Student Learning Outcomes (Competences) in the STEM* Disciplines: Uses in Course Development

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*Science, Technology, Engineering and Math

"Teaching is leading students into a situation in which they can only escape by thinking"

BUILDING EDUCATION FOR THE 21ST CENTURY

This Workshop

- Introductions
- What are Student Learning Outcomes (SLO)
- Developing Courses Using
  - Understanding by Design or Backwards Design?
- Three Cornerstones for Good Teaching

How long have you been teaching ?

1) 1-3 years
2) 3-5 years
3) 5-10 years
4) 10-20 years
5) >20 years

I did my graduate work primarily in:

1) Korea
2) The United States
3) Europe
4) Asia other than Korea
5) A combination of the above

My discipline area is:

1) Biological Sciences
2) Chemistry or Physics
3) Engineering
4) Mathematics
5) Computer science
6) Other

The primary goal in my course is to?

1. Cover the basic material
2. Impart new discipline knowledge
3. Facilitate student learning
4. Ensure student success

Activity One

The biggest challenge I face in my teaching is?

Activity One

The biggest challenge/obstacle in my teaching is _____

The biggest teaching challenge I face is ?

1. Motivating students
2. Covering the material
3. Developing assessments
4. Finding appropriate new instructional material
5. Other

Learning Outcomes

Learning outcomes are enduring understandings that students will take away from your course

Learning Outcomes (LO)

- LO answer the following guiding questions:
  - What will my students know?
  - What will my students understand?
  - What will my students be able to do?
  - What will my students be able to appreciate?
- LO are determined by the faculty

Learning Outcomes Characteristics

- They are stated from the student's perspective—i.e. the Student Will Be Able To [SWBAT] . . .
- They define and capture expected student learning in programs or courses.
- They are a framework within which faculty can think deeply about student learning, their course, and academic programs.
- They are a tool for evidence based improvements to courses and programs

Learning Outcome Characteristics.

- The specified learning action by the student must be observable.
- The specified learning action by the student must be measurable.
- The specified learning action must be done by the students.

Effective Learning Outcomes
NEED to **MAKE SENSE**

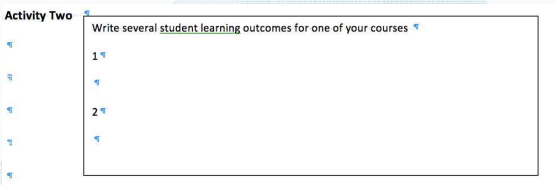
Course Goals vs. Outcomes

Goals and outcomes are not the same thing

- Goals are the overarching guide and envisioned endpoint, often they are not readily measurable
  - Student are life-long learners
- Outcomes are things one can readily, and directly measureable
  - Students can describe __XX_____
- Some goals and outcomes overlap

Activity Two

- Write several learning learning outcomes for one of your courses. Students will _____



Share Your Student Learning Outcomes with the Person(s) Side of You

Writing Clear Learning Outcomes

- Often learning outcomes, are unclear or represent elements of a curriculum rather than some action the participants will demonstrate.
- Two Examples:
  - Participants will understand the five reasons for conducting an environmental assessment.
  - Participants will develop an appreciation of cultural diversity in the workplace

Refined Learning Outcomes

- Original
  - Participants will understand the five reasons for conducting an environmental assessment.
- Refined
  - Participants will describe five reasons for conducting an environmental assessment.
- Original
  - Participants will develop an appreciation of cultural diversity in the workplace
- Refined
  - Participants will summarize in writing their feelings about cultural diversity in the workplace

Examples

An Example - CHEM. BCHM, BSCI

The guiding question: *What will our students be able to do?*

- **Students should demonstrate an ability to use and apply quantitative methods, especially:**
  - **Interpretation of graphical or tabular data;**
  - **Expression of physical, chemical, or biological process in mathematical form;**
  - **Solving equations to determine the value of physical, chemical, or biological variables**

Clear and specific enough to be measured and embedded in the activities that the students already do?

