2016

STEM Gateway Course Redesign Teaching Professional Development: Resources for Teaching and Learning

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STEM Gateway Course Redesign
Teaching Professional Development

Resources for Teaching and Learning
2015-2016

Gary Smith

Audriana Stark

Project for Inclusive Undergraduate STEM Success

The University of New Mexico STEM Gateway program is funded through a U.S. Department of Education TITLE V grant, 2011-2016 (total anticipated funding $3.82 million).

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STEM Gateway
Course Redesign Teaching Professional Development Program:

Course Redesign Institute

1. … explain the motive for redesigning the course
2. …define measurable learning outcomes for the course
3. …identify pedagogical/curricular changes that could address problems that motivated redesign
4. …develop criteria for selecting, creating, and integrating specific tools, assignments, and assessments to achieve learning outcomes
5. … create a course curriculum of teachable units that integrate in-class and out-of-class learning
6. … construct a plan with a timeline, milestones, and goals for partial to full implementation of redesign, which identifies additional STEM Gateway consultation and other resource needs
7. …develop an assessment plan that tracks student achievement of outcomes and affect and instructor affect towards redesign efforts
8. … use data to inform modification of redesign plans including a process for determining when modifications should be made and who will make modifications
9. …create a plan for sustaining the redesign and expanding to include all instructors of the course

STEM GATEWAY
Project for Inclusive Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

STEM Gateway
Course Redesign Institute

Gary Smith
Audriana Stark

STEM GATEWAY

Project for Inclusive
Undergraduate STEM Success

Getting into a teaching and learning frame of mind…

Choose <u>one</u> image that describes your perceptions of what happens in undergraduate courses in your field.

Then – introduce yourself and *<u>very briefly (1 minute)</u>* explain how this image is a metaphor or analogy for …

"How I perceive what happens in a course"

Part I: Warming Up: The Instructional Change Process

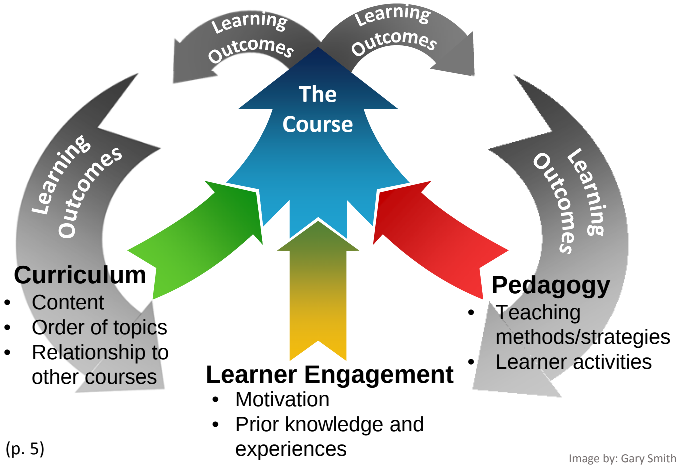
Part I outcomes:

You will be able to …

… explain the components of a course, including the roles of teachers, learners, subject matter and intended course outcomes

… describe the process of instructional change

What is a course?



Curriculum
- Content
- Order of topics
- Relationship to other courses

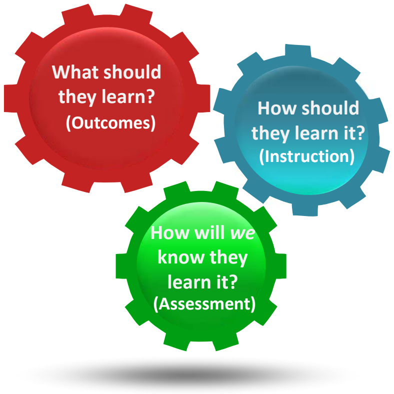
Learner Engagement
- Motivation
- Prior knowledge and experiences

Pedagogy
- Teaching methods/strategies
- Learner activities

(p. 5)

Image by: Gary Smith

Effective course design *integrates* activities that are formed around these questions:



What should they learn? (Outcomes)

How should they learn it? (Instruction)

How will *we* know they learn it? (Assessment)

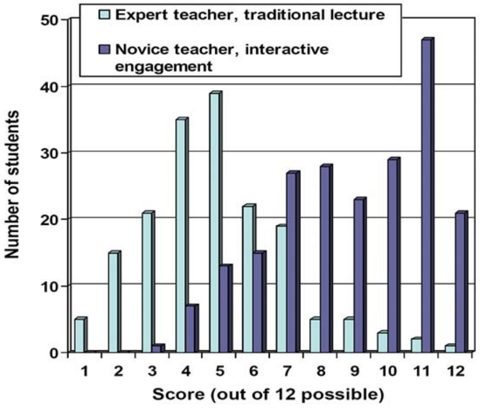
(p. 5)

Image by: Gary Smith

Let’s ponder a case-study in teaching and learning

How was the difference in learning related to the difference in teaching?

We will revisit this question.



Deslauriers et al., 2011, Improved learning in a large-enrollment physics class, *Science*, 332: 862

STEM Gateway Course Redesign Projects draw on the fundamental role of faculty to change student outcomes

> “… student success, however it is defined and measured, must have at its core success in individual classes. Though student success is indeed everyone’s business, it is the business of faculty in particular.”

Tinto, V., and Pusser, B., 2006, *Moving from theory to action: Building a model of institutional action for student success*

> “The biggest and most long-lasting reforms of undergraduate education will come when individual faculty or small groups of instructors adopt the view of themselves as reformers, within their immediate sphere of influence, the classes they teach every day.”

K. Patricia Cross, Professor of Higher Education, University of California, Berkeley; Trustee, Carnegie Foundation for the Advancement of Teaching

Where are we going?

(photo, Karl Wirth)

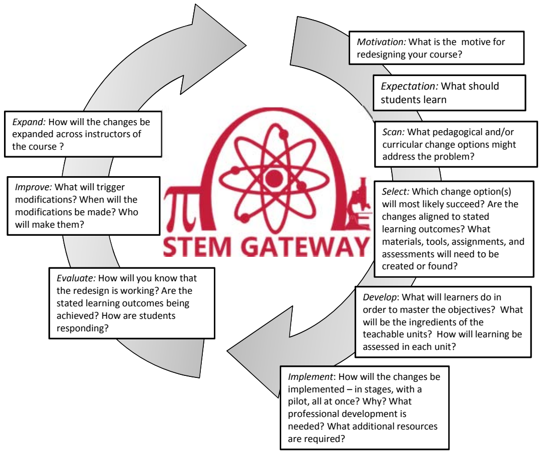
Clear the fog with …

Clear objectives… outcomes of the journey we're beginning

(photo, Karl Wirth)

STEM Gateway Professional Development Program

Designing Instructional Change to Improve Student Success



Motivation: What is the motive for redesigning your course?

Expectation: What should students learn

Scan: What pedagogical and/or curricular change options might address the problem?

Select: Which change option(s) will most likely succeed? Are the changes aligned to stated learning outcomes? What materials, tools, assignments, and assessments will need to be created or found?

Develop: What will learners do in order to master the objectives? What will be the ingredients of the teachable units? How will learning be assessed in each unit?

Implement: How will the changes be implemented – in stages, with a pilot, all at once? Why? What professional development is needed? What additional resources are required?

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Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

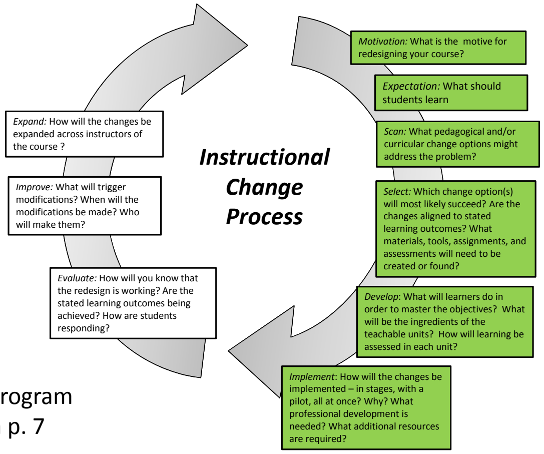
(p. 6)

STEM Gateway Professional Development Program

Designing Instructional Change to Improve Student Success

Focus of the institute …

… with ongoing activities throughout the year



Instructional Change Process

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(p. 6)

Matched to program outcomes, on p. 7

Part II: What Motivates You and Your Learners?

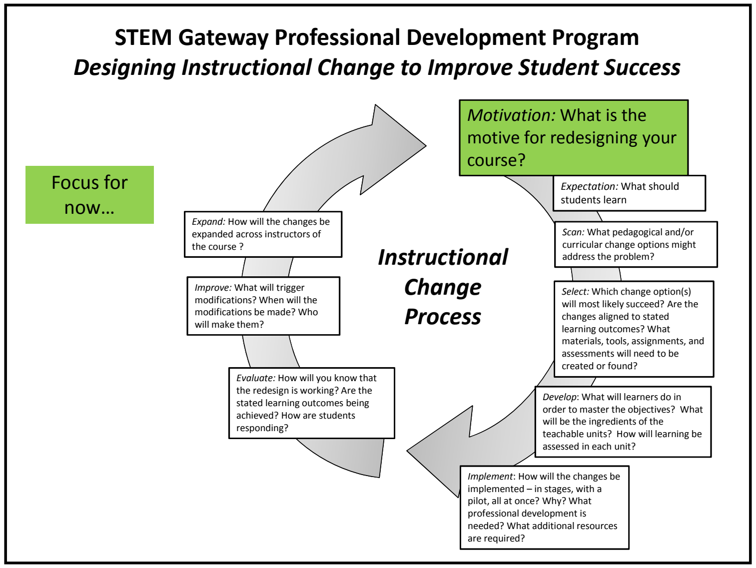
Part II outcomes:

You will be able to …

… explain why STEM-course redesign is important to student success

… articulate a vision for their redesign project

… use expectancy-value motivation as a foundation for engaging learners



STEM Gateway Professional Development Program
Designing Instructional Change to Improve Student Success

Focus for now…

Instructional Change Process

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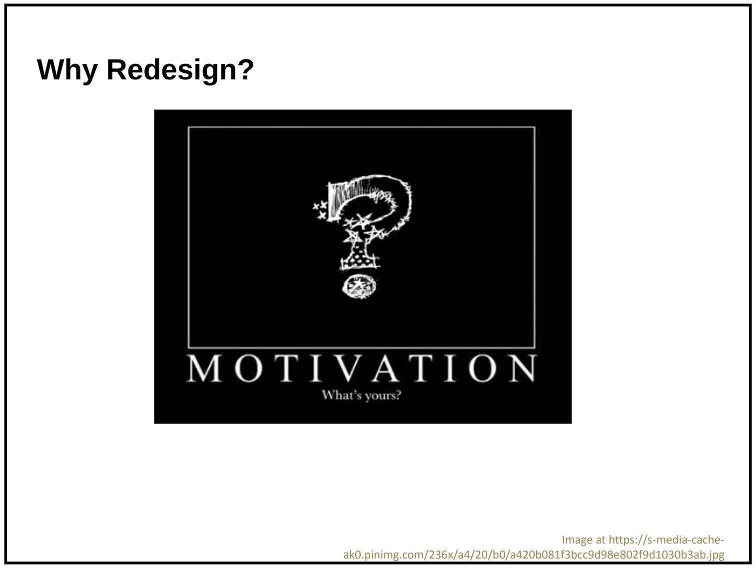
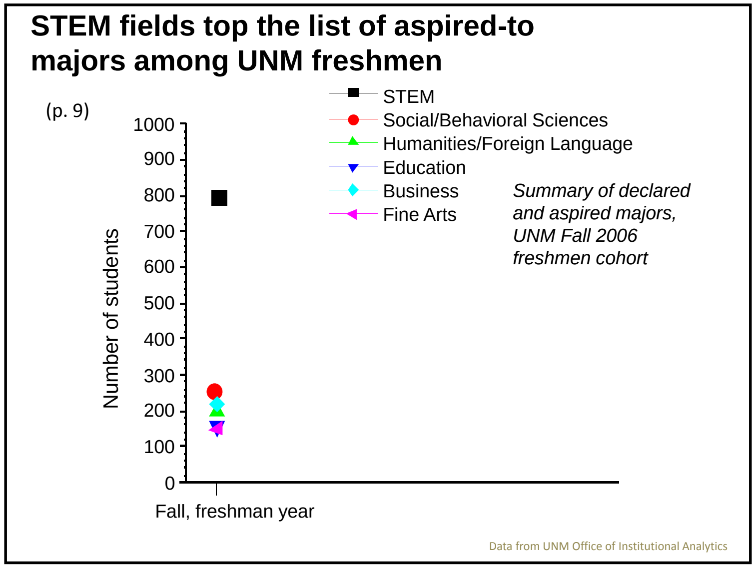


Why Redesign?

Image at https://s-media-cache-ak0.pinimg.com/236x/a4/20/b0/a420b081f3bcc9d98e802f9d1030b3ab.jpg

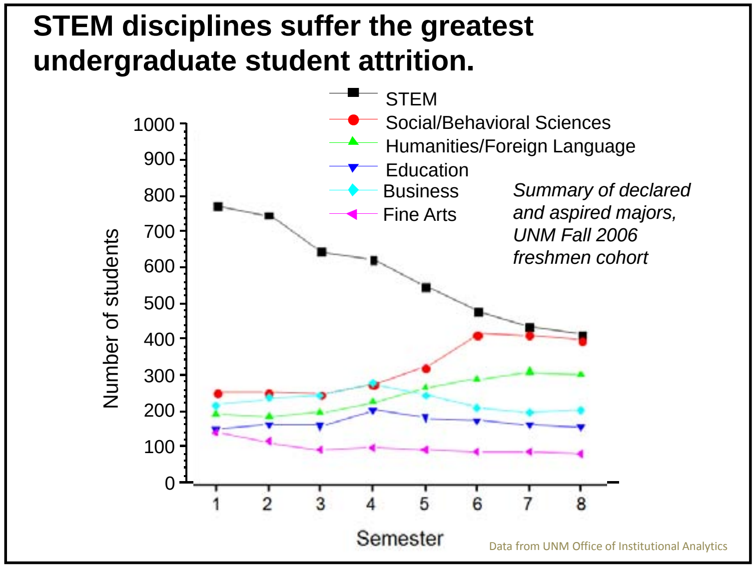


STEM fields top the list of aspired-to majors among UNM freshmen

(p. 9)

Summary of declared and aspired majors, UNM Fall 2006 freshmen cohort

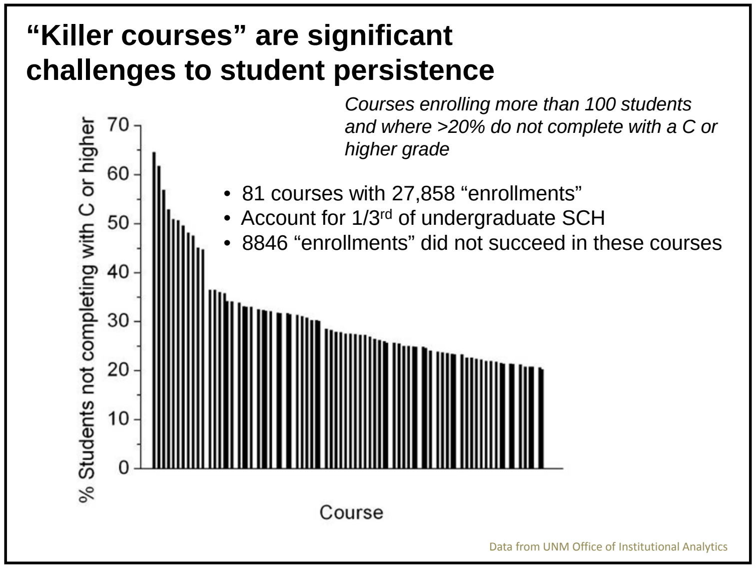
Data from UNM Office of Institutional Analytics



STEM disciplines suffer the greatest undergraduate student attrition.

