge.

Students think and write out answers individually.

Students pair up & combine their best answers.

Students share their new improved answer with the class.
Student Response Systems

Evidence-Based Practices in Instruction
“Active Learning Should be the Central Dogma of Science Education”

Active learning increases student performance in science, engineering, and mathematics

Scott Freeman, Sarah L. Eddy, Miles McDonough, Michelle K. Smith, Nnadozie Okoroafor, Hannah Jordt, and Mary Pat Wenderoth

The effect sizes indicate that on average, student performance on examinations and concept inventories increased by 0.47 SDs under active learning (n = 158 studies), and that the odds ratio for failing was 1.95 under traditional lecturing (n = 67 studies). These results indicate that average examination scores improved by about 6% in active learning sections, and that students in classes with traditional lecturing were 1.5 times more likely to fail than were students in classes with active learning.

The STEM disciplines, that active learning increases scores on concept inventories more than on course examinations, and that active learning appears effective across all class sizes—although the greatest effects are in small (n ≤ 50) classes. Trim and fill analyses and fail-safe n calculations suggest that the results are not due to publication bias. The results also appear robust to variation in the methodological rigor of the included studies, based on the quality of controls over student quality and instructor identity. This is the largest and most comprehensive metaanalysis of undergraduate STEM education published to date. The results raise questions about the continued use of traditional lecturing as a control in research studies, and support active learning as the preferred, empirically validated teaching practice in regular classrooms.
Highly structured course designs benefit all students, but especially disadvantaged students.
On average, how learner-centered is your classroom?

Learner Centered  |  Instructor Centered

Each person should place a line on the spot that represents where you feel you would fall on this continuum from learner to instructor centered.
Think-Pair-Share

What is student-centered teaching?
What is student-centered teaching?

*Student-centered teaching methods* shift the focus of activity from the teacher to the learners. An emphasis is placed on student engagement.
Think-Pair-Share

What is student engagement?
Student Engagement

• Degree Attention, curiosity, interest, optimism, and passion that students show when they are learning or being taught.

• Affects level of motivation they have to learn and progress in their education.

• **Learning improves** when students are inquisitive, interested, or inspired

• **Learning tends to suffer** when students are bored, dispassionate, disaffected, or otherwise “disengaged.”

http://edglossary.org/student-engagement/
What does this figure communicate to you?
How People Learn

National Research Council 1999

Findings Include:

1. Learning builds on prior knowledge (must address students’ misconceptions)
2. Making sense of factual knowledge requires a strong conceptual framework.
3. Learning is enhanced by the practice of monitoring it (metacognition)
Metacognition

The ability to:
• think about thinking
• be consciously aware of oneself as a problem solver
• to monitor and control one’s mental processing
• to be aware of the type of learning that you are doing
Scientific Teaching
A student-centered approach
What is Scientific Teaching?

Approach teaching as a scientist:
• read the literature
• set specific learning objectives
• measure the results
• improve course design based on outcomes results
  • the classroom should reflect the process of science – evidence based
  • the classroom should capture the rigor, iterative nature, and spirit of discovery of science at its best
  • the content should be scientific
  • the classroom should include all students

*Handelsman et al., 2004 Science 304:521-522.*
Active Learning

How can we get our students actively engaged with the content and process of science?
Assessment

How can we measure how well our teaching is working?
How can we make our classroom activities inclusive of all students, regardless of backgrounds, to benefit maximally from the richness of student diversity?
What is the point of class?
What do you want them to get out of class?
Major Elements of Scientific Teaching

• Active learning

• Assessment

• Diversity
Active Learning
What is Active Learning?

• The process of having students:
  – Engage
  – Reflect
  – Think
  – Problem solving
Where does Active Learning fit in?

- Learning Goals and Objectives
- Active Learning
- Students Demonstrate Mastery
Think like a scientist

Critical Thinking skills (higher level)

Science content knowledge (lower level)

The Roles of Active Learning

- Expertise
- New connections
- Participation
- Engagement
- Attention
When and how do we start designing a course containing the elements of scientific teaching?
Communicating to students

At the beginning of a course, how do we (traditionally) communicate with students about the content of the course?
How have you typically prepared for teaching a class or how do you think faculty typically prepare for a class?

• Shout it out!
Traditional and Backward Design

**Instructor-centered**
- Standard course planning
  - Choose textbook
  - Create syllabus
  - Write/revise lectures, notes, prepare PowerPoint presentations
  - Write homework, exam questions

**Student-centered**
- Versus
- Backward design
  - Formulate broad learning goals
  - Set specific learning objectives
  - Design assignments (formative and summative)
  - Prepare learning activities

Wood WB. 2009.