- Clear and Specific?
  - YES, one can measure how well students do each of the task.
- Embedded?
  - YES, majors CHEM BCHEM, BSCI are required in several courses to apply quantitative methods

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An Example - MECHANICAL ENGINEERING, BS

The guiding question: *What will our students be able to do?*

- **Students will be able to design systems, components or processes to meet designated needs**

Clear and specific enough to be measured and embedded in the activities that the students already do?

- Clear and Specific?
  - YES, one can measure how well students do the task.
- Embedded?
  - YES, Project in ENME 371: Product Development and Manufacturing
  - Students are required to improve upon a selected design feature of a power tool

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General Education Outcomes Sciences

On completion of a Natural Sciences course, students will be able to:

- Demonstrate a broad understanding of scientific principles and the ways scientists in a particular discipline conduct research.
- Apply quantitative, mathematical analyses to science problems.
- Solve complex problems requiring the application of several scientific concepts.
- Look at complex questions and identify the science and how it impacts and is impacted by political, social, economic, or ethical dimensions.
- Critically evaluate scientific arguments and understand the limits of scientific knowledge.
- Communicate scientific ideas effectively.

External Standards

ABET Accreditation Criteria for Engineering Programs

a. Ability to apply math, science and engineering

b. Ability to design and conduct experiments, analyze and interpret data

c. Ability to design a system, component or process to meet desired needs

d. Ability to function on multi-disciplinary teams

e. Ability to identify, formulate and solve engineering problems

f. Understanding of professional and ethical responsibility

g. Ability to communicate effectively

h. Broad education to understand impact of engineering solutions in a global and societal context

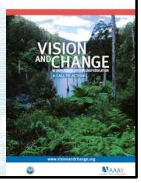
i. Recognition of the need for lifelong learning

j. Knowledge of contemporary issues

k. Ability to use the techniques, skills, and modern engineering tools necessary for practice

AAAS Core Competencies in the Life Sciences*

1. ABILITY TO APPLY THE PROCESS OF SCIENCE:
2. ABILITY TO USE QUANTITATIVE REASONING:
3. ABILITY TO USE MODELING AND SIMULATION:
4. ABILITY TO TAP INTO THE INTERDISCIPLINARY NATURE OF SCIENCE:
5. ABILITY TO COMMUNICATE AND COLLABORATE WITH OTHER DISCIPLINES:
6. ABILITY TO UNDERSTAND THE RELATIONSHIP BETWEEN SCIENCE AND SOCIETY:



* From AAAS 2010 Vision and Change Report

AAAS Competencies in Biology

Table 2.1: Core Competencies and Disciplinary Practices. A competency-based approach to undergraduate biology education focuses on demonstrating analytical, experimental, and technical skills as measurable outcomes of student learning. Biology literacy is defined primarily in terms of acquired competencies, demonstrated within the context of fundamental biology concepts.

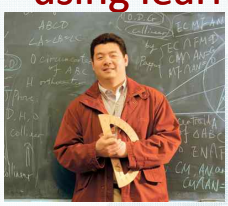
Core Competency	Ability to apply the process of science	Ability to use quantitative reasoning	Ability to use modeling and simulation	Ability to tap into the interdisciplinary nature of science	Ability to communicate and collaborate with other disciplines	Ability to understand the relationship between science and society
Instantiation of Ability in Disciplinary Practice	Biology is an evidence-based discipline	Biology relies on applications of quantitative analysis and mathematical reasoning	Biology focuses on the study of complex systems	Biology is an interdisciplinary science	Biology is a collaborative scientific discipline	Biology is conducted in a societal context
Demonstration of Competency in Practice	Design scientific process to understand living systems	Apply quantitative analysis to interpret biological data	Use mathematical modeling and simulation tools to describe living systems	Apply concepts from other sciences to interpret biological phenomena	Communicate biological concepts and interpretations to scientists in other disciplines	Identify social and historical dimensions of biology practice
Examples of Core Competencies Applied to Biology Practice	Observational strategies Hypothesis testing Experimental design Evaluation of experimental evidence Developing problem-solving strategies	Developing and interpreting graphs Applying statistical methods to diverse data Mathematical modeling Managing and analyzing large data sets	Computational modeling of dynamic systems Applying informatics tools Managing and analyzing large data sets Incorporating stochasticity into biological models	Applying physical laws to biological dynamics Chemistry of molecules and biological systems Applying imaging technologies	Scientific writing Explaining scientific concepts to different audiences Team participation Collaborating across disciplines Cross-cultural awareness	Evaluating the relevance of social contexts to biological problems Developing biological applications to solve societal problems Evaluating ethical implications of biological research