Summary of declared and aspired majors, UNM Fall 2006 freshmen cohort

Data from UNM Office of Institutional Analytics

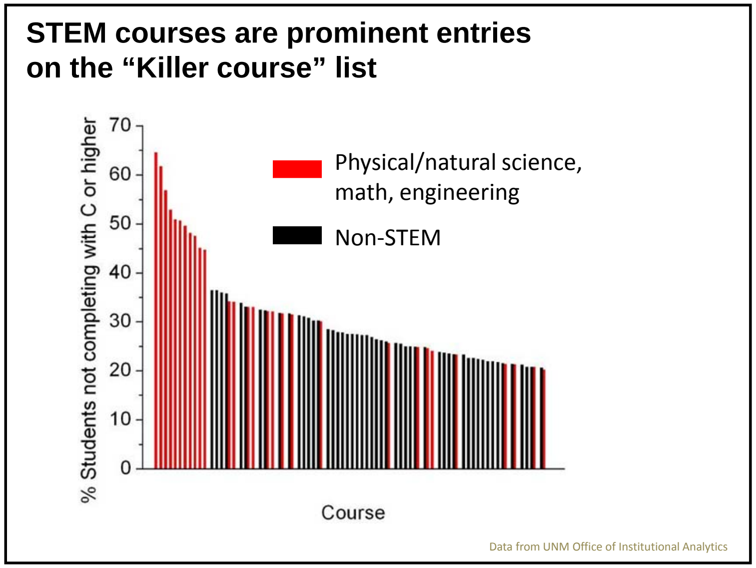


"Killer courses" are significant challenges to student persistence

Courses enrolling more than 100 students and where >20% do not complete with a C or higher grade

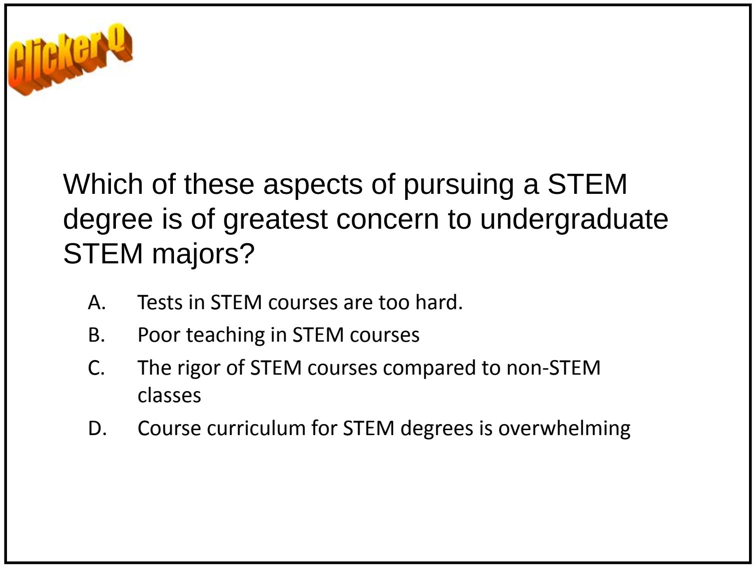
- 81 courses with 27,858 "enrollments"
- Account for 1/3rd of undergraduate SCH
- 8846 "enrollments" did not succeed in these courses

Data from UNM Office of Institutional Analytics



STEM courses are prominent entries on the "Killer course" list

Data from UNM Office of Institutional Analytics



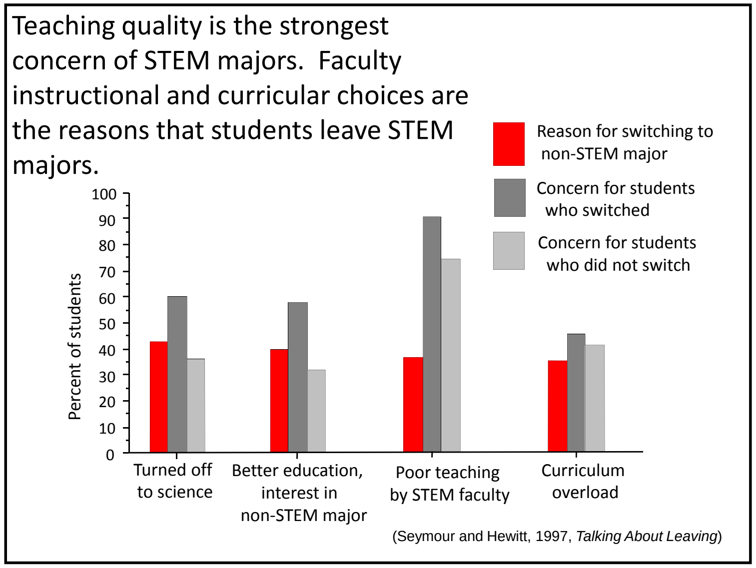
Which of these aspects of pursuing a STEM degree is of greatest concern to undergraduate STEM majors?

A. Tests in STEM courses are too hard.

B. Poor teaching in STEM courses

C. The rigor of STEM courses compared to non-STEM classes

D. Course curriculum for STEM degrees is overwhelming



Teaching quality is the strongest concern of STEM majors. Faculty instructional and curricular choices are the reasons that students leave STEM majors.

(Seymour and Hewitt, 1997, *Talking About Leaving*)

Why Redesign?

Activity

7 minutes

Review your objectives and the "significance" part of your proposal. Summarize the factors that motivate your team to redesign the course.

With your team, construct a *vision statement*.

(p. 11)

What motivates students to learn?

Activity

(p. 12)

Write

↘

Pair

↘

Share

Achievement motivation relies on *value* and *expectancy*

A goal that I value …

… and a belief that I can make it!

(p. 13)

Photo at : http://cdn.coresites.factorymedia.com/cooler_new/wp-content/uploads/2015/04/rock-climbing-almost-there-1.jpg

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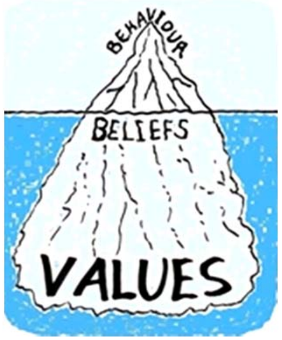
What We Value

Underlies What We Do



And How We Do It

Image at: http://everyoneagreeswithtom.com/wp-content/uploads/2010/02/TOM-Floor-Mat-Values-400.jpg

Keep track of ideas as they come to mind …

Reflect and Apply

Interesting idea to remember and think about further	Idea that I can use now

… in your journal

Part III: What Should Students Learn? Defining *Course-Level* Outcomes

Part III outcomes:

You will be able to …

… define SMART student learning outcomes for their course

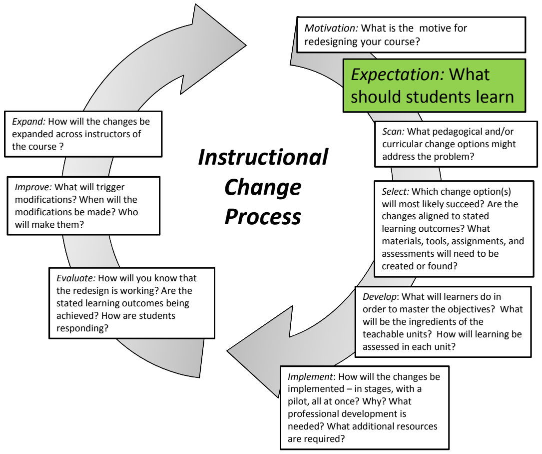
… analyze the cognitive processes and knowledge acquisition specified by a SMART outcome

(p. 14)

STEM Gateway Professional Development Program

Designing Instructional Change to Improve Student Success

Focus for now…



Instructional Change Process

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Expand: How will the changes be expanded across instructors of the course ?

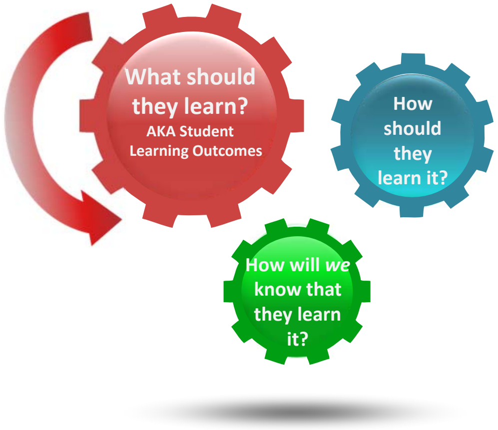
Effective course design and teaching builds courses backwards from where we expect students to finish.

> **"If you don't know where you're going, chances are you will end up somewhere else."**
>
> Yogi Berra

Left Image at: http://2.bp.blogspot.com/-au8FR3xi8Fs/U7lY0oflAYI/AAAAAAAAAKY/a0GTU2e4BUg/s1600/puzzle.jpg

Right Image at: http://amazingwizkids.com/wp-content/uploads/2015/07/Luncheon-of-the-Boating-Party-500-504-piece-puzzle-box-side-view-640-x-495.jpg

When using backwards design, begin with asking:



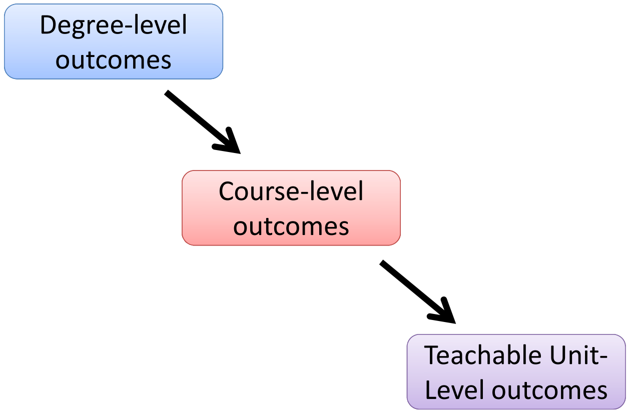
What should they learn?
AKA Student Learning Outcomes

How should they learn it?

How will *we* know that they learn it?

Image by: Gary Smith

Outcomes should exist at multiple, connected levels



Degree-level outcomes

Course-level outcomes

Teachable Unit-Level outcomes

Student learning outcomes (objectives) focus on the learner.

What ***students*** will ***know*** and be able to ***do,*** or ***value*** as a result of having completed the course

Image at: https://bobchoat.files.wordpress.com/2012/11/success.jpg

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Student learning outcomes are SMART.

(p. 15)

Specific

Measurable

Attainable for target audience

Relevant and ***r***esults-oriented

Targeted to the learner and the desired level of learning

Let's evaluate: *What do you think of the quality of these outcomes?*

(p. 16)

- I want to encourage writing fluency and confidence.
- In this course students will understand that poverty is a complex issue.
- Students will be able to identify rocks and minerals.
- Students will solve linear equations in one variable.
- Students will be able to apply their knowledge of statistics to analyze reports and claims in the popular press.

Bloom's taxonomy describes the types of thinking and learning we want to achieve.

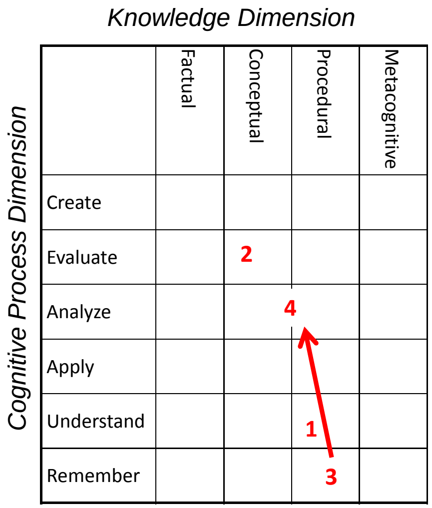
Cognitive process:	What the learner does:
Create	Brings together parts to form a new whole or solve a problem that requires new creative thinking.
Evaluate	Judges the value of something by application of criteria, processes, or standards.
Analyze	Identifies how parts relate to one another or to a larger structure or purpose; considers available evidence to reach a conclusion, inference or generalization
Apply	Use methods, concepts, principles, theories in new situations; solve realistic problems that require the identification of issues and use of appropriate generalizations and skills.
Understand	Constructs meaning by explaining, classifying, comparing, summarizing
Remember	Recalls or recognizes information: facts, definitions, generalizations

Anderson & Krathwohl, 2001, A Taxonomy for Learning, Teaching, and Assessing: Longman Publishing Group.

Bloom's taxonomy also considers different types of knowledge that are acquired

Knowledge type:	Knowledge gained:
1. Factual	Basic elements (e.g., terms, people, formulas) that learners must know to be acquainted with a discipline or solve problems in the discipline.
2. Conceptual	The interrelationships among the basic elements within a larger structure that enables the elements to function together (e.g., classifications, principles, theories, models, structures).
3. Procedural	How to do something — methods of inquiry, algorithms, techniques — along with criteria for when to use appropriate procedures
4. Metacognitive	Knowledge of the nature of a cognitive task in relation to one's own cognitive abilities, knowledge of how and when to effectively use cognitive strategies – "knowing what you do and do not know"

Anderson & Krathwohl, 2001, A Taxonomy for Learning, Teaching, and Assessing: Longman Publishing Group.



Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate		2		
Analyze			4	
Apply				
Understand			1	
Remember			3	

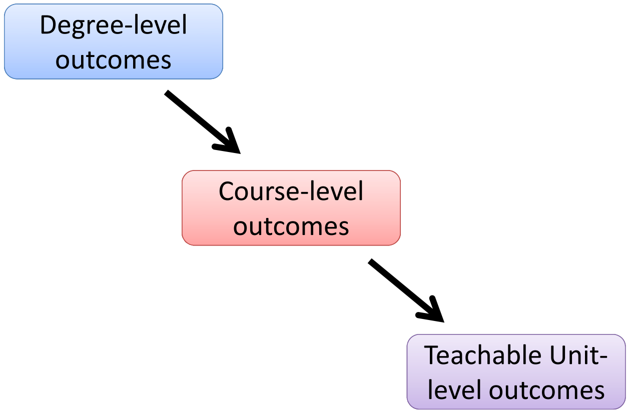
Where do these outcomes plot?

(p. 19)

Students will be able to:

1. … solve linear equations in one variable.
2. … apply their knowledge of statistics to analyze reports and claims in the popular press.
3. … identify rocks and minerals.
4. … analyze rock samples from a locality and interpret the geologic processes that occurred.

Outcomes should exist at multiple, connected levels



Degree-level outcomes

Course-level outcomes

Teachable Unit-level outcomes

"Bloom" your course outcomes on the wall charts (also p.20)

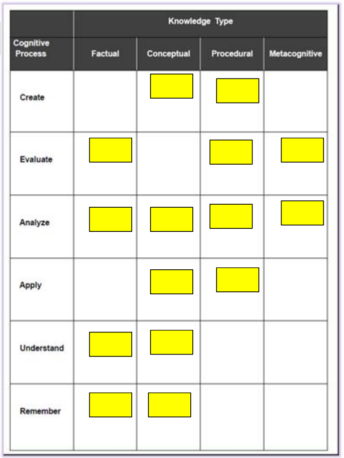
Activity

30 minutes

Match each outcome to Bloom dimensions

Place non-SMART or otherwise problematic objectives on the side

Room for improvement? Edit as you go and consider adding more high-order outcomes while reserving low-order one for class-level, rather than course-level, outcomes.



Cognitive Process	Knowledge Type			
	Factual	Conceptual	Procedural	Metacognitive
Create		🟨	🟨	
Evaluate	🟨		🟨	🟨
Analyze	🟨	🟨	🟨	🟨
Apply		🟨	🟨	
Understand	🟨	🟨		
Remember	🟨	🟨		

Part IV: What Should Students Learn? Defining *Teachable-Unit-Level* Outcomes

Part IV outcomes:

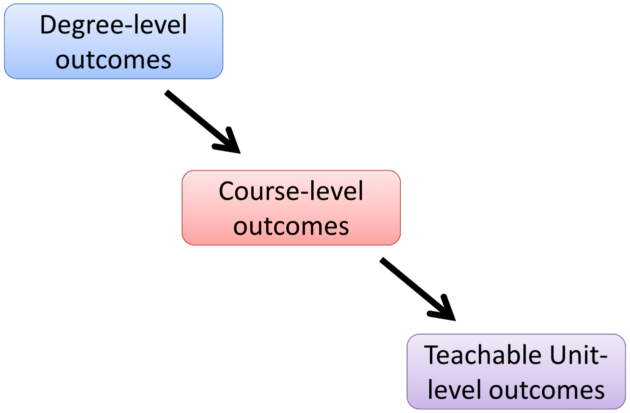
You will be able to …

… define a teachable unit as an explicit, outcomes-driven module for a course

… connect teachable-unit-level outcomes to course-level outcomes as a process of scaffolded learning

(p. 22)

Outcomes should exist at multiple, connected levels



Degree-level outcomes

Course-level outcomes

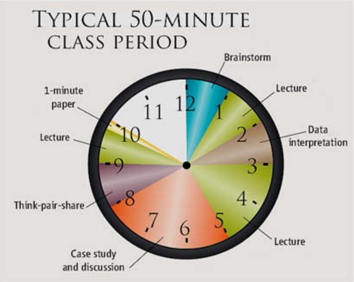
Teachable Unit-level outcomes

Throughout the institute, you will build a teachable unit.

Instructional materials that enclose the activities, assignments, and assessments within a time-defined part of the course that are designed to achieve learner mastery of an essential concept and/or a course outcome.

May be a plan for one class period, one week, or some other part of the whole course.

Is constructed so that other instructors could execute the unit.



(Handelsman et al., 2007, *Scientific teaching*: Freeman; Miller et al., 2008, Scientific teaching in practice: *Science*, v. 322, p. 1329)

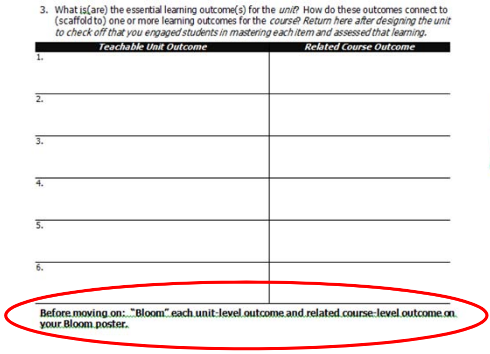
(p. 23)

When starting a teachable unit, begin with answering:

Teachable Unit Guide
(p. 94 or Word file)

Questions 1 and 2

With your team/partner, define and Bloom your teachable unit outcomes (What should students learn?)



3. What is(are) the essential learning outcome(s) for the *unit*? How do these outcomes connect to (scaffold to) one or more learning outcomes for the *course*? *Return here after designing the unit to check off that you engaged students in mastering each item and assessed that learning.*

Teachable Unit Outcome	Related Course Outcome
1.	
2.	
3.	
4.	
5.	
6.	

Before moving on: "Bloom" each unit-level outcome and related course-level outcome on your Bloom poster.