Annual Reviews
Backward Design – The Scientific Teaching Approach

Goals
Communication
What should students know, be able to do?
Identify desired results & Determine acceptable evidence

Assessment
Data
What evidence will we accept?
Data on learning & Feedback given

Instruction
Experiment
How can we best prepare students?
Planned learning experiences and instruction

Adapted from Wiggins and McTighe (1998)
Backward Design: Planning

1. Goals
2. Assessment
3. Instruction

Backwards Design: Implementation

1. Goals
2. Instruction
3. Assessment

Assessments communicate to students priorities for their learning.
21 Teaching Strategies that Structure Learning Environments and Promote Fairness in Undergraduate Classrooms

1. Think-Pair-Share: providing an opportunity for students to first think quietly and then share their ideas with a partner can help students rehearse and build confidence to share with the whole class, increasing participation.

2. Ask Open-ended Questions: instead of asking verbal questions with only one possible answer (closed-ended questions), ask questions with multiple possible answers (open-ended questions).

3. Allow Students Time to Write: an opportunity to write down their ideas on paper helps many students revisit what they know, formulate questions, and rehearse what they may want to share, increasing participation.

4. Multiple Hands, Multiple Voices: after you ask a question, say that you'll wait for at least 5 students to raise their hands before you call on anyone, and then really wait for 5 hands. Promote more participation this way.

5. Wait Time: pause for 3 to 5 seconds (longer than you think!) after you ask a question before you call on anyone to speak or answer the question yourself. Longer wait times will allow more students thinking time.

6. Hand Raising: in large group discussions, have students raise their hands. Avoid unstructured speaking situations where a subset of students can dominate. Work to call on all students who haven't yet spoken.

7. Use Popsicle Sticks/Index Cards: write the name of every student in your class on an individual popsicle stick/index card and put in a cup. When asking a question, pull out 2-5 sticks to randomly call on students.

8. Assign Reporters for Small Groups: assign who will speak on behalf of a small group. Randomly determine this by assigning the reporter as the person who has the longest hair, darkest shirt, upcoming birthday, etc.

9. Whisper: ask a question that has many possible answers and have every student share his/her brief answer.

10. Don't Judge Responses: encourage students to honestly share their ideas. Avoid immediately correcting wrong answers or incorrect ideas. Student misconceptions can be addressed at a later point in time.

11. Use Praise with Caution: "excellent job" and "great answer" can inadvertently discourage other students from participating if they think they can't do better than the previous student's response.

12. Learn Students' Names: know your students' names and use them. Only knowing some students names can make others feel like they don't belong. Avoid calling on groups by one person's name (e.g. Billy's group).

13. Use Varied Active Learning Strategies: hands-on activities, think-pair-shares, jigsaw discussions, group presentations, and case studies provide more points of access for students than a teacher-centered lecture.

14. Collect Assessment Evidence from Every Student, Every Class: increase the flow of information from students to instructor by collecting an index card question or an online reflection every class to gauge student learning, student confusions, and student perspectives on their experiences. Grade for participation only!

15. Work in Stations/Small Groups: to decrease effective class size and provide more opportunity for interaction and discussion, consider organizing multiple activities as stations that small groups rotate through.

16. Monitor Student Participation: pay attention to which students are or are not participating. Actively encourage student participation and ask for feedback when students haven't yet heard from.

17. Integrate Culturally Diverse and Relevant Examples: connect the concepts you are teaching to real-world examples that span diverse communities and cultures. Show images of culturally diverse people in your class.

18. Establish Classroom Community and Norms: explicitly state that students should work together, help each other, share resources, support one another's learning, and be open to divergent points of view.

19. Don't Plan Too Much: Students need time to think, do, and talk about what they are learning.

20. Be Explicit About Promoting Access and Equity for All Students: Share with students why you use the teaching strategies that you use. Let them know that you want and expect everyone to learn.

21. Teach Students from the Moment They Arrive: remember that students are learning about classroom culture in addition to biological concepts as soon as they enter the classroom.
Terminology review

**Learning Goal**: Broad description of what students will understand and learn: not necessarily assessable with single question.

*Example*: Understand how chromosomes align and separate during the process of meiosis (the production of sperm/egg cells)

**Learning Objective**: specific, action-oriented description of what students will be able to do: assessable.

*Example*: Predict the probability of a certain phenotype among children of two individuals, one with a sex chromosomal abnormality
What is your level of experience with learning objectives?