Summary and Take Home

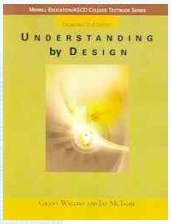
- Learning outcomes are measurable changes in student knowledge, skills and attitudes/appreciation (KSAs) as the result of a course of study e.g. learning
- They are determined by the faculty

Spencer Stops Talking Questions Comments ?

How do you design a course using learning outcomes?

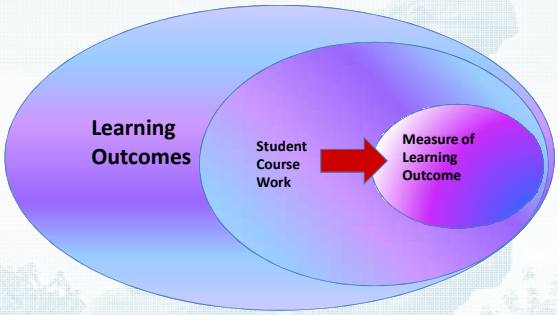


Reference



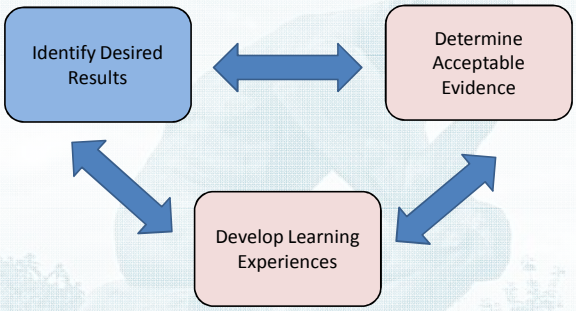
- Understanding by Design
  - AKA Backwards Design
  - Grant Wiggins and Jay McTighe
- http://www.grantwiggins.org/ubd/ubd.lasso
- The link below will allow you to access the book via the web.
- http://books.google.com/books?id=N2EfKlyUN4QC&dq=understanding+by+design&printsec=frontcover&source=bn&hl=en&ei=moM1SuOiLteOkAXw5LicCg&sa=X&oi=book_result&ct=result&resnum=4#PPA16,M1

Course or Program Design

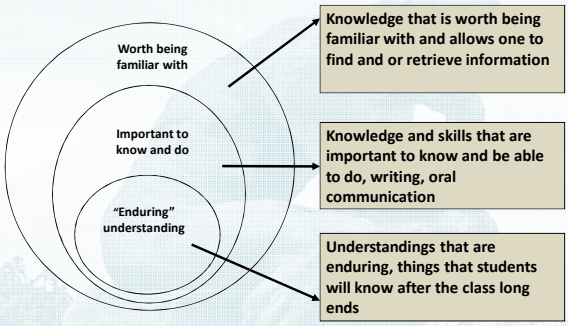


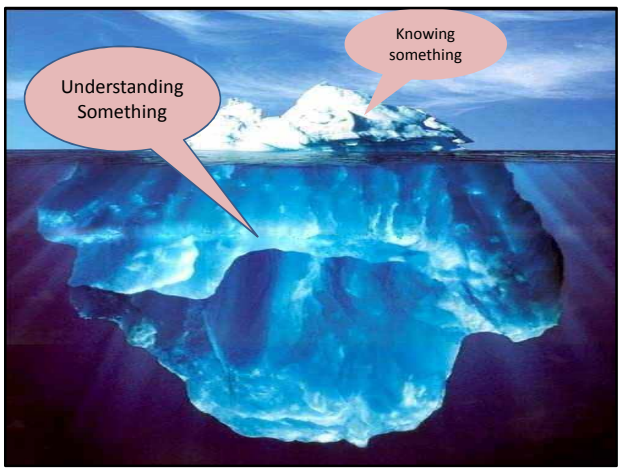
Understanding by Design

This is a reiterative process



Establish Priorities



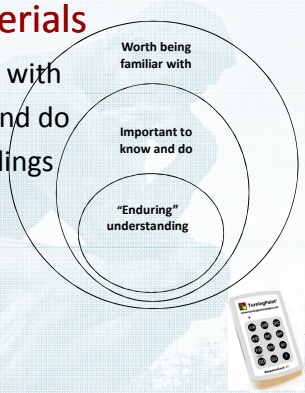


Does Knowing = Understanding ?