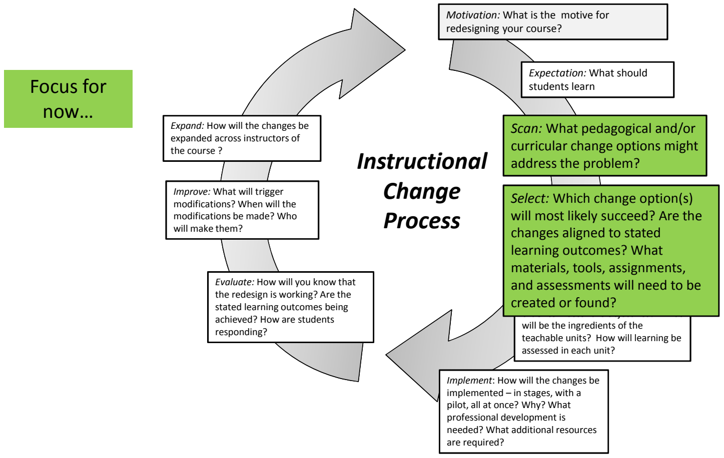
(p. 94)

30 minutes

Congratulations!
You have just completed a teachable-unit milestone

Image at: http://societyforpsychotherapy.org/wpcontent/uploads/2015/07/HiRes1.jpg

STEM Gateway Professional Development Program
Designing Instructional Change to Improve Student Success



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Expand: How will the changes be expanded across instructors of the course ?

Instructional Change Process

Part V: How will Students Learn? Where Learning Begins

(p. 24)

Part V outcomes:

You will be able to …

… describe the fundamental learning centers in the brain

… begin an analysis of how students' prior knowledge affects learning in the targeted course

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"It dawned on me about two weeks into the first year that it was not teaching that was taking place in the classroom, but learning."

Pop star Sting, reflecting upon his early career as a teacher

Left photo at: http://i.perezhilton.com/wp-content/uploads/2008/04/sting__oPt.jpg

Right image at: https://lh3.googleusercontent.com/-ZH99eX3woyo/T7UbQe69rAI/AAAAAAAARug/QxdfMxsW1O0/w426-h331/teachlearn.jpg

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What Does it Mean "to Learn?"

Write answers to these questions in the spaces provided on page 25

- What is your definition of "learning?"
- What is your definition of "teaching?"

Left photo courtesy of UNM

Center photo by: Gary Smith

Right photo courtesy of UNM

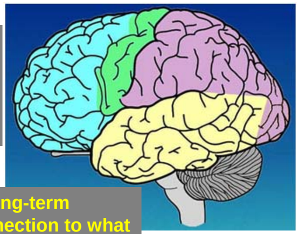
Example definitions of teaching and learning

"Learning is the stabilization, through repeated use, of certain appropriate and desirable synapses in the brain."

"Teaching means any activity that has the conscious intention of, and potential for, facilitating learning in another person."

R. Leamnson, 1999, *Thinking about teaching and learning*

The most effective learning triggers all learning centers in the brain



Actions: writing, discussing, experimenting, testing

Integration: "making sense", new understanding, manipulating working memory

Sensory input: sight and sound; concrete experience

Integration: long-term memory; connection to what is already known; forming new neural networks through repetition, elaboration, and sleep

(after Zull, 2002, *The Art of Changing the Brain)*

(p. 26)

Image modified from Brain-Behavior Optimization Center: http://www.brainbehavioroptimization.com/index.php?rmm=Brain

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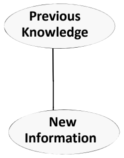
Learning starts with what is already known … or thought to be known

"If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly"

David Ausubel

Ausubel, D. P. (1968). *Educational psychology: A cognitive view.* New York: Holt, Rinehart and Winston.

Knowledge is associative—it is linked to prior mental models and cognitive structures



Previous Knowledge

New Information

Teaching is not about pouring knowledge into the learners' empty brains

(p. 27)

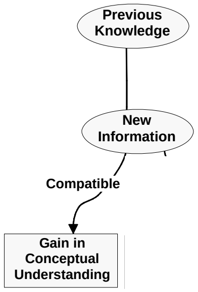
Image at: http://medicine.ukzn.ac.za/Libraries/Division_of_Clinical_Medicine/fact_pouring.sflb.ashx

How People Learn, National Research Council, 2000

Chapter 2 Active Learning
Scientific Teaching

Knowledge is associative—it is linked to prior mental models and cognitive structures …

… and can include prior misconceptions.



How People Learn, National Research Council, 2000

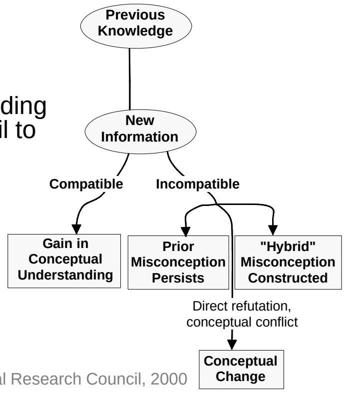
Photo by: Gary Smith

Knowledge is associative—it is linked to prior mental models and cognitive structures …

… and can include prior misconceptions.

If a learner's initial misunderstanding is not engaged he or she may fail to grasp new concepts, correct concepts, or both.

> *"It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so."*
> *- Mark Twain*



How People Learn, National Research Council, 2000

A Private Universe
(Harvard commencement)

Photo from A Private Universe

Clicker Q

Ice is floating in a glass of water that is filled to the rim. When the ice melts, the water level will …

A. … rise, so that the water overflows the rim
B. … stay the same, so that the water level remains at the rim
C. … fall, so that the water level drops below the rim
D. ... depend on the density of the ice

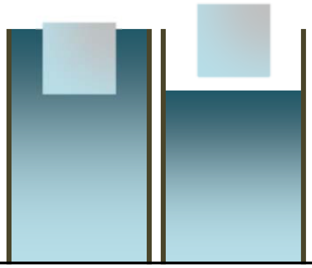
Based on a 2200-year-old physics principle …
… the water level will be unchanged

"Any solid lighter than a fluid will, if placed in the fluid, be so far immersed that the weight of the solid will be equal to the weight of the fluid displaced."

Archimedes of Syracuse, c. 225 BCE, *Floating Bodies*

Ice density is 90% of the density of freshwater, so it floats with 90% of its volume submerged.

Without the ice, the water level is lower, because a weight of water equal to that of the ice cube had been displaced.



Based on a 2200-year-old physics principle …
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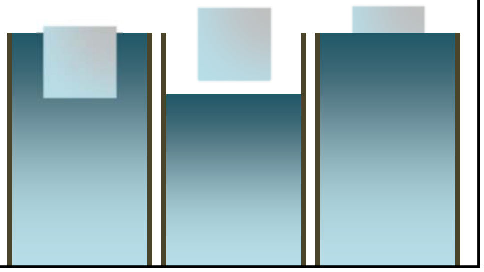
"Any solid lighter than a fluid will, if placed in the fluid, be so far immersed that the weight of the solid will be equal to the weight of the fluid displaced."

Archimedes of Syracuse, c. 225 BCE, *Floating Bodies*

Ice density is 90% of the density of freshwater, so it floats with 90% of its volume submerged.

Without the ice, the water level is lower, because a weight of water equal to that of the ice cube had been displaced.

When the ice melts, the volume of added water will be 90% of the ice volume because of the density difference.

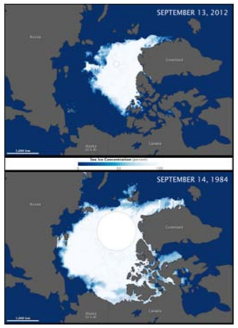


Clicker Q

Floating sea ice and icebergs in the Arctic Ocean are melting at faster rates during the summer than they form during the winter. As a result …

A. … sea level will rise
B. … sea level will stay the same
C. … sea level will fall
D. … sea level change will depend on the density of the ice

Summer sea ice, 1979

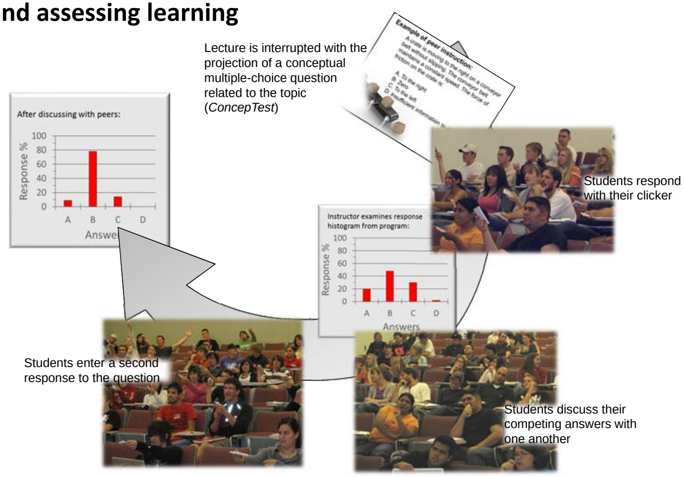


Maps at: http://nsidc.org/

Which freezes more readily?

A. Fresh water
B. Sea water
C. There is no difference

Peer instruction is an evidence-based use of clickers to expose weak prior knowledge while promoting and assessing learning



Lecture is interrupted with the projection of a conceptual multiple-choice question related to the topic (*ConcepTest*)

Students respond with their clicker

Students discuss their competing answers with one another

Students enter a second response to the question

Photos by Aurora Pun

Activity

15 minutes

The Impact of Learner Prior Knowledge for Learning from Your Teachable Unit

Complete the work-sheet on p. 95 with your redesign team

STEM GATEWAY

Part VI: **How will Students Learn?**
The Science Behind Scientific Teaching

Part VI outcomes:

You will be able to …

… apply cognitive psychology principles to determine the likely efficacy of instructional approaches

… recognize learning along the interactive-passive continuum

…explain to a colleague why active learning generates greater learning achievements than traditional lecture

---

Write

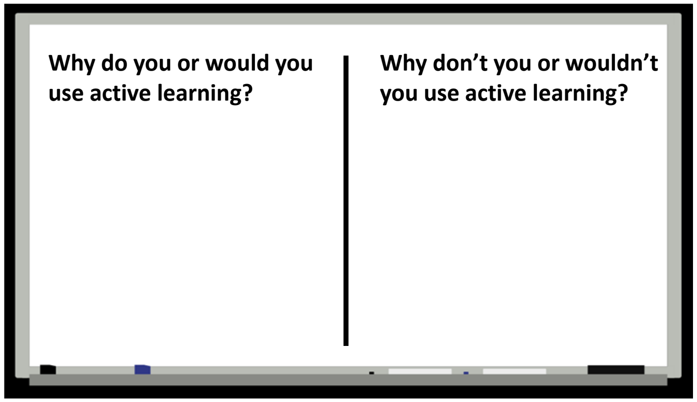
Pair

Share

Describe in your own words…
What is active learning?

Classroom active learning includes any activity that “involves students in doing things and thinking about the things they are doing”

(Bonwell and Eison, 1991, *Active learning: Creating excitement in the classroom*)



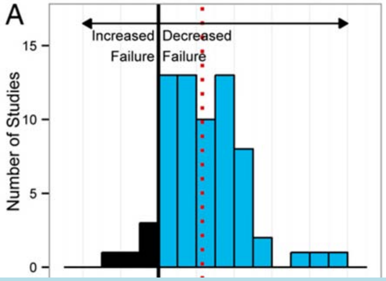
Why do you or would you use active learning?

Why don’t you or wouldn’t you use active learning?

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

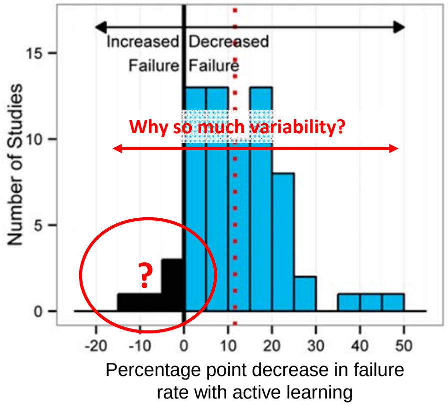
Scott Freeman and 6 others, 2014, *Proceedings of the National Academy of Sciences*

Failure rates under traditional lecturing (avg. 33.8%) increase by 55% over the rates observed under active learning (21.8%).



“If the experiments analyzed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit—meaning that enrolling patients in the control condition might be discontinued because the treatment being tested was clearly more beneficial.”

What intrigues us the most about these types of research results…



Freeman et al., 2014, *Proceed. Nat’l. Acad. Sci.*

An implementation problem?

If possible – observe the technique being used

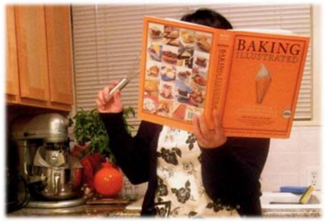
Photo at: http://i.stack.imgur.com/OgkQD.jpg

Not all active-learning strategies are equal …

… so they won't all lead to the same amount of learning.

Photo at: http://getthepetnanny.com/wp-content/uploads/2015/09/Dogs01.jpg

If all you know is a recipe …



… and it fails to produce the desired result…

… how can you figure out what went wrong and what to do about it?

Left photo at
http://images.teamsugar.com/files/users/
1/15259/32_2007/IMG_1528_2.preview.J

Right photo at: http://www.efficientmomma.com/tag/veggie-burger/

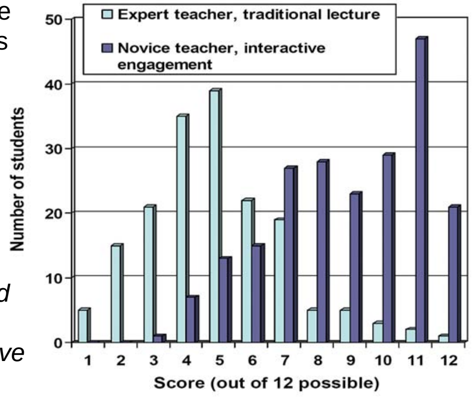
Effective design and diagnosis of learning activities requires some level of knowledge of how learning works

Coming up:

- **A few key concepts from cognitive psychology**
- **An approach for "rating" active-learning instructional elements**

Returning to our case-study in teaching and learning

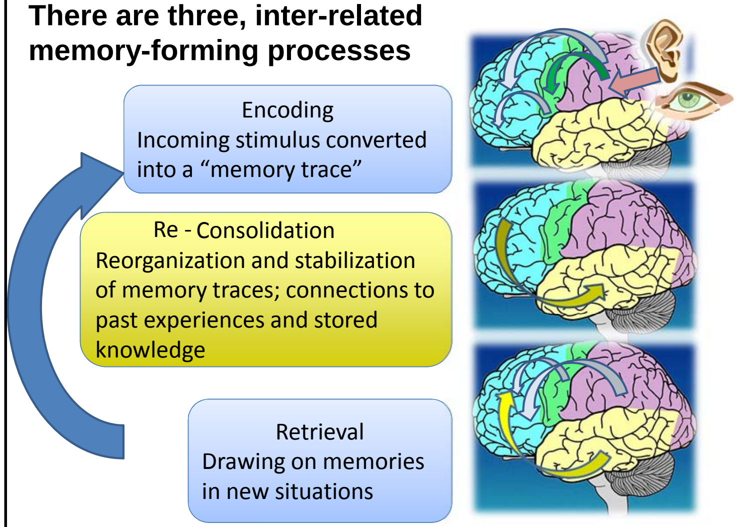
Can you explain the learning differences in the physics classes?



Keep in mind the information provided on page 31 as we contemplate cognitive processes

Deslauriers et al., 2011, Improved learning in a large-enrollment physics class, *Science*, 332: 862

There are three, inter-related memory-forming processes

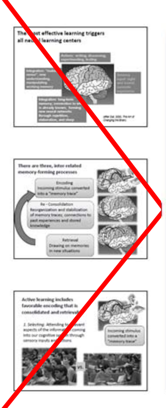


Encoding
Incoming stimulus converted into a "memory trace"

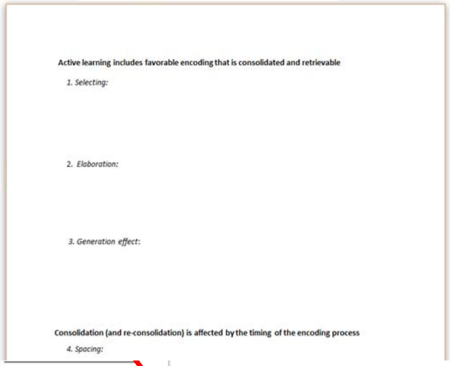
Re - Consolidation
Reorganization and stabilization of memory traces; connections to past experiences and stored knowledge

Retrieval
Drawing on memories in new situations

Note-taking helps to encode memories



Skeletal notes (p. 33)



Active learning includes favorable encoding that is consolidated and retrievable

1. Selecting:

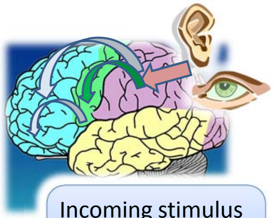
2. Elaboration:

3. Generation effect:

Consolidation (and re-consolidation) is affected by the timing of the encoding process

4. Spacing:

Active learning includes favorable encoding that is consolidated and retrievable



1. Selecting: Attending to relevant aspects of the information coming into our cognitive system through sensory inputs and actions

Incoming stimulus converted into a "memory trace"

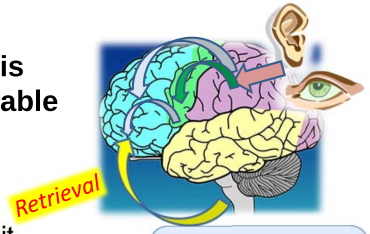
VS.

Photos by: Aurora Pun

Active learning includes favorable encoding that is consolidated and retrievable

1. *Selecting*

2. *Elaboration:* interpreting new information, connecting it with other information, and mulling it over.



Incoming stimulus converted into a "memory trace"

Left photo at: http://3.bp.blogspot.com/-xL4vfHlyl3c/UjdqtWzaH6I/AAAAAAAAAZ8/41szdUpUR9k/s1600/lecture1.jpg Right photo by: Gary Smith

---

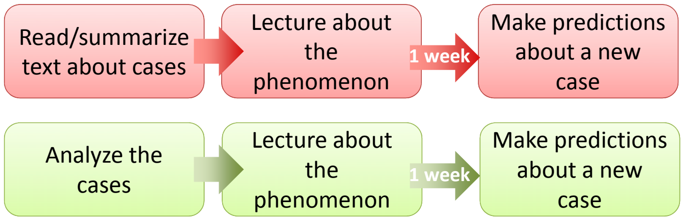
Which of these approaches do you think generates the greater learning?