A. I didn’t know what they were until today
B. I am familiar with them but have not used them in my courses.
C. I write learning objectives for my courses and use them only for myself.
D. I write learning objectives for my courses and share them with my students.
How do we communicate our intent meaningfully?

A tool for classification: Bloom’s taxonomy

What is it?
Bloom's Six Levels of Understanding

- **Remembering**: Can the student recall or remember the information?
  - define, duplicate, list, memorize, recall, repeat, state

- **Understanding**: Can the student explain ideas or concepts?
  - classify, describe, discuss, explain, identify, locate, recognize, report, select, translate, paraphrase

- **Applying**: Can the student use information in a new way?
  - choose, demonstrate, dramatize, employ, illustrate, interpret, operate, schedule, sketch, solve, use, write

- **Analyzing**: Can the student distinguish between different parts?
  - appraise, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test

- **Evaluating**: Can the student justify a stand or decision?
  - appraise, argue, defend, judge, select, support, value, evaluate

- **Creating**: Can the student create a new product or point of view?
  - assemble, construct, create, design, develop, formulate, write
“Blooms’” verbs that communicate what you want students to be able to do

1. **Remember**: arrange, define, duplicate, label, list, memorize, name, order, recognize, relate, recall, repeat, reproduce state.

2. **Comprehend**: classify, describe, discuss, explain, express, identify, indicate, locate, recognize, report, restate, review, select, translate,

3. **Apply**: apply, choose, demonstrate, dramatize, employ, illustrate, interpret, operate, practice, schedule, sketch, solve, use, write.

4. **Analyze**: analyze, appraise, calculate, categorize, compare, contrast, criticize, differentiate, discriminate, distinguish, examine, experiment, question, test.

5 and 6:

**Evaluate**: appraise, argue, assess, defend, estimate, judge, predict, rate, select, support, value, evaluate.

**Create**: compose, construct, create, design, develop, formulate, manage, organize, plan, prepare, propose, set up, write.

Verbs that don’t communicate well

“Understand”
“Realize”
“Be aware of”
# REVISED Bloom’s Taxonomy Action Verbs

<table>
<thead>
<tr>
<th>Definitions</th>
<th>I. Remembering</th>
<th>II. Understanding</th>
<th>III. Applying</th>
<th>IV. Analyzing</th>
<th>V. Evaluating</th>
<th>VI. Creating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bloom’s Definition</td>
<td>Exhibit memory of previously learned material by recalling facts, terms, basic concepts, and answers.</td>
<td>Demonstrate understanding of facts and ideas by organizing, comparing, translating, interpreting, giving descriptions, and stating main ideas.</td>
<td>Solve problems to new situations by applying acquired knowledge, facts, techniques and rules in a different way.</td>
<td>Examine and break information into parts by identifying motives or causes. Make inferences and find evidence to support generalizations.</td>
<td>Present and defend opinions by making judgments about information, validity of ideas, quality of work based on a set of criteria.</td>
<td>Compile information together in a different way by combining elements in a new pattern or proposing alternative solutions.</td>
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<tr>
<th>Verbs</th>
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<tbody>
<tr>
<td>Choose</td>
<td>Define</td>
<td>Find</td>
<td>How</td>
<td>Label</td>
<td>List</td>
<td>Match</td>
</tr>
<tr>
<td>Name</td>
<td>Omit</td>
<td>Recall</td>
<td>Relate</td>
<td>Select</td>
<td>Show</td>
<td>Spell</td>
</tr>
<tr>
<td>Tell</td>
<td>What</td>
<td>When</td>
<td>Where</td>
<td>Which</td>
<td>Who</td>
<td>Why</td>
</tr>
<tr>
<td>Choose</td>
<td>Classify</td>
<td>Compare</td>
<td>Contrast</td>
<td>Demonstrate</td>
<td>Explain</td>
<td>Extend</td>
</tr>
<tr>
<td>Apply</td>
<td>Build</td>
<td>Choose</td>
<td>Construct</td>
<td>Develop</td>
<td>Experiment with</td>
<td>Identify</td>
</tr>
<tr>
<td>Analyze</td>
<td>Assess</td>
<td>Award</td>
<td>Choose</td>
<td>Compare</td>
<td>Conclude</td>
<td>Contrast</td>
</tr>
<tr>
<td>Agree</td>
<td>Appraise</td>
<td>Assume</td>
<td>Assess</td>
<td>Award</td>
<td>Choose</td>
<td>Compare</td>
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<tr>
<td>Adapt</td>
<td>Build</td>
<td>Change</td>
<td>Choose</td>
<td>Combine</td>
<td>Compile</td>
<td>Compose</td>
</tr>
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</table>