- Evidence of understanding is a greater challenge than evidence that the student knows a correct or valid answer
  - Understanding is inferred, not seen
  - It can only be inferred if we see evidence that the student knows *why* (it works) *so what?* (why it matters), *how* (to apply it) – not just knowing *that* specific inference
- Understanding requires higher order thinking and deeper understanding
- It goes beyond surface knowledge and memorization

My course primarily focuses on materials

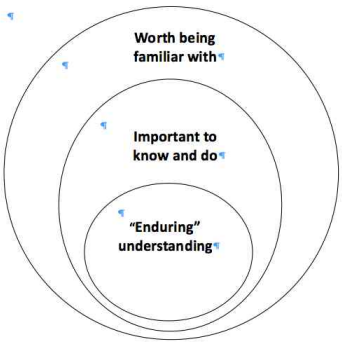
1. Worth being familiar with
2. Important to know and do
3. Enduring understandings



Activity Three

Activity Three

Using one of your courses write one or two items for each level



Share Your Definition of Student Learning Outcomes with the Person(s) Side of You

Example

An Example

- Microbes and Society
  - non-majors general education course
- 1st year to – 4th year students
- Considerations
  - May be the only and last science/biology course they take
  - They will not be scientists/biologists
  - Science/microbiology will impact their lives
  - Some will be teachers and impact 1000s of students
  - What will they remember in 10 years about microbiology?

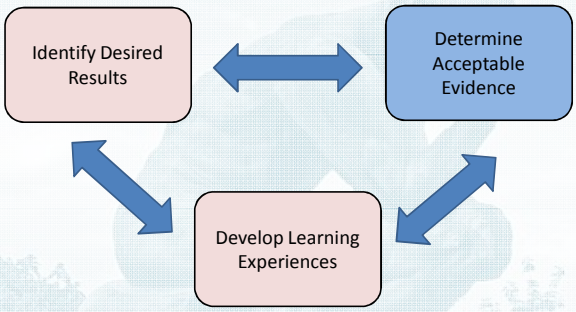
My Design Process

- Brainstormed with colleagues and students
- Drafted a list of course goals
- Converted goals to learning outcomes (LO)
- Decided on types of assessments I would use
- Decided on types of pedagogy I would use
- Continually asked,
  - "Do my goals, LO, assessments and pedagogy align?"
  - Is this transparent to students?
  - Will students be engaged?

Microbes and Society
Course Goals/Objectives

1. To introduce students to the basic principles, concepts, theories, and language that constitutes the discipline of microbiology
2. To provide a framework for understanding how microbiology impacts life and society
3. To foster the ability to critically assess biological and microbiology information from books, the popular press, journals, and other sources
4. To understand that science is a part of everyday life
5. To see that science has cultural and social dimensions

Understanding by Design
This is a reiterative process



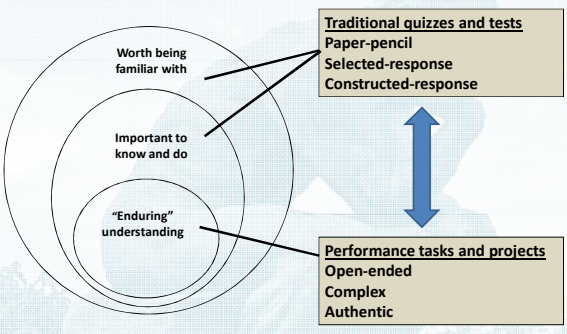
Characteristics of Good Evidence?

- Course and discipline dependent
  - Speech course requires speaking
- Align with the goal or outcome
  - A writing goal requires writing
- Critical thinking requires appropriate materials
- Is meaningful to student and peers
- Is embedded in the course activities

The assessments in my course are primarily?