Clicker Q

A. Learner attempts to solve problems and/or answer questions about a new topic *before* the instructor explains it in class.

B. Learner attempts to solve problems and/or answer questions about a new topic *after* the professor explains it in class.

The roles of *constructed* and *transmitted* knowledge examined through transfer of understanding to explain cases

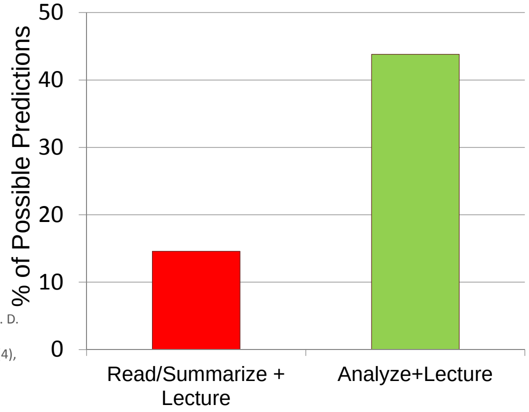


Read/summarize text about cases → Lecture about the phenomenon → 1 week → Make predictions about a new case

Analyze the cases → Lecture about the phenomenon → 1 week → Make predictions about a new case

Schwartz, D. L., & Bransford, J. D. (1998). A Time for Telling. *Cognition and Instruction*, *16*(4), 475–522.

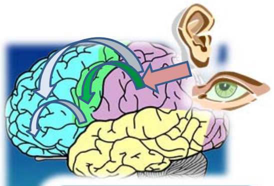
Expert explanation *after* novice construction of knowledge leads to better learning transfer



Schwartz, D. L., & Bransford, J. D. (1998). A Time for Telling. *Cognition and Instruction*, *16*(4), 475–522.

Active learning includes favorable encoding that is consolidated and retrievable

1. *Selecting*
2. *Elaboration*



Incoming stimulus converted into a "memory trace"

3. Generation effect: Memories are more strongly encoded when knowledge is partly or wholly *constructed* in one's mind rather than only received.

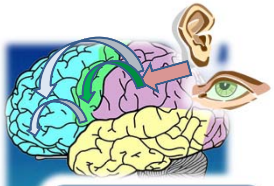
vs.

Left photo at: http://www.emergingedtech.com/wp/wp-content/uploads/2014/11/marsblog-lecture-full-bored-1024x424.jpg

Right photo by Gary Smith

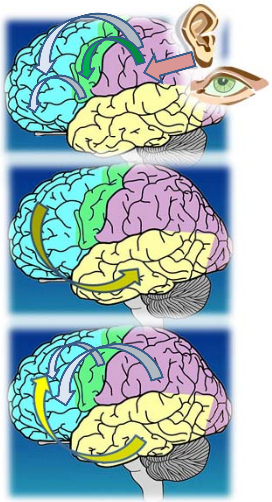
Active learning includes favorable encoding that is consolidated and retrievable

1. *Selecting*
2. *Elaboration*
3. *Generation effect*



Incoming stimulus converted into a "memory trace"

There are three, inter-related memory-forming processes



✓ Encoding
Incoming stimulus converted into a "memory trace"

Consolidation
Reorganization and stabilization of memory traces; connections to past experiences and stored knowledge

Retrieval
Drawing on memories in new situations

Clicker Q

Which strategy do you think is most effective for consolidating memories of new concepts or procedures?

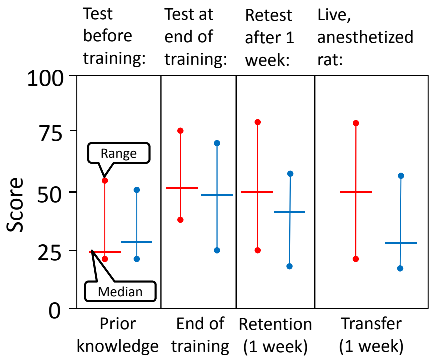
A. *Spaced learning* in short time increments across a long time interval.

B. *Massed learning* in a single, long learning session

Learning retention and transfer is improved by spaced rather than massed study

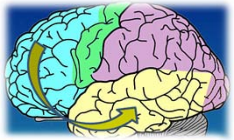
Students were taught a microsurgical procedure in either:

- 1, 8-hour session (massed)
- 4, 2-hour weekly sessions (spaced)



Moulton et al., 2006, Teaching surgical skills: What kind of practice makes perfect? *Annals of Surgery*, 244(3): 400-409

Consolidation (and re-consolidation) is affected by the timing of the encoding process

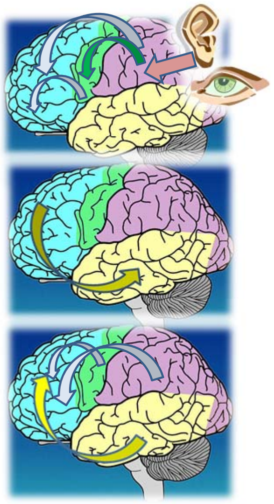


1. *Selecting*
2. *Elaboration*
3. *Generation effect*

Reorganization and stabilization of memory traces; connections to past experiences and stored knowledge

4. *Spacing:* Repetition, with time in between learning occurrences, better consolidates long-term memory for retrieval.

There are three, inter-related memory-forming processes



✓ Encoding
Incoming stimulus converted into a "memory trace"

✓ Consolidation
Reorganization and stabilization of memory traces; connections to past experiences and stored knowledge

Retrieval
Drawing on memories in new situations

Which of these approaches do you think will most benefit students to prepare for an exam?

A. Providing students a review sheet related to the exam topics.

B. Quizzing the students about the exam topics.

Testing, and learner self-explanation are critical to effective, long-term learning

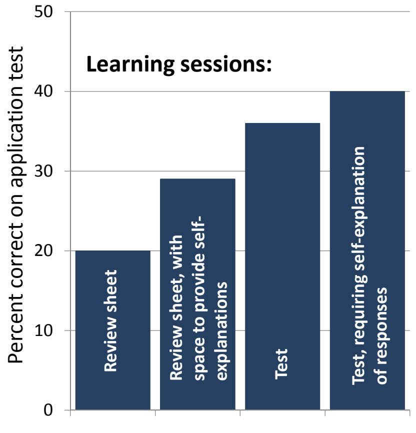
Students …

a) Received lecture instruction on 4 topics,

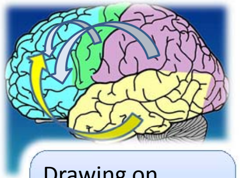
b) received one of 4 of four weekly learning sessions following each topic, and

c) were assessed with a knowledge-application test on the four topics, 6 months later.

Larsen, Butler, and Roediger, 2013, Comparative effects of test-enhanced learning and self-explanation on long-term retention. *Medical Education*, 47: 674–682.



Retrieval is part of learning as well as testing



1. *Selecting*
2. *Elaboration; including self-explanation*
3. *Generation effect*
4. *Spacing*

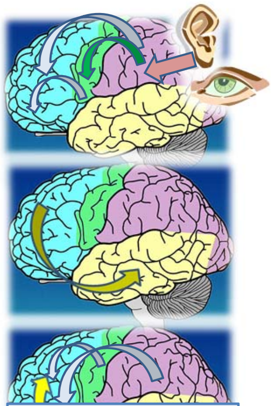
Drawing on memories in new situations

5. Testing effect: Every time a memory is retrieved and utilized it is changed and reconsolidated in long-term memory

Effortful recall or practice helps to integrate learning into *mental models*, in which sets of inter-related ideas are fused into a meaningful whole that can be used in later situations

---

There are three, inter-related memory-forming processes



✓ Encoding
Incoming stimulus converted into a "memory trace"

✓ Consolidation
Reorganization and stabilization of memory traces; connections to past experiences and stored knowledge

✓ Retrieval
Drawing on memories in new situations

Results of the data studies are provided on p. 42

Effective design and diagnosis of learning activities requires some level of knowledge of how learning works

Coming up:

- ~~**A few key concepts from cognitive psychology**~~
- **An approach for "rating" active-learning instructional elements**

⚠WARNING

Active learning is about to be used differently than was previously defined

---

The ICAP model *differentiates learning activities* on the basis of the learner's overt behaviors

Top photo by Gary Smith

Interactive
Collaborating in Dialogue

Photo by Aurora Pun

Constructive
Generating, Producing

Photo by Aurora Pun

Active
Selecting, Manipulating
Se

Passive
Receiving

More details on p. 34

Chi, 2009, *Topics in Cognitive Science*, 1(1): 73-105

The ICAP model demonstrates that not all learning activities generate the same depth of learning

Interactive
Collaborating in Dialogue

Constructive
Generating, Producing

Active
electing, Manipulating
Se

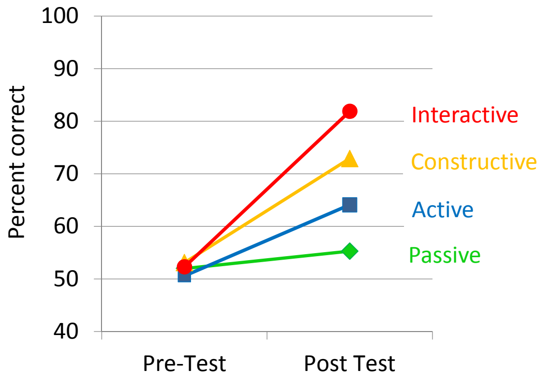
Passive
Receiving

Depth of learning:

Interactive > Constructive > Active > Passive

Chi, 2009, *Topics in Cognitive Science*, 1(1): 73-105

ICAP hypothesis is supported by learning-achievement data from an introductory materials science course



(p. 35)

Menekse et al., 2013, *J. of Engineering Education*, 102(3): 346-374

ICAP the following workshop examples

1. Each participant reads part of a book and answers accompanying guiding reading questions individually.
2. Each participant listens to a lecture and elaborates on the skeleton notes about *Selecting, Elaborating, Generation Effect, Spacing,* and *Testing Effect* provided in their workbook during the workshop.
3. Each participant listens to the facilitator explain where learning takes place in the brain, and the three components of memory formation
4. Each participant answers a clicker question and then discusses and debates answers with colleagues. Answers are resubmitted via clickers.

5 minutes

ICAP descriptions: p. 34
Checklist: p. 36

Part VII: Where does learning take place?

Part VII outcome:

You will be able to …

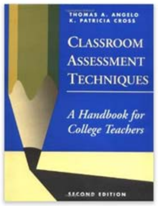
… sketch the learning-activity sequence as a framework for building a teachable unit

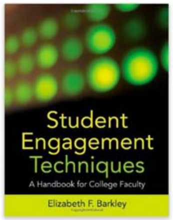
(p. 38)

Sometimes, the focus is on reproducing a single activity (dish)

Photo by: Mangan Enak

Photo at: http://simplylosingit.com/wp-content/uploads/2015/09/Suprised-Man-Cooks.jpg





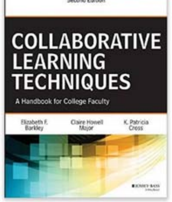


Photo at Amazon.com

And… there are plenty of "dish-by-dish cookbooks" for educators

---

The most effective teacher with active learning is a chef …

Photo at: http://ftjcolley.weebly.com/uploads/1/7/4/6/17462145/199154_orig.jpg

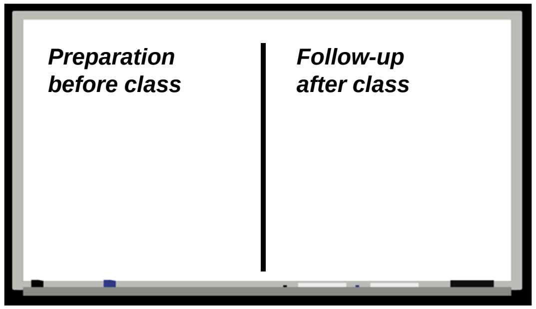
… who prepares multiple-course meals

Photo at: http://i1.ypcdn.com/blob/cea37c4dd8b49f9eafbba7a9c5b1e5753b1491f2_50x50_crop.jpg?3347ce7

Where does active learning take place?

Very limited time is spent with students physically present in-class.

To maximize our time, what could we provide as:



Preparation before class

Follow-up after class

The *learning activity sequence* structures what is learned both in and out of class

Learning Before Class ➡ **Learning In Class** ➡ **Learning After Class** (p. 40)

Learning Activity Sequence

Photo by Aurora Pun

Photo by Aurora Pun

Photo by UNM

First contact with content before *and* outside of class

Interactive learning during *and* inside class

Monitoring and elaborating on learning after *and* outside of class

Assessing learning

Muddy Point Question

Before leaving, take 10 minutes to answer -

What ideas or application of concepts discussed today remain unclear?

Or

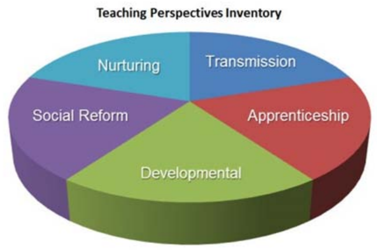
What ideas or application of concepts were most interesting? Why?

STEM Gateway
Course Redesign Institute

Gary Smith
Audriana Stark

STEM GATEWAY
Project for Inclusive
Undergraduate STEM Success

Teaching Perspective Inventory Reflection- A Gallery Walk



Locate the poster sheet with the name of your dominant perspective. List the advantages of having this perspective on the sheet.

Image from: http://www.teachingperspectives.com/tpi/

Teaching Perspective Inventory Reflection- A Gallery Walk

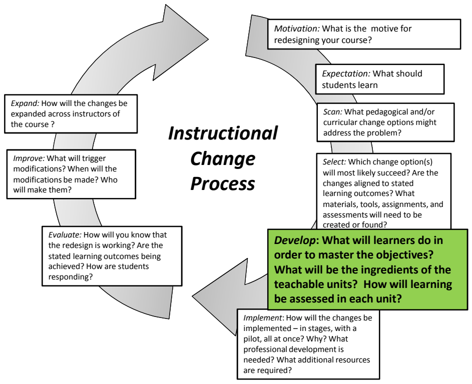
Pg. 45-47

Walk around the room to each station reviewing, adding to, and taking note of the advantages to the various perspectives.

Image from: http://www.teachingperspectives.com/tpi/

STEM Gateway Professional Development Program
Designing Instructional Change to Improve Student Success

Focus for now…



Instructional Change Process

Motivation: What is the motive for redesigning your course?

Expectation: What should students learn

Scan: What pedagogical and/or curricular change options might address the problem?

Select: Which change option(s) will most likely succeed? Are the changes aligned to stated learning outcomes? What materials, tools, assignments, and assessments will need to be created or found?

***Develop*: What will learners do in order to master the objectives? What will be the ingredients of the teachable units? How will learning be assessed in each unit?**

Implement: How will the changes be implemented – in stages, with a pilot, all at once? Why? What professional development is needed? What additional resources are required?

Evaluate: How will you know that the redesign is working? Are the stated learning outcomes being achieved? How are students responding?

Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

Part VIII: Building a Teachable Unit – Selecting Pedagogy and Content for Student Success

Part VIII outcomes:

You will be able to …

…draft peer instruction Q & A prompts

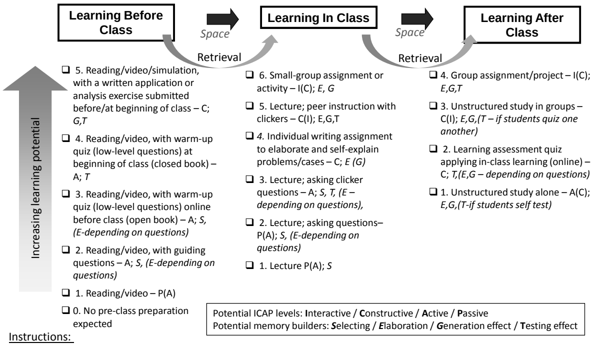
… create teachable units for your redesigned course using the learning activity sequence

… analyze a teachable unit to assure alignment of learning activities with learning outcomes

---

Start where you are at, now, and set a goal for enhancing learning

p. 49



Learning Before Class

- ☐ 5. Reading/video/simulation, with a written application or analysis exercise submitted before/at beginning of class – C; *G,T*
- ☐ 4. Reading/video, with warm-up quiz (low-level questions) at beginning of class (closed book) – A; *T*
- ☐ 3. Reading/video, with warm-up quiz (low-level questions) online before class (open book) – A; *S, (E-depending on questions)*
- ☐ 2. Reading/video, with guiding questions – A; *S, (E-depending on questions)*
- ☐ 1. Reading/video – P(A)
- ☐ 0. No pre-class preparation expected

Learning In Class

- ☐ 6. Small-group assignment or activity – I(C); *E, G*
- ☐ 5. Lecture; peer instruction with clickers – C(I); E,G,T
- ☐ *4.* Individual writing assignment to elaborate and self-explain problems/cases – C; *E (G)*
- ☐ 3. Lecture; asking clicker questions – A; *S, T, (E – depending on questions),*
- ☐ 2. Lecture; asking questions– P(A); *S, (E-depending on questions)*
- ☐ 1. Lecture P(A); *S*

Learning After Class

- ☐ 4. Group assignment/project – I(C); *E,G,T*
- ☐ 3. Unstructured study in groups – C(I); *E,G,(T – if students quiz one another)*
- ☐ 2. Learning assessment quiz applying in-class learning (online) – C; *T,(E,G – depending on questions)*
- ☐ 1. Unstructured study alone – A(C); *E,G,(T-if students self test)*

Potential ICAP levels: **I**nteractive / **C**onstructive / **A**ctive / **P**assive
Potential memory builders: ***S***electing / ***E***laboration / ***G***eneration effect / **T**esting effect

Instructions:

1. Place an × in the box that is most representative of each learning-sequence stage in your *current* teaching sessions
2. Place a ✓ in the box that represents your goal for each learning-sequence stage in your *future* teaching

---

"From Questions to Concepts"

Interactive Teaching DVD: Promoting Better Learning Using Peer Instruction and Just-In-Time Teaching

Image from DVD

Debriefing … "From Questions to Concepts"

How is the learning activity sequence being applied?