Genetics Syllabus

-DNA replication and the Central Dogma (Review)
  DNA replication
  Transcription
  Translation

-Principles of heredity: how traits are transmitted
  Alleles
  Dominant and recessive traits

-The chromosome theory of inheritance
  Meiosis

-Linkage and recombination

Etc.
Syllabus

Learning Objectives - be able to:

Transcription

• Define transcription.
• Name the enzyme that catalyzes it.
• Distinguish between transcription and translation.
• Compare transcription in bacteria and eukaryotes.
• Diagram a DNA duplex in the process of transcription showing base-pairing and strand polarity for all polynucleotides.
One Method for Thoughtfully Integrating Active Learning Into a Class:

*The 5E Model*

- **Engage**
- **Explore**
- **Explain**
- **Elaborate**
- **Evaluate**
The 5E Model of Instruction

<table>
<thead>
<tr>
<th>Phase</th>
<th>Definition</th>
<th>Teacher Behavior</th>
<th>Student Behavior</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain</td>
<td>Connects prior knowledge and background to new discoveries. Communicate new understandings. Connect formal language to informal language.</td>
<td>Encourages students to explain their observations and findings in their own words. Provides definitions, new words, and explanations. Listens and builds upon discussion form students. Asks for clarification and justification. Accepts all reasonable responses.</td>
<td>Explains, defines, and questions. Uses previous observations and findings. Provides reasonable responses to questions. Interacts in a positive, supportive manner.</td>
</tr>
<tr>
<td>Extend/Elaborate</td>
<td>Applies new learning to a new or similar situation. Extend and explain concept being explored. Communicate new understanding with formal language.</td>
<td>Uses previously learned information as a vehicle to enhance additional learning. Encourages students to apply or extend the new concepts and skills. Encourages students to use terms and definitions previously acquired.</td>
<td>Applies new terms and definitions. Uses previous information to probe, ask questions, and make inquiries. Provides reasonable conclusions and solutions. Records observations, explanations, and solutions.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Assess understanding (Self, peer, and teacher evaluation). Demonstrate understanding of new concept by observation or open-ended responses. Apply within problem situation. Show evidence of accomplishment.</td>
<td>Observes student behaviors as they observe and apply new concepts and skills. Assesses students’ knowledge and skills. Encourages students to assess their own learning. Asks open-ended questions.</td>
<td>Demonstrates an understanding of the concept or skill. Evaluates his or her own progress and knowledge. Answers open-ended questions by using observations, evidence, and previously accepted explanations. Asks related questions that would encourage future investigations.</td>
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What Should Be Happening at Each Stage?

<table>
<thead>
<tr>
<th>Phase</th>
<th>Student Role</th>
<th>Teacher Role</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement</td>
<td>Creates interest. Shows interest in the topic. Asks questions such as, “Why did this happen?” “What else can I find out about this?”</td>
<td>Encourages the students to work together without direct instruction from the teacher. Observes and listens to the students as they interact. Asks probing questions to redirect the students’ investigations when necessary. Provides time for the students to puzzle through problems. Acts as a consultant for students. Creates a “need to know” setting.</td>
</tr>
<tr>
<td>Exploration</td>
<td>Forms new predictions and hypotheses. Tests predictions and hypotheses. Records observations and ideas.</td>
<td></td>
</tr>
<tr>
<td>Explanation</td>
<td>Listens critically to others’ explanations. Explains own answers or possible solutions to others.</td>
<td>Encourages the students to explain concepts and definitions in their own words. Ask for justification (evidence and clarification from students. Formally clarifies definitions, explanations, and new labels when needed. Use students’ previous experiences as the basis for explaining concepts. Assesses students’ growing understanding.</td>
</tr>
<tr>
<td>Elaboration</td>
<td>Applies new labels, definitions, explanations, and skills in a new or similar situation.</td>
<td></td>
</tr>
<tr>
<td>Evaluation</td>
<td></td>
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</table>

Based on the 5E Instructional Model presented by Dr. Jim Selle at the Eisenhower Science Collaborative Conference in Austin, Texas, July 2000.
Strategies for Using the 5E Model in Your Teaching