1. Multiple choice exams
2. Essay exams
3. Mixed format exams
4. Papers
5. Projects
6. Presentations
7. Other

Assessment Alignments



Example

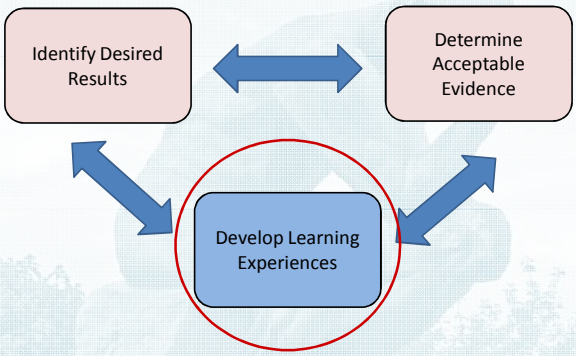
Microbes and Society
Students Learning Outcomes

1. Students will be able to describe the basic principles, concepts, theories, and language that constitutes the discipline of microbiology
2. Students will be able to demonstrate an understanding how microbiology impacts life and society
3. Students will be able to critically read biological and microbiology information from books, the popular press, journals, and other sources
4. Students will be able to describe how science is a part of everyday life
5. Students will be able to identify and appreciate the cultural and social dimensions of science

Microbe and Society
Assessments […] refer to SLO

- Weekly online M/C quizzes on the readings [1]
- Writing (two short pieces, one on a museum visit) [1,2,4,5]
- Group project
  - In a social relevant aspect of microbiology, e.g. HIV-AIDS in and East Asian Country [2,3,4,5]
- Five 30-minute in class exams
  - Short answer and essay [1,2,4]
  - Read and write about a recent news article [3]

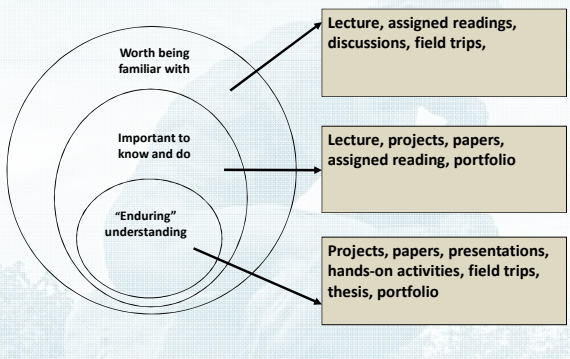
Understanding by Design
This is a reiterative process



Learning Experiences

- Need to align with the course goals
  - The learning activities need to support the outcomes/goals
- Need to engage the student in active learning
  - Enduring understanding requires active and multiple engagements
- Need to align with the measures/assessment
  - Answers – How does this activity increase the performance of students on the assessment ?
- Need to be transparent
  - Student need to know what is expected on them and when

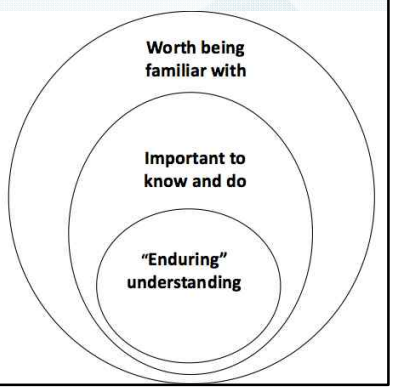
Learning Activities



Activity Five

Activity Five

Describe a learning activity you might uses for each of the levels



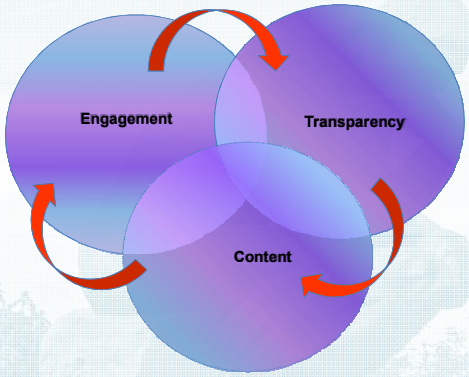
Spencer Stops Talking
Questions Comments ?