Learning Before Class → **Learning In Class** → **Learning After Class**

Photo by Aurora Pun

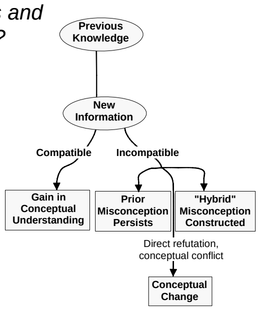
Photo by Aurora Pun

Photo by UNM

Debriefing …
“From Questions to Concepts”

p. 50

How are students’ misconceptions and prior knowledge being addressed?



Debriefing …
“From Questions to Concepts”

Why is it important to make learning “visible”?

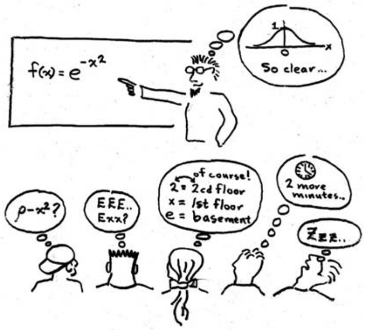


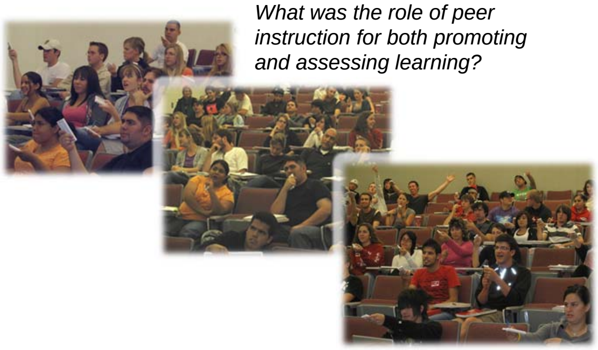
Image at http://www.mollyigood.com/courses-and-workshops.html

Debriefing …
“From Questions to Concepts”

Where does pre-class work plot on the ICAP framework?
Where does in-class work plot on the ICAP framework?

Debriefing …
“From Questions to Concepts”

What was the role of peer instruction for both promoting and assessing learning?



Photos by Aurora Pun

Now you try…

Draft ***3 peer instruction*** questions with accompanying answers.

*Questions must be connected to the ***outcomes*** for your teachable unit!

p.96

Activity

Part VIII: **Building a Teachable Unit – Selecting Pedagogy and Content for Student Success**

Part VIII outcomes:

You will be able to …

… create teachable units for your redesigned course using the learning activity sequence

… analyze a teachable unit to assure alignment of learning activities with learning outcomes

…draft peer instruction Q & A prompts

Effective course design *integrates* activities that are formed around these questions:

What should they learn? (Outcomes)

How should they learn it? (Instruction)

How will *we* know they learn it? (Assessment)

"It is the one who does the work who does the learning"

Terry Doyle, 2008, *Helping students learn in a learner-centered environment*

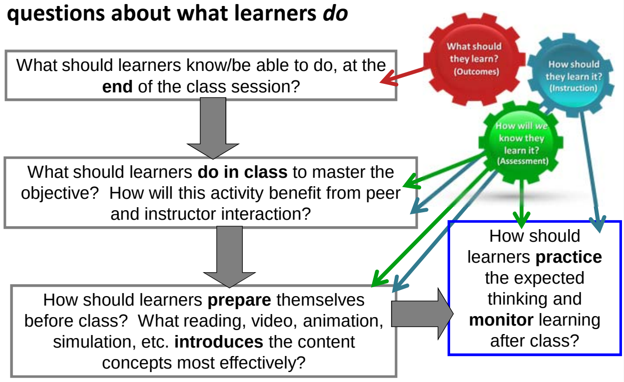
"Don't re-teach yourself. Standing at the front of the room talking and writing on the board is you re-enforcing what *you* know. *Engage* your students… we need to *work* with the material, *talk* about it, *think* about it, *not listen to you* all of the time."

Photo by UNM

- UNM student panelist, "Improving Native American Student Success"

Photo by Aurora Pun

Building a teachable unit focuses on questions about what learners *do*



What should learners know/be able to do, at the **end** of the class session?

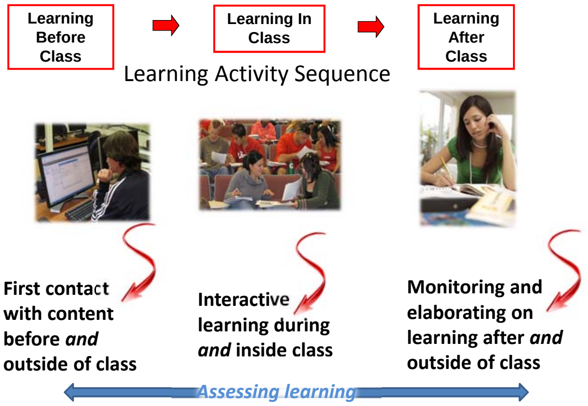
What should learners **do in class** to master the objective? How will this activity benefit from peer and instructor interaction?

How should learners **prepare** themselves before class? What reading, video, animation, simulation, etc. **introduces** the content concepts most effectively?

How should learners **practice** the expected thinking and **monitor** learning after class?

p.53

The *learning activity sequence* structures what is learned both in and out of class



Learning Before Class → **Learning In Class** → **Learning After Class**

Learning Activity Sequence

First contact with content before *and* outside of class

Interactive learning during *and* inside class

Monitoring and elaborating on learning after *and* outside of class

Assessing learning

Within the learning activity sequence…

… students engage with learning the content during class time with peer and instructor influence, …

Top Left Photo by UNM. Top right/ Bottom Photos by Aurora Pun

---

Within the learning activity sequence…

… students engage with learning the content during class time with peer and instructor influence, …

… which means that students must be prepared by making **first contact with (and thinking about) content prior to class**.

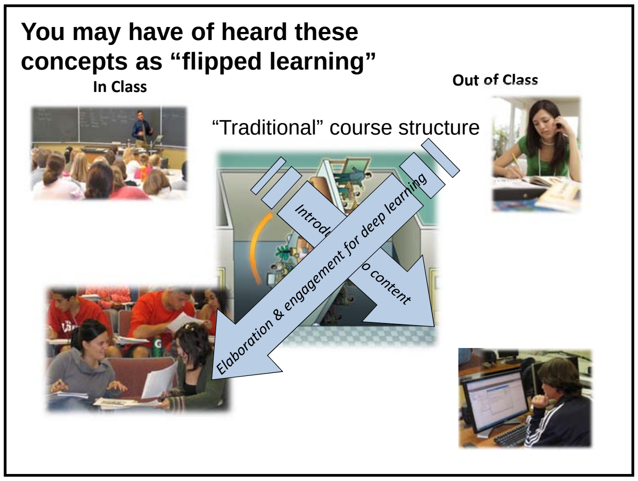
Photo by Aurora Pun

Photo by UNM

Photo by UNM

Photo by Aurora Pun

Photo by Aurora Pun



You may have of heard these concepts as "flipped learning"

Activity

Building a Teachable Unit

Chapter 5 of *Scientific Teaching. P. 97-104*

Complete the worksheet with your redesign team

Chapter 5
Scientific Teaching p. 83

Congratulations!

You have just completed a milestone

Part IX: Building a Teachable Unit – Assessing What students are Learning

Part IX outcomes:

You will be able to …

… develop formative and summative assessments of learning outcomes

… analyze assessments to assure alignment with learning outcomes and learning activities

p. 56

Measuring learning gains by…

… pre and post testing with a concept inventory and a knowledge survey

Retake the CI/KS

Individually, please!

The handbook has more references about concept inventories and knowledge surveys

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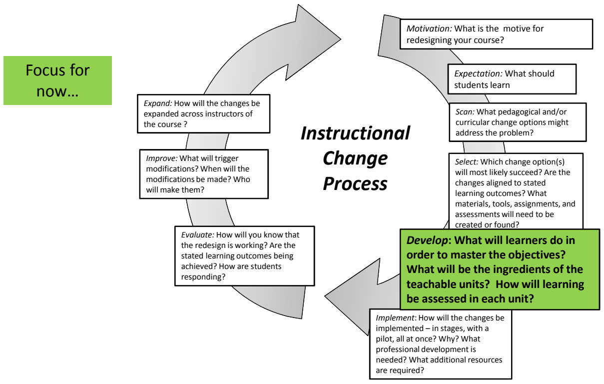
STEM Gateway Professional Development Program
Designing Instructional Change to Improve Student Success



Focus for now…

Instructional Change Process

Motivation: What is the motive for redesigning your course?

Expectation: What should students learn

Scan: What pedagogical and/or curricular change options might address the problem?

Select: Which change option(s) will most likely succeed? Are the changes aligned to stated learning outcomes? What materials, tools, assignments, and assessments will need to be created or found?

***Develop*: What will learners do in order to master the objectives? What will be the ingredients of the teachable units? How will learning be assessed in each unit?**

Implement: How will the changes be implemented – in stages, with a pilot, all at once? Why? What professional development is needed? What additional resources are required?

Evaluate: How will you know that the redesign is working? Are the stated learning outcomes being achieved? How are students responding?

Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

Effective course design *integrates* activities that are formed around these questions:

What should they learn? (Outcomes)

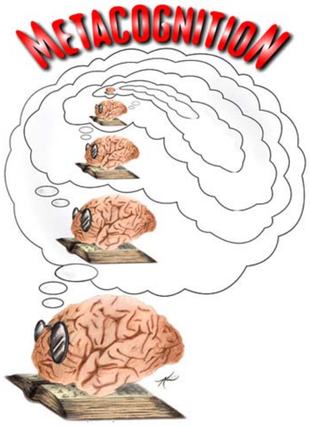
How should they learn it? (Instruction)

How will *we* know they learn it? (Assessment)

Is it the responsibility of *students* or *instructors* to monitor and assess learning?

"It sort of makes you stop and think, doesn't it."

Cartoon by Sam Gross



- Knowledge about one's own cognition
- Thinking about one's own thinking
- Asking what do I know and what don't I know
- Regulating how we go about learning

Image by N. Kremenek

N. Kremenek

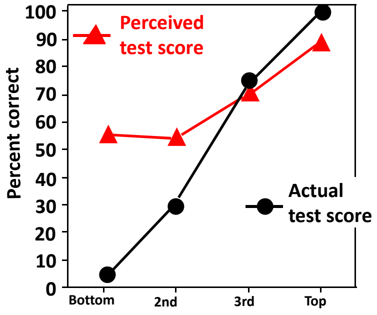
Exploring Metacognition

Write → **Pair** → **Share**

(go as far as you can in the allotted time- 6 minutes)

Knowing what you do and do not know.

High-performing students possess better *metacognition* than low-performing students.



Learners must develop metacognition to take control of their own learning.

p.58

(after Kruger and Dunning, 1999, *J. of Personality and Social Psychology*)

Implications for teaching

Metacognition must be integrated into the curriculum by defining learning outcomes and providing opportunities for students to monitor their progress in achieving them.

How People Learn, National Research Council, 2000

Photos by Aurora Pun

How can you help your students to be more metacognitive?

Model metacognition

p.59

Image at: http://ambertraining.org.uk/wp-content/uploads/2012/12/Student-comic.jpg

How can you help your students to be more metacognitive?

Provide assignments or discussion opportunities that initiate metacognition

Muddy-point question: What seems murky and unclear and is slowing down your learning progress? What is your plan for clearing up this concern?

Photo at: http://www.sowetanlive.co.za/incoming/2011/09/06/mud.jpg/RESIZED/mediumRectangle/mud.jpg

Two-minute paper: Before leaving, write down the most important thing you learned today and why it is important.

Image at: http://images.pensfatales.com/uploaded_images/clock-cartoon-798489.jpg

p. x

"Learning is not necessarily an outcome of teaching"

Science for All Americans (AAAS, 1989)

Chapter 3 Assessment
Scientific Teaching p. 47

Comic by Bud Blake

Faculty commonly overlook the significance of monitoring student learning.

How faculty plan introductory courses was evaluated by a survey of 2311 faculty members from 267 institutions in 12 disciplinary fields.

When asked how they knew that students were learning…

…70% responded that most often they watch students' faces, observe course attendance, and observe student participation in course discussion.

Joan Stark, 2000, Planning introductory college courses: Content, context, and form. *Instructional Science*

Program assessment asks, *"Is our department preparing our majors well?"*

- **A. Analyzing whether the department curriculum is meeting the intended learning goals**
- B. Giving a final exam to students
- C. Ongoing two-way communication with students regarding where they are at in a given class

p.60

Summative course assessment asks, "*What learning has taken place with each student?*

- A. Analyzing whether the department curriculum is meeting the intended learning goals
- **B. Giving a final exam to students**
- C. Ongoing two-way communication with students regarding where they are at in a given class

---

Formative course assessment asks, "*What learning is taking place with each student?*

- A. Analyzing whether the department curriculum is meeting the intended learning goals
- B. Giving a final exam to students
- **C. Ongoing two-way communication with students regarding where they are at in a given class**

Assessment is…

Collecting data about what learners understand and can do, evaluating those data, and **making decisions** based on that evaluation.

Summative assessments are high stakes but if they are not carefully constructed they will produce grades that do not relate to what students learned.

Are your questions valid for measuring the outcomes that you expect students to learn?

Are tests constructed properly? *One study found that flawed multiple-choice test items accounted for as much as 41% (median 20%) of the variance in test scores; 10-15% of students who failed the tests arguably should have received passing grades.*

Have students received formative feedback on the types of learning that will be summatively assessed?

(see Links on Writing Exam Questions pg. 62)

Formative assessment is all about feedback …

Think- Pair -Share

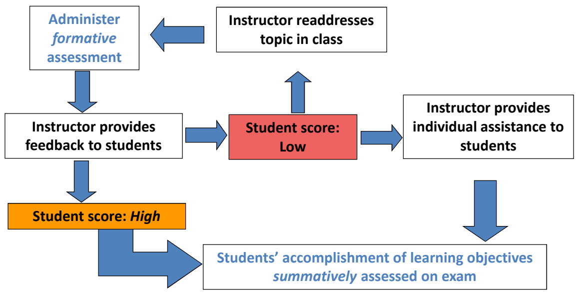
… to whom?

… for what reason?

… when?

(Pg. 61)

Formative and summative assessment should be related in order to promote learning



Administer *formative* assessment

Instructor readdresses topic in class

Instructor provides feedback to students

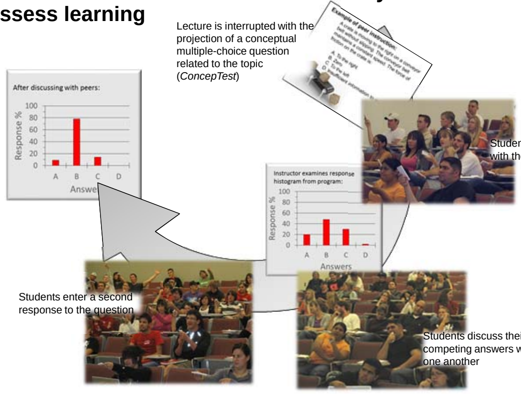
Student score: Low

Instructor provides individual assistance to students

Student score: *High*

Students' accomplishment of learning objectives *summatively* assessed on exam

Peer instruction is a research-backed use of clickers to both activate and formatively assess learning



Lecture is interrupted with the projection of a conceptual multiple-choice question related to the topic (*ConcepTest*)

Students respond with their clicker

Students discuss their competing answers with one another

Students enter a second response to the question

Photo by Aurora Pun

How often should we do formative assessment?

p.61

Formative assessment need not add another layer of instructor work

Make the most of your assignments: *In-class-learning assignments can also serve as formative learning assessments.*

Administer online assessments using Blackboard Learn.

But – you do need to review student work and adjust instruction, otherwise formative assessment is incomplete and useless.

Activity

Return to: Building a Teachable Unit- Assessment (Part III)

p. 105-106 of workbook

Complete the worksheet with your redesign team. Bloom your assessments when you have finished.

Measuring Learning Gains by…

…pre and post testing with a concept inventory and knowledge survey

Retake the CI/KS *Individually, please.*

p. 63 of workbook

For more references to knowledge surveys

Part X: Aligning and Evaluating the Teachable Unit

Part X outcome:

You will be able to …

… align the outcomes, activities, and assessments for your teachable unit

…evaluate the strengths and weaknesses of a teachable unit

Effective course design *aligns* activities that are formed around these questions:

What should they learn? (Outcomes)

How should they learn it? (Instruction)

How will we know they learn it? (Assessment)

How do we know if our teachable unit components align?

Activity

Aligning a Teachable Unit (p. 107-110)

With your redesign-team, align the outcomes, instruction, and assessments for your teachable unit. Use your bloom chart to guide the process.

30 minutes

How do we know if we have built a complete teachable unit?

How can we offer constructive feedback?

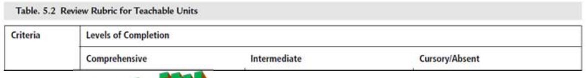


Table. 5.2 Review Rubric for Teachable Units

Criteria	Levels of Completion		
	Comprehensive	Intermediate	Cursory/Absent

Activity

Evaluating the Quality of a Teachable Unit (pg.111)

With your redesign-team, evaluate the teachable unit your team developed using the “Review Rubric”. (p.67-68)

Chapter 5
Scientific Teaching p. 86

Congratulations!
You've achieved another milestone

How will *we* know they learn it?