• Start your class/lesson with something that Engages students and Elicits their prior knowledge.
  – Questions are your friend! What do you already know about (today’s topic)? How is (today’s topic) relevant to your everyday life? A challenge statement based on a common misconception about the topic…
  – Demonstrations, personal stories, a current events…

• Allow for Exploration before you Explain or give mini-lectures.
  – consider placing mini-lectures in the middle or at the end of a lesson
  – recognize post-activity discussions as a time to explain information, when students are most interested and the information is most relevant
  – be selective in what questions you answer during the exploration phase of a lesson

• Collect some form of assessment/ Evaluation from your students every class.
  – minute paper or drawing at beginning and/or end of class that pertains to the lesson and aligns with your goals for that lesson
  – personal reflection on what they learned (What did you learn today?)
Examples of Active Learning Methods

• Two Minute Paper
• Student-generated test questions
• Problem-Based Learning (PBL)
• Think-Pair-Share
• Flipped Classroom

Major Elements of Scientific Teaching

- Active learning
- Assessment
- Diversity
Assessment
Assessments communicate your intent
It is very important to learn about traxoline. Traxoline is a new form of zionter. It is montilled in Ceristanna. The Ceristannians found that they could gristerlate large amounts of fervon and then bracter it to quasel traxoline. This new, more efficient bracterillation process has the potential to make traxoline one of the most useful products within the molecular family of lukizes snezlaus.

QUIZ:
1. What is traxoline?
2. Where is it montilled?
3. How is traxoline quaseled?
4. Why is traxoline important?

• An exam communicates what the instructor cares about
• If you test them on fact-based knowledge, then that is what they will study!
THE MONTILLATION OF TRAXOLINE

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   a. It is a new and more efficient bracterillation process

• An exam communicates what the instructor cares about
• If you test them on fact-based knowledge, then that is what they will study!
Different kinds of Assessments

- **Summative assessments**: Measures the level of success or proficiency that has been obtained at the end of an instructional unit, by comparing it against some standard or benchmark.
  - Exams, papers, presentations
  - Typically occur at the end of teaching
  - Usually part of grade for the class

- **Formative assessments**: Gathers feedback that can be used by the instructor and the students to guide improvements in the ongoing teaching and learning context.
  - In-class work, homework, pre-class online assignments
  - Can be for a grade or for participation
<table>
<thead>
<tr>
<th>Learning Goal</th>
<th>Learning Objective <em>(content + behavior)</em></th>
<th>Summative Assessment <em>(exam question)</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>What will students learn?</td>
<td>If they have learned it, what will students know and be able to do?</td>
<td>How will students demonstrate they know it or are able to do it?</td>
</tr>
<tr>
<td>Students will understand the transfer of information from DNA to proteins</td>
<td>Predict changes in amino acid sequences caused by mutations</td>
<td>Deva has cystic fibrosis. By looking at this section of her DNA sequence and comparing it to her mother’s DNA sequence, find her mutation, and predict the amino acid sequence that will result. Suggest a different DNA mutation in the same codon that would NOT have resulted in cystic fibrosis</td>
</tr>
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Learning Outcomes Review
Learning Outcomes

• The Participants will be able to:
  – Define Scientific Teaching
  – Name at least two active learning techniques
  – Explain Bloom’s Taxonomy of Learning
  – Implement backward design in courses.
  – Name two forms of assessments
  – Begin assembling an action plan that leads to departmental and institutional transformation in pedagogy by using Scientific Teaching
Design a Course: In Practice

What is environmental science? Environmental science is the science of the interactions between the physical, chemical, and biological components of the environment, including their effects on all types of organisms but more often refers to human impact on the environment.

Introduction to Environmental Studies:

"Environmental Studies" requires insights from many disciplines, including the social as well as biophysical science and the humanities. This introduction offers an overview of the field, examining both our planet and the ways in which we humans depend on it.
Designing a course
Using the Framework for a Teachable Unit

Title of Course:

**Learning Goals:** Broad description of what students will understand and learn: not necessarily assessable with single question.

**Learning Outcomes:** What will the students know, understand, and be able to do? What performances or behaviors will indicate achievement of the goals? Use measurable verbs to address Bloom’s Taxonomy low and high cognitive skills.

**Assessment:** How will students and instructors gauge learning throughout the unit? Use formative and summative assessments.

**Activities:** What will students and instructors do to engage a diversity of students in achieving the goals?

**Scientific Teaching:** How does the teachable unit address? Diversity, Active Learning, Assessment.
Recommendations

• PULSE web site-
  http://www.pulsecommunity.org/