Seven Principles of Good Teaching Practice

1. Encourages student-faculty contact
2. Encourages cooperation among students
3. Encourages active learning
4. Provides prompt feedback
5. Emphasizes time on task
6. Communicates high expectations
7. Respects diverse talents and ways of learning

Arthur W. Chickering and Zelda F. Gamso

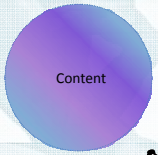
Three Cornerstones



Appropriate Course Content

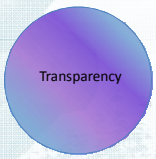
What makes some content better for learning then other content?

- Relevant to students
- Engaging
- At the right level
- Visual
  - Graphic
  - Moving Images; You-tube, Google, etc



Be Transparent

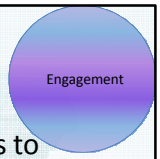
- In everything you do in your class ask “do the students understand what is expected”
- Don’t assume that just because you said it they heard or understand.



Why Transparency Matters

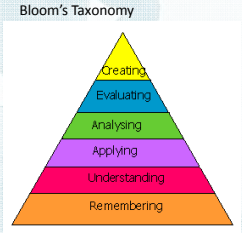
"One of the things that I've learned in forty years of teaching and twenty-five years of trying and studying educational reforms is that it's not enough to "just make the changes". If your changes violate what students expect is going to happen in your class, you're in for a lot of resistance, hostility, and foot dragging. I've had the most success when I have explained to the students what I'm doing up front as clearly as I can, and even then I have had to continue to "negotiate my meaning" throughout the class, often because they didn't understand what I meant in my initial explanation. But having done that initial explanation turned out to be very valuable to refer back to throughout the class" .. Joe Redish UM-PERG

Engage Students



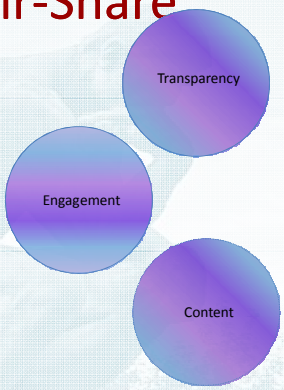
Increased student engagement leads to increased student learning

Bloom's Taxonomy

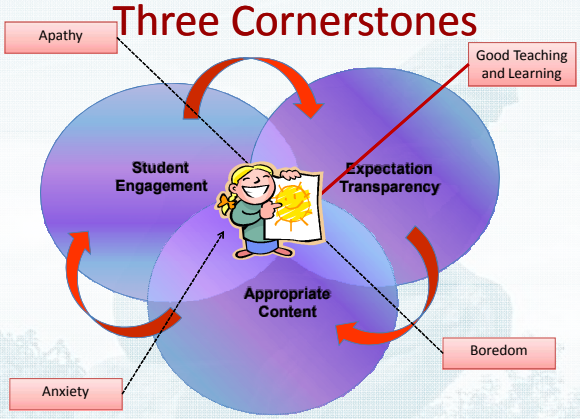


Think-Pair-Share

Choose one of the three cornerstones and write down an example of how you address it



Three Cornerstones



Of the three cornerstones the most important one is?

1. Appropriate content
2. Transparency of expectations
3. Student engagement

Thank You

QUESTIONS/COMMENTS?

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"Teaching is leading students into a situation in which they can only escape by thinking"

UMD Teaching Resource Guide Free Downloadable
http://www.cte.umd.edu/TRG.pdf

Nine Books on Teaching Worth Having in Your Own Teaching Library

Useful Teaching Resources

- **"*Teaching at its Best: A Research-Based Resource for College Instructors.*"** Linda Nilson
- ***"McKeachie's Teaching Tips, Strategies, Research, and Theory for College and University Teachers"*** William McKeachie
- ***"Classroom Assessment Techniques: A Handbook for College Teachers"*** Thomas A. Angelo and K. Patricia Cross
- ***"Effective Grading : A Tool for Learning and Assessment"*** Barbara Walvoord, Virginia Anderson,
- **"*Understanding by Design*"** Wiggins and McTighe
- ***"Introduction To Rubrics: An Assessment Tool To Save Grading Time, Convey Effective Feedback and Promote Student Learning"*** Dannelle D. Stevens, Antonia J. Lev
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