You have successfully built a teachable unit

But your mission is not complete yet!

Where do teachable units go?

Image at: http://www.spyontech.com/wp-content/uploads/2012/12/Folder_1.png

---

You Have Options!

Dropbox.com

DropBox

Googledrive.com

GoogleDrive

OneDrive

OneDrive Onedrive.com

PBwiki.com

PBWiki

With your team-

Take 10 and designate a site…

Creating a culture of sharing, communicating, and working together to improve STEM student success

Dialogue about teaching within a social network (communities of practice) that diffuses and supports innovation within and across departments.

Image at: http://cvjointchamber.com/uploads/images/networking.jpg

Muddy Point Question

Before leaving, take 5 minutes to answer-

What ideas or application of concepts discussed today remain unclear?

Or

What ideas or application of concepts were most interesting? Why?

STEM Gateway
Course Redesign Institute

Gary Smith
Audriana Stark

STEM GATEWAY
Project for Inclusive
Undergraduate STEM Success

Getting into a teaching and learning frame of mind…

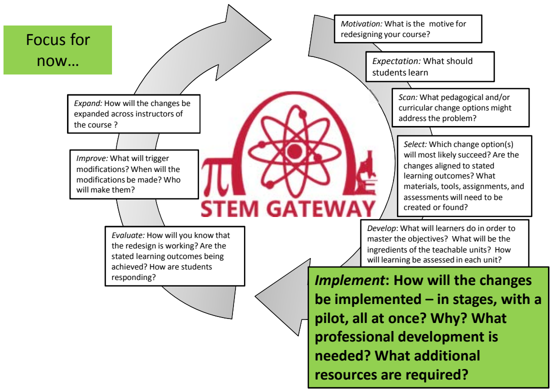
Go to page 1: Reflect and Choose *one* quote of particular interest. Join with a colleague and share why this quote is of particular interest to you.

STEM GATEWAY

What was muddy?

- [Enter summary points]

STEM Gateway Professional Development Program
Designing Instructional Change to Improve Student Success



Focus for now…

Motivation: What is the motive for redesigning your course?

Expectation: What should students learn

Scan: What pedagogical and/or curricular change options might address the problem?

Select: Which change option(s) will most likely succeed? Are the changes aligned to stated learning outcomes? What materials, tools, assignments, and assessments will need to be created or found?

Develop: What will learners do in order to master the objectives? What will be the ingredients of the teachable units? How will learning be assessed in each unit?

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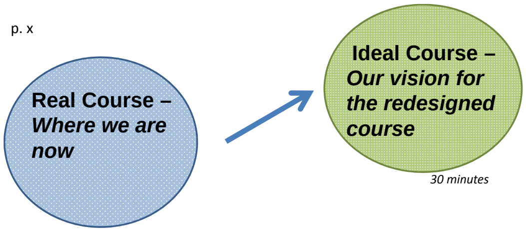
Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

STEM GATEWAY

Identifying Where You Are and Where You Want to Be

p. x



30 minutes

1. Assign a scribe to record the team's consensus on the board.
2. List the features of the "ideal" vision of the course you are redesigning.
3. Then, list the "real" view of the current course features.

Answer honestly- an honest reflection will show areas of growth and achievement.

Planning a Redesign Project

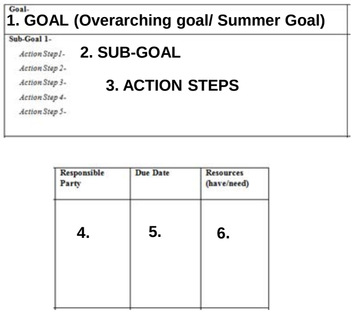
Activity

Creating A Redesign Planner

Detail goals, milestones, action steps, resources, due dates

Answer the questions on p. 86-87 and complete the table on p. 89 or on your laptop with your redesign team

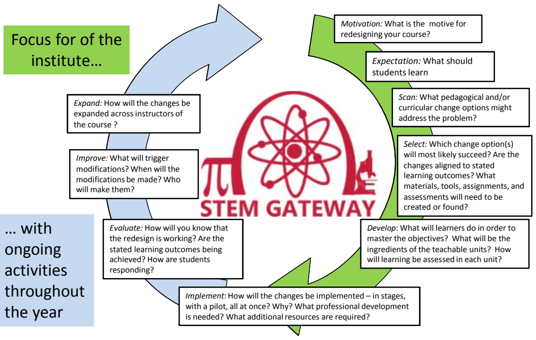
Summer 2015



2 hours

STEM Gateway Professional Development Program

Designing Instructional Change to Improve Student Success



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Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

STEM Gateway

Course Redesign Institute

May 14, 15, & 18, 2015

The STEM Gateway program is funded through a U.S. Department of Education Title V grant, 2011-2016, 100% grant funded (total anticipated funding $3.82 million)

STEM Gateway Course Redesign Institute- May 14, 15, & 18, 2015

Thursday, May 14, 2015	Friday, May 15, 2015	Monday, May 18, 2015
Part I: Warming Up- The Instructional change Process 9:00-9:40 Greetings and Getting to Know Each Other 9:40-9:50 Course Design and Instructional Change Part II: Motivation 9:50-10:20 Exploring What Motivates STEM Gateway, Course Designers, and Students 10:20-10:30 Break Part III: What Should Students Learn? Defining Course Level Outcomes 10:30-11:30 Writing and Blooming Well-Constructed Course-Level Outcomes Part IV: What Should Students Learn? Defining Teachable Unit Level Outcomes 11:30-11:45 Introducing the Teachable Unit (TU). **11:45-12:30 Working Lunch –** Select your TU 12:30-1:00 Defining and Blooming TU outcomes Part V: How will Students Learn? Where Learning Begins 1:00-1:25 What Does it Mean to Learn? 1:25-1:40 Targeting Bottlenecks and Misconceptions to Learning in the TU Part VI: How will Students Learn? The Science Behind Scientific Teaching 1:40-2:50 Interactive Learning about Active Learning Part VII: Where does learning take place? 2:50-3:15 Learning Activity Sequence as a Framework for the Teachable Unit 3:15-3:30 Muddy Point Reflection	9:00-9:05 Gathering and Greeting 9:05-9:15 What was Muddy? 9:15-9:35 Reflecting on Our TPI Part VIII: Building a Teachable Unit- Selecting Pedagogy and Content for Student Success 9:35-9:50 Starting TU Design from Where we are Now 9:50-10:20 Video: *From Questions to Concepts* 10:20-10:35 Writing Peer Instruction Questions 10:35-12:00 Building, Blooming, and ICAPing Instructional Activities **12:00-12:45 Working Lunch** Part IX. Assessing What students are Learning 12:50-1:05 The Role of Metacognition 1:05- 1:25 Approaches to Assessing Students Learning- Not Just Tests 1:25-2:10 Building and Blooming Assessments for the TU 2:10-2:20 Using Knowledge Surveys and Concept Inventories Part X: Aligning and Evaluating the Teachable Unit 2:20-2:50 Aligning Components of a TU 2:50-3:05 Evaluating the TU 3:05-3:20 Sharing and Communicating with Your Team 3:20-3:30 Muddy Point Reflection	9:00-9:05 Gathering and Greeting 9:05-9:20 Reflecting on Others' Words about STEM Teaching and Learning 9:20-9:30 What was Muddy? Part XI: Planning and Rolling Out the Redesign 9:30-10:00 Real versus Ideal---A Pathway to Success 10:00-11:45 Planning Implementation of the Redesign 11:45-12:00 Where are We and Where are We Going?
		Homework to be completed by Friday May 15: Reading in *Scientific Teaching* (p. 47-64, 95-100); Teaching Perspectives Inventory (http://www.teachingperspectives.com)

STEM Gateway
Course Redesign Institute

May 14, 15, & 18, 2015

Facilitators:

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STEM Gateway Teaching Professional Development Assistant
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The STEM Gateway program is funded through a U.S. Department of Education Title V grant, 2011-2016, 100% grant funded (total anticipated funding $3.82 million)

Gateway Science and Math Course Redesign Project Description

Issues to Address

- Aspiring and declared STEM majors experience high failure rates in gateway science and math courses
- Research shows that perceived poor quality instruction in science and math courses is the primary factor leading students to depart STEM fields and is a major concern of those who persist
- Implementation of curricular and pedagogical redesign, primarily focused on various aspects of interactive engagement, has improved student learning in STEM gateway courses, across the disciplines

The culture of teaching and learning among STEM educators at UNM will be characterized by:

- On-going exploration and adoption of evidence-based and research informed instructional practices.
- Continuous improvement of teaching and learning through reflective practice and meaningful assessment
- Dialogue about teaching within a social network (communities of practice) that diffuses and supports innovation within and across departments.

Individual Course Redesign Projects

One (or two instructors) working to redesign a course that is required and is foundational to at least one STEM major (Contact Gary Smith, gsmith@unm.edu to confirm that your course qualifies). Tenure-stream and Lecturer faculty in natural science, mathematics, and engineering departments are eligible to apply; a graduate student or part-time instructor can partner with a regular faculty member.

Successful applicants will form a faculty learning community. To encourage access to close collaborators, preference will be given to applicants who are either proposing a partner on their project or where two separate proposals are submitted by faculty in the same department

Course Redesign Teams

Each course-reform team consists of:

3-4 UNM faculty who frequently teach the targeted gateway course

+

1 UNM Graduate Assistant from the gateway-course department

Timeline

Proposal

March

Redesign Work

May-August

Implementation (one or both semesters)

Fall Semester

Spring Semester

Assessment

Expanded implementation Plan

May

STEM Gateway compensation:

The STEM Gateway program is funded through a U.S. Department of Education TITLE V grant, 2011-2016 (total anticipated funding $3.82 million).

> "It now appears that all traditionally taught college courses are markedly (though unintentionally) biased against many non-traditional students, and, indeed, against most students who have not attended elite preparatory schools. Thus, when we teach merely in traditional ways we probably discriminate strongly on grounds quite different from those we intend. Easily accessible changes in how we teach have been shown repeatedly to foster dramatic changes in student performance with no change in standards."
>
> Craig E. Nelson, Professor of Evolutionary Biology, Indiana University
> *American Behavioral Scientist*, 40(2):165, 1996

> "The biggest and most long-lasting reforms of undergraduate education will come when individual faculty or small groups of instructors adopt the view of themselves as reformers, within their immediate sphere of influence, the classes they teach every day."
>
> K. Patricia Cross, Professor of Higher Education, University of California, Berkeley
> Trustee, Carnegie Foundation for the Advancement of Teaching
> *Cited in:* Tobias, S., 1990, *They're not dumb, they're different; stalking the second tier*

Gateway Science and Math Course Redesign Projects

2012-2013

- General Chemistry II (CHEM 122)
- College Algebra (Math 121)
- General Physics (PHYS 160/161)

2014-2015

- Plant & Anima Form and Function (BIO 204)
- Precalculus and Trigonometry (Math 116)
- Introduction to Genetics (BIO 202)

- Faculty are a large part of the solution, because they make the changes to curriculum and instruction. STEM Gateway staff and visiting experts provide guidance and resources from workshops help to develop and incubate ideas, but STEM Gateway focuses on empowering faculty as informed change agents.
- Most of the instructors teaching the targeted courses, not just an interested individual, are involved in the STEM Gateway redesign projects, increasing likelihood of high-impact success. Instructional and assessment resources are archived for use by all instructors and pedagogical training is designed so as to sustain the redesign despite instructor turnover.
- The STEM Gateway redesign process is rewarded through faculty compensation for curriculum and instructional reform work. GA support, and potential PLF assistance during implementation. Faculty work is publicly recognized on both campuses, and they are encouraged to under ake publishable classroom action research.

2013-2014

- Plant & Animal Form and Function (BIOL 204L)
- General Chemistry I (CHEM 121)
- General Physics (PHYS 103)

2015-2016

- Chemistry in our Communities (CHEM 101)
- Blue Planet Laboratory (ENVS 102L)
- Principles of Chemistry (CHEM131/132)
- Ecology and Evolution (Biol203/Biol203L)

http://stemgateway.unm.edu/

Some Recommended Books for STEM Teachers

STEM GATEWAY

About Learning

Ambrose, S.A., Bridges, M.W., DiPietro, M., Lovett, M.C., Norman, M.K. (2010). *How Learning Works: 7 Research-Based Principles for Smart Teaching*. Jossey-Bass

Brown, P.C., Roediger, H.L. III, McDaniel, M.A. (2014) *Make it Stick: The Science of Successful Learning.* Harvard University Press/Belknap

Zull, J.E. (2002) *The Art of Changing the Brain: Enriching the Practice of Teaching by Exploring the Biology of Learning*. Stylus

Teaching in STEM

Handelsman, J., Miller, S., Pfund, C (2007) *Scientific Teaching*. Freeman

Kalman, C.S. (2007) *Successful Science and Engineering Teaching in Colleges and Universities*. Anker Publishing

Kober, N. (2015) *Reaching Students: What Research Says About Effective Instruction in Undergraduate Science and Engineering* (Washington D.C.: Board on Science Education, Division of Behavioral and Social Sciences and Education. National Academies Press. http://www.nap.edu/catalog.php?record_id=18687

Light, G., and Micari, M. (2013*) Making Scientists: Six Principles for Effective College Teaching.* Harvard University Press.

Mintzes, J.J., and Leonard, W.H. eds. (2006) *Handbook of College Science Teaching*. National Science Teachers Association

Singer, S. R, Nielsen N.R., and Schweingruber, H.A. (2012). *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. National Academies Press http://www.nap.edu/catalog.php?record_id=13362

Wood, B.S. (2009) *Lecture-Free Teaching: A Learning Partnership between Science Educators and Their Students*. National Science Teachers Association.

Ideas for Interactive Learning

Angelo, T.A. and Cross, K.P. (1993) *Classroom Assessment Techniques: A Handbook for College Teachers.* Jossey-Bass

Barkley, E.F. (2009) Student Engagement Techniques: A Handbook for College Faculty. Jossey-Bass

Barkley, E.F., Cross, K.P., and Major, C.H. (2014) *Collaborative Learning Techniques: A Handbook for College Faculty* (2nd ed.). Jossey-Bass

Bean, J.C. (2011) *Engaging Ideas: The Professor's Guide to Integrating Writing, Critical Thinking, and Active Learning in the Classroom* (2nd ed). Jossey-Bass

STEM Gateway
Course Redesign Institute

Part I: Warming Up-
The Instructional Change Process

After completing this session of the institute, course designers will be able to…

- … explain the components of a course, including the roles of teachers, learners, subject matter and intended course outcomes
- … describe the process of instructional change

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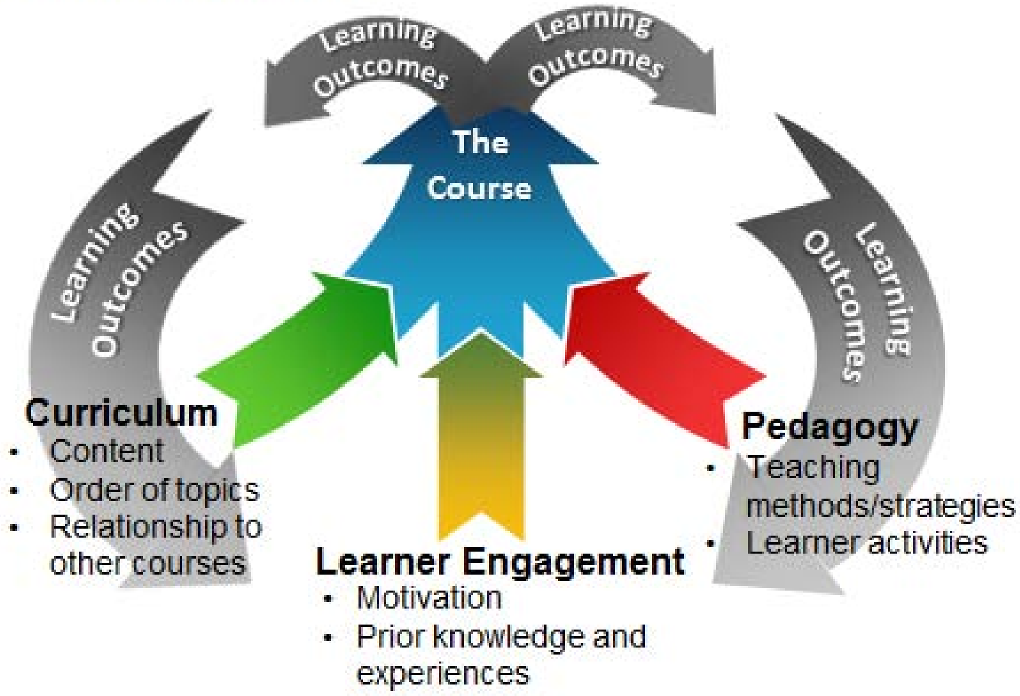
What is a course?

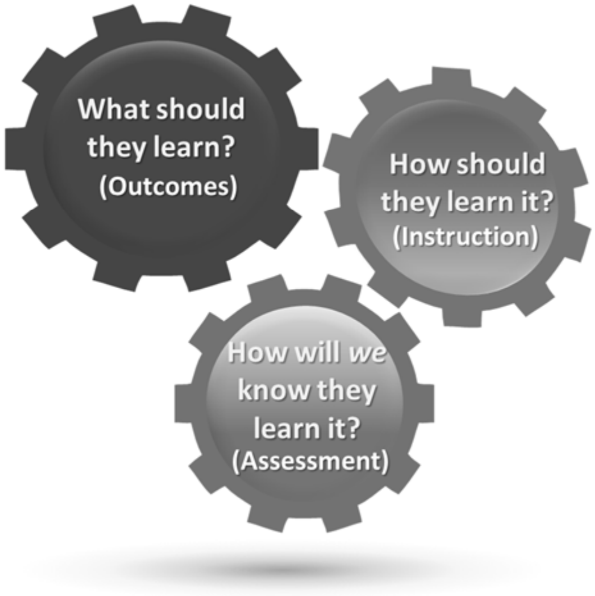


Curriculum
- Content
- Order of topics
- Relationship to other courses

Learner Engagement
- Motivation
- Prior knowledge and experiences

Pedagogy
- Teaching methods/strategies
- Learner activities

Effective course design *integrates* activities that are formed around these questions:


What should they learn? (Outcomes)

How should they learn it? (Instruction)

How will *we* know they learn it? (Assessment)

Graphics by Gary Smith

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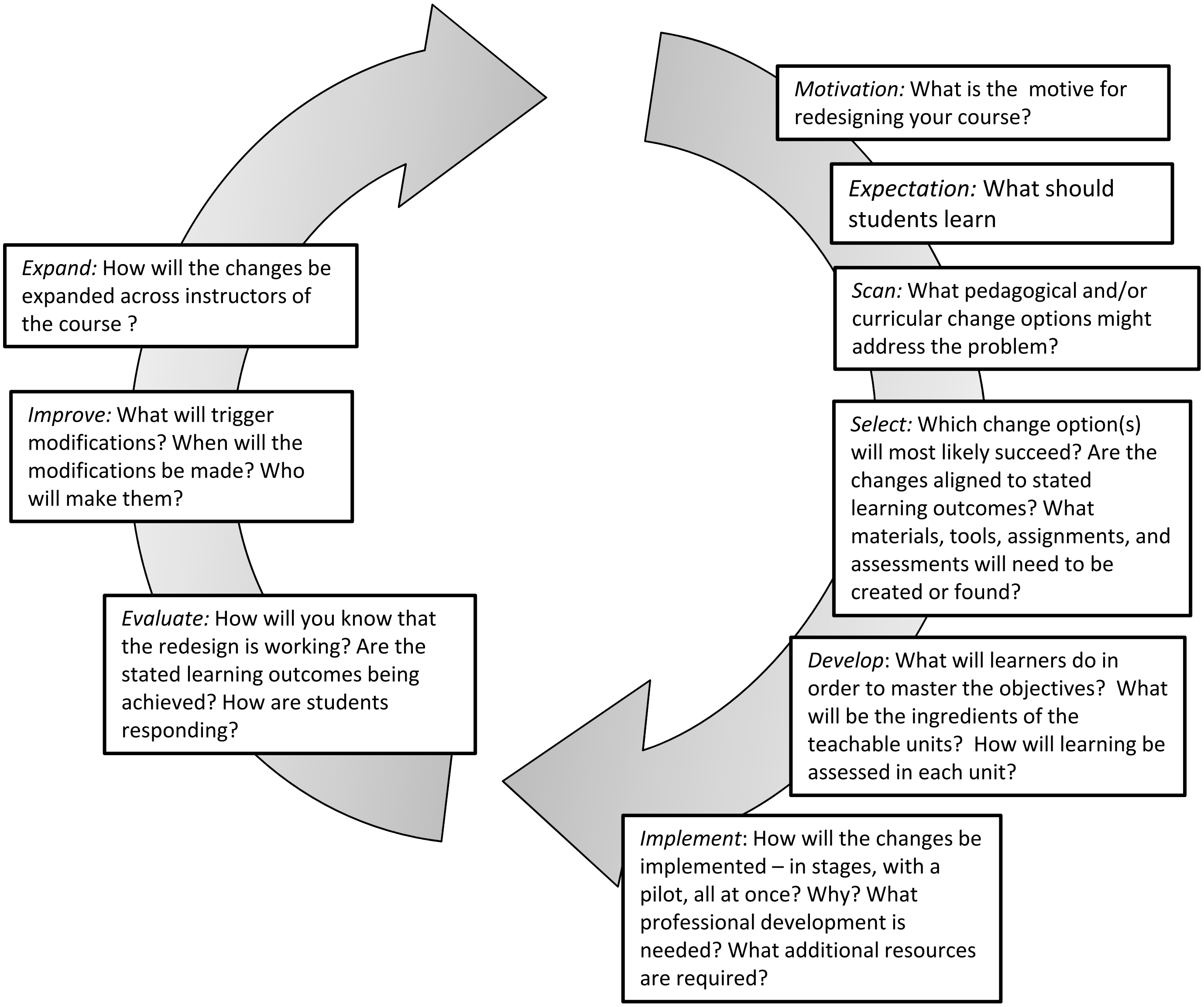
Designing Instructional Change to Improve Student Success

Instructional Change Process



Motivation: What is the motive for redesigning your course?

Expectation: What should students learn

Scan: What pedagogical and/or curricular change options might address the problem?

Select: Which change option(s) will most likely succeed? Are the changes aligned to stated learning outcomes? What materials, tools, assignments, and assessments will need to be created or found?

Develop: What will learners do in order to master the objectives? What will be the ingredients of the teachable units? How will learning be assessed in each unit?

Implement: How will the changes be implemented – in stages, with a pilot, all at once? Why? What professional development is needed? What additional resources are required?

Evaluate: How will you know that the redesign is working? Are the stated learning outcomes being achieved? How are students responding?

Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

STEM Gateway Course Redesign Professional Development Program Outcomes

Redesign Program instructors will be able to…

1. **… explain the motive for redesigning the course**
2. **…define measurable learning outcomes for the course**
3. **…identify pedagogical/curricular changes that address the problems that motivated redesign**
4. **…develop criteria for selecting, creating, and integrating specific tools, assignments, and assessments to achieve learning outcomes**
5. **… create a course curriculum of teachable units that integrate in-class and out-of-class learning**
6. **… construct a plan with a timeline, milestones, and goals for partial to full implementation of redesign, which identifies additional STEM Gateway consultation and other resource needs**
7. …develop an assessment plan that tracks student achievement of outcomes and affect, and instructor affect towards redesign efforts
8. … use data to inform modification of redesign plans including a process for determining when modifications should be made and who will make modifications
9. …create a plan for sustaining the redesign and expanding to include all instructors of the course

Outcomes 1-6 are targeted at the redesign institute, including creation of a complete teachable unit

STEM Gateway
Course Redesign Institute

Part II: What Motivates You and Your Learners

After completing this session of the institute, course designers will be able to…

… explain why STEM-course redesign is important to student success

… articulate a vision for their redesign project

… use expectancy-value motivation as a foundation for engaging learners

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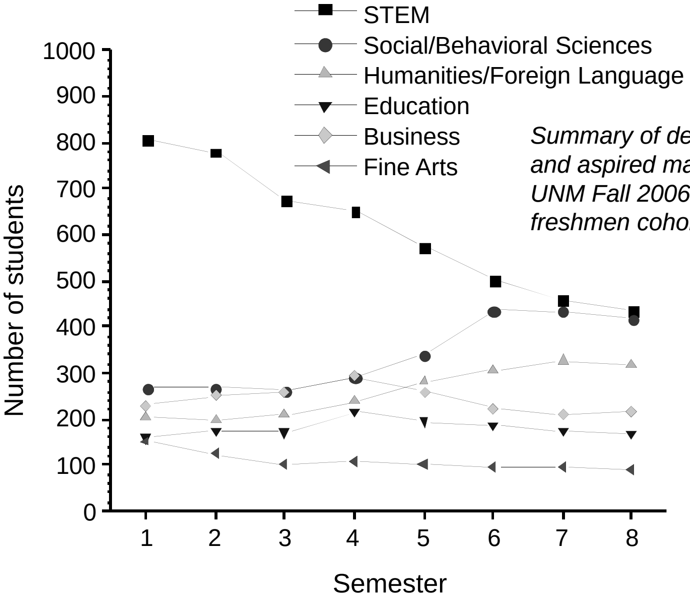
Motivation for Course Redesign

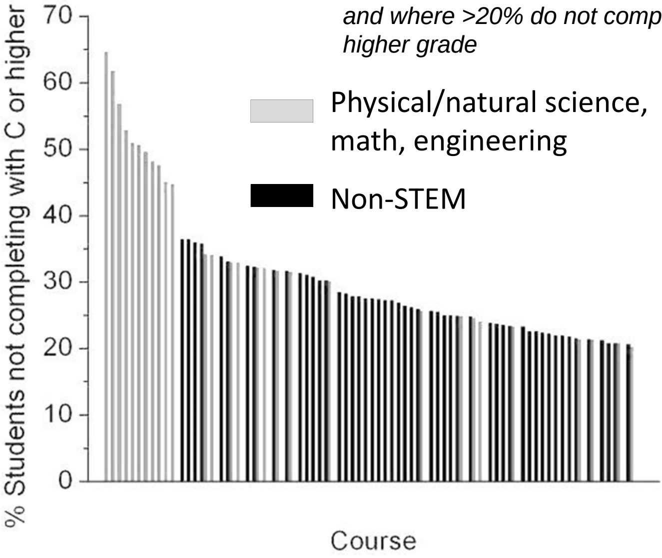
STEM disciplines suffer the greatest undergraduate student attrition.



Summary of declared and aspired majors, UNM Fall 2006 freshmen cohort

STEM courses are prominent entries on the "Killer course" list

Courses enrolling more than 100 students and where >20% do not complete with a C or higher grade



Data from UNM Office of Institutional Analytics

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The STEM Gateway Course Redesign Program

Vision

The culture of teaching and learning among STEM educators at UNM will be characterized by:

- On-going exploration and adoption of evidence-based and research-informed instructional practices.
- Continuous improvement of teaching and learning through reflective practice and meaningful assessment
- Dialogue about teaching within a social network (communities of practice) that diffuses and supports innovation within and across departments

Fulfilling this vision will result in improved student achievement of learning outcomes, recruitment to STEM fields, and retention in STEM to degree attainment, especially among Hispanic and low-income students.

(Inspired by WIDER PERSIST, Boise State University)

Mission

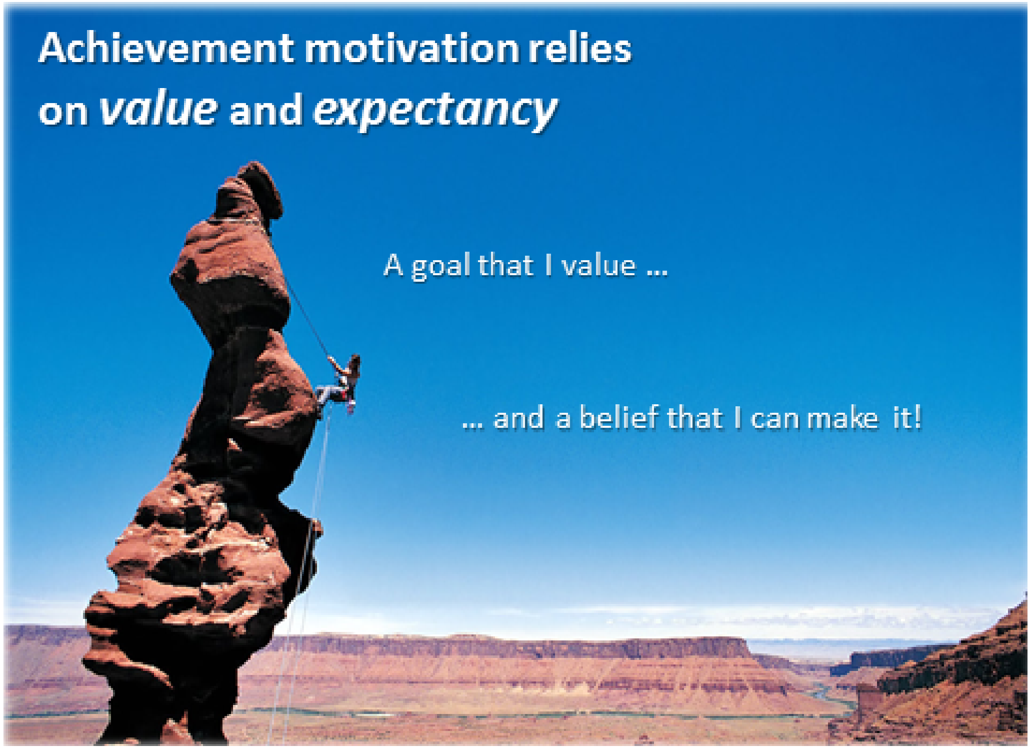
The STEM Gateway Course Redesign Program informs and guides STEM educators to effectively implement evidence-based and research-informed pedagogies through individual and community-based professional development in order to improve the academic success of undergraduate STEM students, especially of Hispanic and/or low-income backgrounds.

What is Your Vision?

A vision statement defines a mental picture of the optimal future state of your redesign project… a “North Star” that all aspects of your redesign effort are navigating toward.

What motivates students to learn?

Think both generally and specifically in your course. Consider how these motivating factors do or can influence your instructional choices.



Achievement motivation relies on *value* and *expectancy*

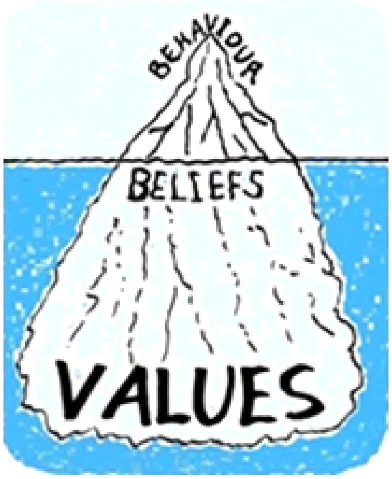
A goal that I value …

… and a belief that I can make it!

Photo at : http://cdn.coresites.factorymedia.com/cooler_new/wp-content/uploads/2015/04/rock-climbing-almost-there-1.jpg

What We Value

Underlies What We Do



And How We Do It

Image at: http://everyoneagreeswithtom.com/wp-content/uploads/2010/02/TOM-Floor-Mat-Values-400.jpg

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Course Redesign Institute

Part III: What Should Students Learn? Defining Course Level Outcomes

After completing this session of the institute, course designers will be able to…

… define SMART student learning outcomes for their course

… analyze the cognitive processes and knowledge acquisition specified by a SMART outcome

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Developing Learning Objectives: The Foundation for Effective Course Design

(Source: UNM Office for Medical Educator Development)

What is a learning objective?

A learning objective is an outcome statement that captures specifically what knowledge and skills *learners* should be able to exhibit following instruction. A common misapplication of objectives is for the teacher/presenter to state what he/she is going to do (e.g., "My plan this morning is to talk about…"), rather than what the student is expected to be able to do (e.g., "After this session, you should be able to…").

Why have learning objectives?

Creating clear learning objectives during the planning process of a course/unit/week/individual session serves the following purposes:

- Helps instructors and course leaders to integrate across a day/week/unit of learning.
- Connect course content and assessment to the learning process.
- Gives learners a clear picture of what to expect and what's expected
- Forms the basis for evaluating teacher, learner, and curriculum effectiveness

What are the key components of a learning objective?

Learning objectives should be "*SMART"*:

Specific
Measurable
Attainable for target audience within scheduled time and specified conditions
Relevant and results-oriented
Targeted to the learner and to the desired level of learning

How do I create a useful learning objective?

To create *specific, measurable, and results-oriented* objectives:

- It's helpful to finish the sentence, "After this unit/week/individual session, you should be able to…"
- Start with an observable-action word that captures what the learner should be able to do
- Avoid ill-defined terms that are open to variable interpretation (e.g., understand, learn, grasp)
- When necessary, specify criteria concerning expected standard of performance (e.g., "Describe a mechanism in support of your hypothesis from the organ system down to the level of cells and molecules.").

To create *attainable* learning objectives:

- Consider the beginning level of understanding/skill of your learners and craft your objective to move them to the *next* level.
- Consider and specify the conditions under which the performance will take place (e.g., "On a written exam, describe…" or "With a standardized or actual patient, demonstrate…")
- Limit the number of objectives to the major learning points you would like students to walk away with.

To create objectives *targeted to the audience and desired level of learning/thinking:*

- Ask yourself whether you want learners to be able to remember, comprehend, apply, analyze, evaluate, or create. These cognitive processes represent progressively higher levels of thinking and determine the learning activities and assessments required for mastery.
- Ask yourself about the type of knowledge that will be mastered by the outcome – factual, conceptual, procedural, and metacognitive. These knowledge types determine the learning activities that will be necessary for developing knowledge.
- Match your action verb to the desired cognitive level.

Let’s evaluate: *What do you think of the quality of these outcomes?*

I want to encourage writing fluency and confidence. ______________

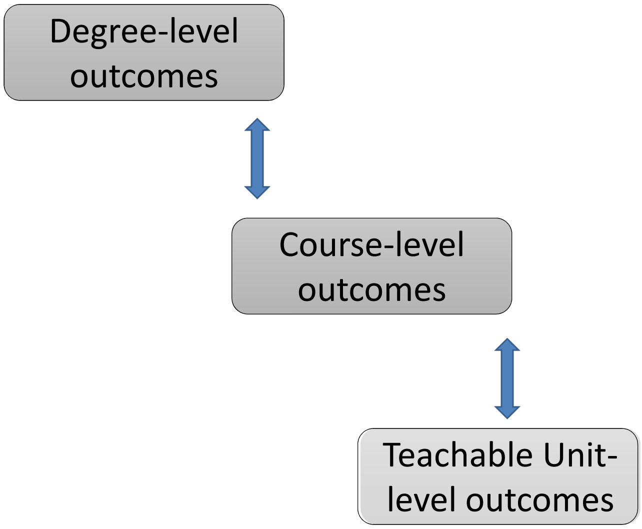
In this course students will understand that poverty is a complex issue. ______________

Students will be able to identify rocks and minerals. ______________

Students will solve linear equations in one variable. ______________

Students will be able to apply their knowledge of statistics to analyze reports and claims in the popular press. ______________

Outcomes should exist at multiple, connected levels



Degree-level outcomes

Course-level outcomes

Teachable Unit-level outcomes

Bloom's Taxonomy of the Cognitive Domain

Anderson & Krathwohl, 2001, *A Taxonomy for Learning, Teaching, and Assessing:* Longman Publishing Group.

Cognitive process:	**What the learner does:**
6. Create	Brings together parts to form a new whole or solve a problem that requires new creative thinking.
5. Evaluate	Judges the value of something by application of criteria, processes, or standards.
4. Analyze	Identifies how parts relate to one another or to a larger structure or purpose; considers available evidence to reach a conclusion, inference or generalization
3. Apply	Use methods, concepts, principles, theories in new situations; solve realistic problems that require the identification of issues and use of appropriate generalizations and skills.
2. Understand	Constructs meaning by explaining, classifying, comparing,, summarizing
1. Remember	Recalls or recognizes information: facts, definitions, generalizations

Knowledge type:	**Knowledge gained:**
1. Factual	*Basic elements* (e.g., terms, people, formulas) that learners must know to be acquainted with a discipline or solve problems in the discipline.
2. Conceptual	The *interrelationships among the basic elements* within a larger structure that enables the elements to function together (e.g., classifications, principles, theories, models, structures).
3. Procedural	*How to do something* — methods of inquiry, algorithms, techniques — along with criteria for when to use appropriate procedures
4. Metacognitive	Knowledge of learning and awareness of one's own cognition – *"knowing what you do and do not know"*

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				

Guide to Using Bloom's Taxonomy of Learning in the Cognitive Domain

Adapted from L. W. Anderson and D. R. Krathwohl (eds). *A Taxonomy for Learning, Teaching and Assessing, 2001* (revised from Bloom's, 1956, Taxonomy)

Cognitive Process	What the Learner Does	Action Verbs for Writing Outcomes	Examples
Remember	Recalls or recognizes information: facts, definitions, generalizations	List, describe (from memory), name, label, repeat, recall, identify, state, select, match, know, locate, recognize, observe, choose, who, what, where, when, cite, define, indicate, memorize, outline, record, relate, reproduce, sort	Students will be able to list five leadership styles and provide a thorough definition of each. Students will be able to match important events in US history to the year in which they occurred. Students will be able to identify rocks and minerals.
Understand	Constructs meaning by interpretation, classification, comparing, explaining, summarizing	Explain, restate, review, relate, clarify, illustrate, demonstrate, translate, diagram, sketch, outline, summarize, organize, paraphrase, transform, compare similarities and differences, give examples, arrange, associate, convert, discuss, estimate, extend, generalize, report, solve/calculate (similar to a solved example)	Students will be able to explain the causes of World War I. Students will be able to summarize opposing points of view about legalizing drug use. Students will be able to sketch a eukaryotic cell and label its parts.
Apply	Uses methods, concepts, principles, and theories in new situations; solve realistic problems that require the identification of issues and use of appropriate generalizations and skills.	Apply, practice, employ, use, illustrate, collect, change, graph, compute, construct, develop, interpret, investigate, manipulate, modify, operate, predict, prepare, produce, schedule, sketch, solve/calculate (for a new situation)	Students will be able to calculate the forces exerted on beams in a building. Students will be able to develop an inventory-control plan for a manufacturing firm. Students will demonstrate the ability to digitally edit a photograph using appropriate software tools.
Analyze	Identifies how parts relate to one another or to a larger structure or purpose; considers available evidence to reach a conclusion, inference or generalization;	Analyze, dissect, detect, test, deconstruct, discriminate, distinguish, examine, focus, find coherence, survey, investigate, separate, structure, determine evidence and conclusions, appraise, break down, deduce, criticize, debate, experiment, infer, inspect, inventory, question, relate, select, map, research, interpret	Students will be able to determine the point of view or bias of an author. Students will be able to test a claim or hypothesis using data tables and graphs. Students will be able to deconstruct a word problem into mathematical expressions.
Evaluate	Judges the value of something by setting up criteria, processes, or standards and then determining how closely the idea or object meets the standards.	Coordinate, judge, select/choose, decide, debate, evaluate, justify, recommend, verify, monitor, the best way, what worked, what could have been different, what is your opinion, appraise, assess, conclude, criticize, discriminate, estimate, grade, prioritize/rank, rate, revise, score, support, value	Students will be able to assess the leadership strengths and weaknesses of recent US presidents. Students will be able to use a rubric to rate design models and recommend changes. Students will be able to choose potential home sites based on their knowledge of geologic hazards.
Create	Brings together parts to form a new whole or solve a problem that requires new creative thinking (at least new to the learner).	Create, hypothesize, design, construct, invent, imagine, discover, develop, induce, bring together, compose, pretend, predict, organize, plan, modify, improve, suppose, produce, set up, propose, formulate, solve (more than one answer), arrange, assemble, combine, devise, generate, manage, perform, prepare, dramatize, paint, compose, rearrange, reconstruct, relate, reorganize, revise, argue for, speculate	Students will create a new product. Students will generate testable hypotheses from existing observations. Students will compose an original score.

Where do these outcomes plot?

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				

Students will be able to:

1. … solve linear equations in one variable.
2. … apply their knowledge of statistics to analyze reports and claims in the popular press.
3. … identify rocks and minerals.
4. … analyze rock samples from a locality and interpret the geologic processes that occurred.

	Knowledge Type			
Cognitive Process	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				

STEM Gateway
Course Redesign Institute

Part IV: What Should Students Learn? Defining Teachable Unit Level Outcomes

After completing this session of the institute, course designers will be able to…

… define a teachable unit as an explicit, outcomes-driven module for a course

… connect teachable-unit-level outcomes to course-level outcomes as a process of scaffolded learning

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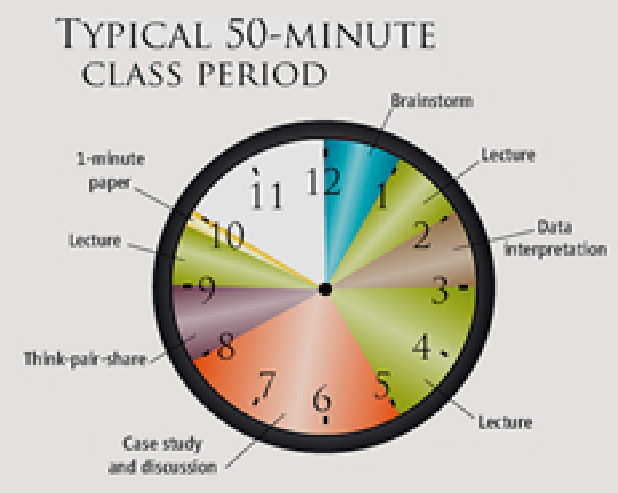
Throughout the institute, you will build a teachable unit.

Instructional materials that enclose the activities, assignments, and assessments within a time-defined part of the course that are designed to achieve learner mastery of an essential concept and/or a course outcome.



(Handelsman et al., 2007, *Scientific teaching*: Freeman; Miller et al., 2008, Scientific teaching in practice: *Science*, v. 322, p. 1329)

May be a plan for one class period, one week, or some other part of the whole course.

Is constructed so that other instructors could execute the unit.

STEM Gateway
Course Redesign Institute

Part V: How Will Students Learn?
Where Learning Begins

After completing this session of the institute, course designers will be able to…

… describe the fundamental learning centers in the brain

… begin an analysis of how students' prior knowledge affects learning in the targeted course

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Left image at: https://lh3.googleusercontent.com/-ZH99eX3woyo/T7UbQe69rAI/AAAAAAAARug/QxdfMxsW1O0/w426-h331/teachlearn.jpg

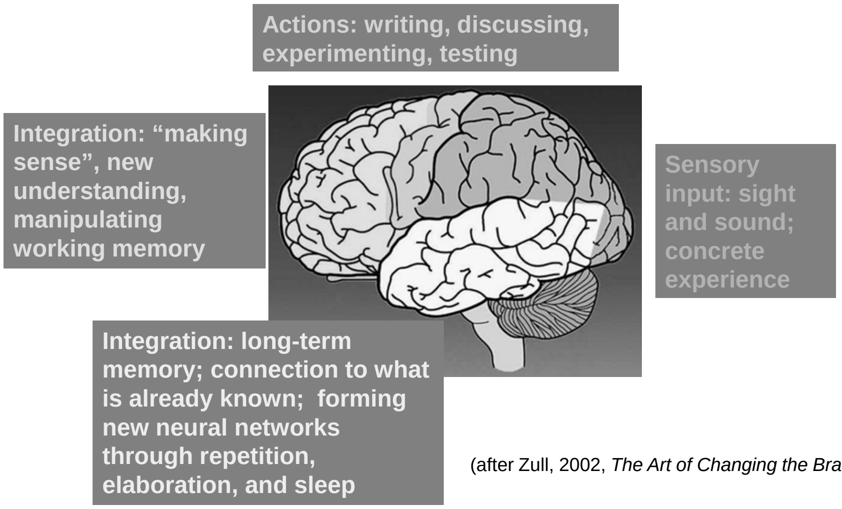
What is your definition of “learning?”

What is your definition of “teaching?”

Above photo at: http://i.perezhilton.com/wp-content/uploads/2008/04/sting__oPt.jpg

“It dawned on me about two weeks into the first year that it was not teaching that was taking place in the classroom, but learning.”

The most effective learning triggers all learning centers in the brain



Actions: writing, discussing, experimenting, testing

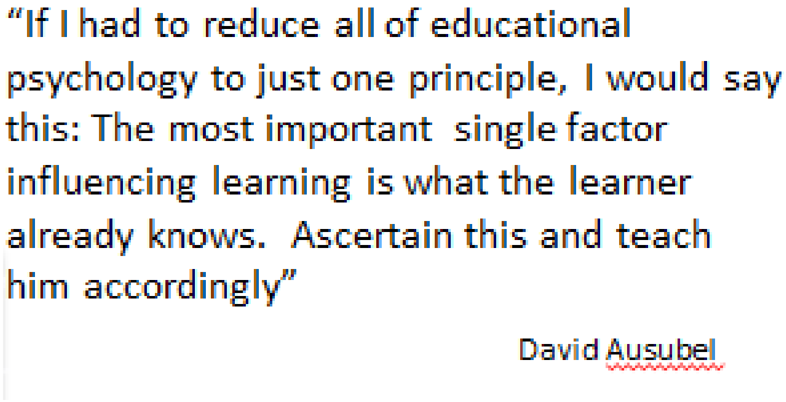
Integration: “making sense”, new understanding, manipulating working memory

Sensory input: sight and sound; concrete experience

Integration: long-term memory; connection to what is already known; forming new neural networks through repetition, elaboration, and sleep

(after Zull, 2002, *The Art of Changing the Brain)*

Image modified from Brain-Behavior Optimization Center:
http://www.brainbehavioroptimization.com/index.php?rmm=Brain

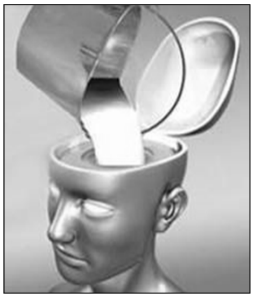


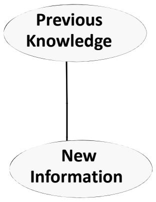
“If I had to reduce all of educational psychology to just one principle, I would say this: The most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly”

David Ausubel

Ausubel, D. P. (1968). Educational psychology: A cognitive view. New York: Holt, Rinehart and Winston.

Knowledge is associative—it is linked to prior mental models and cognitive structures





Previous Knowledge

New Information

If a learner’s initial misunderstanding is not engaged he or she may fail to grasp new concepts, correct concepts, or both.

Teaching is not about pouring knowledge into the learners’ empty brains

How People Learn, National Research Council, 2000

Image at: http://medicine.ukzn.ac.za/Libraries/Division_of_Clinical_Medicine/fact_pouring.sflb.ashx

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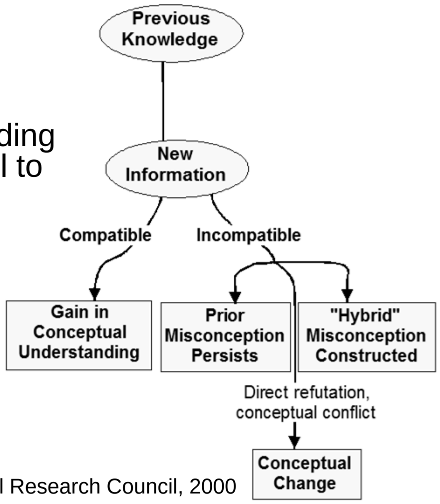
Knowledge is associative—it is linked to prior mental models and cognitive structures …

… and can include prior misconceptions.

If a learner’s initial misunderstanding is not engaged he or she may fail to grasp new concepts, correct concepts, or both.

“It ain't what you don't know that gets you into trouble. It's what you know for sure that just ain't so.”

- Mark Twain



Previous Knowledge

New Information

Compatible

Incompatible

Gain in Conceptual Understanding

Prior Misconception Persists

"Hybrid" Misconception Constructed

Direct refutation, conceptual conflict

Conceptual Change

How People Learn, National Research Council, 2000

STEM Gateway
Course Redesign Institute

Part VI: How Will Students Learn? The Science Behind Scientific Teaching

After completing this session of the institute, course designers will be able to

… apply cognitive psychology principles to determine the likely efficacy of instructional approaches

… recognize learning along the interactive-passive continuum

…explain to a colleague why active learning generates greater learning achievements than traditional lecture

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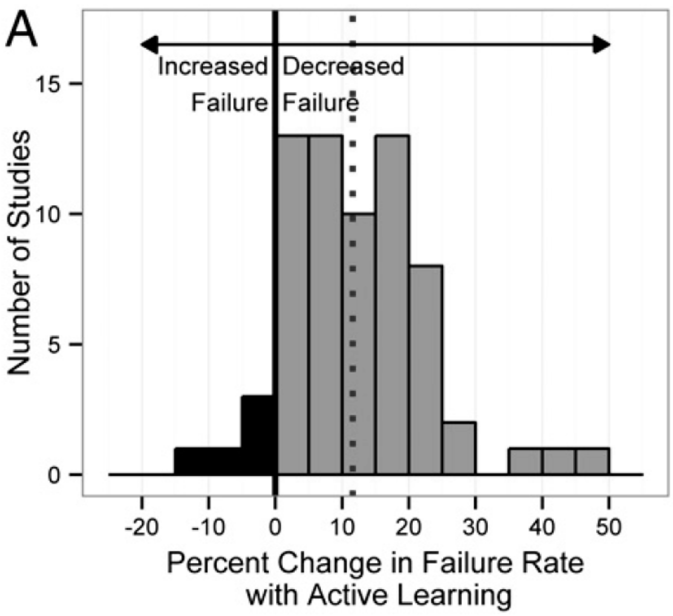
Active learning is:

Why I do or would use active learning	Why I don’t or wouldn’t use active learning

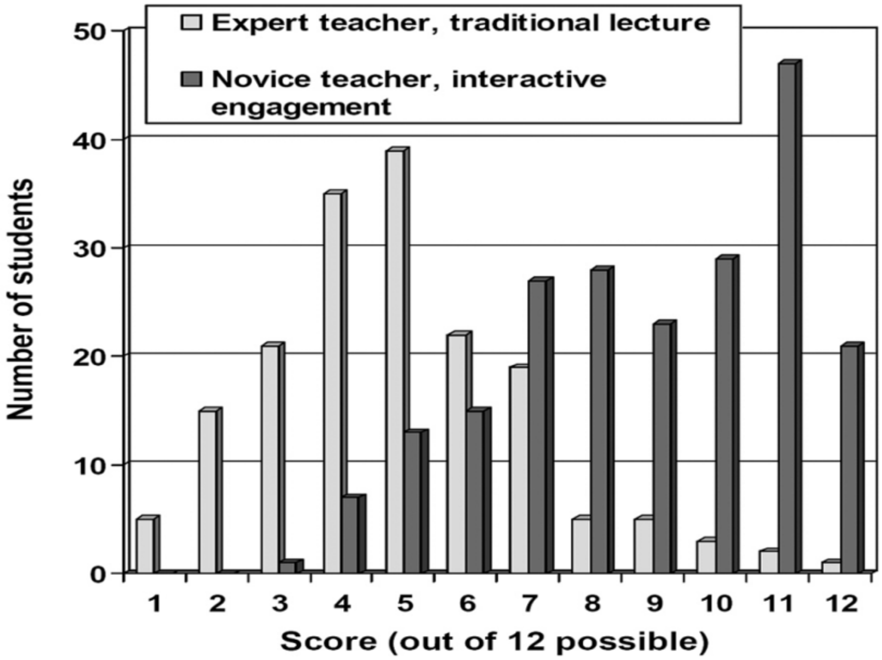


Failure rates under traditional lecturing (avg. 33.8%) increase by 55% over the rates observed under active learning (21.8%).

"If the experiments analyzed here had been conducted as randomized controlled trials of medical interventions, they may have been stopped for benefit—meaning that enrolling patients in the control condition might be discontinued because the treatment being tested was clearly more beneficial."

Freeman et al., 2014, Active Learning Increases Student Performance in Science, Engineering, and Mathematics, *Proceed. Nat. Acad. Sci.*, 111: 8410–15

How does instruction affect how much students learn?



How the classes were taught**:**

Deslauriers et al., 2011, Science

<u>Expert teacher, traditional lecture</u>

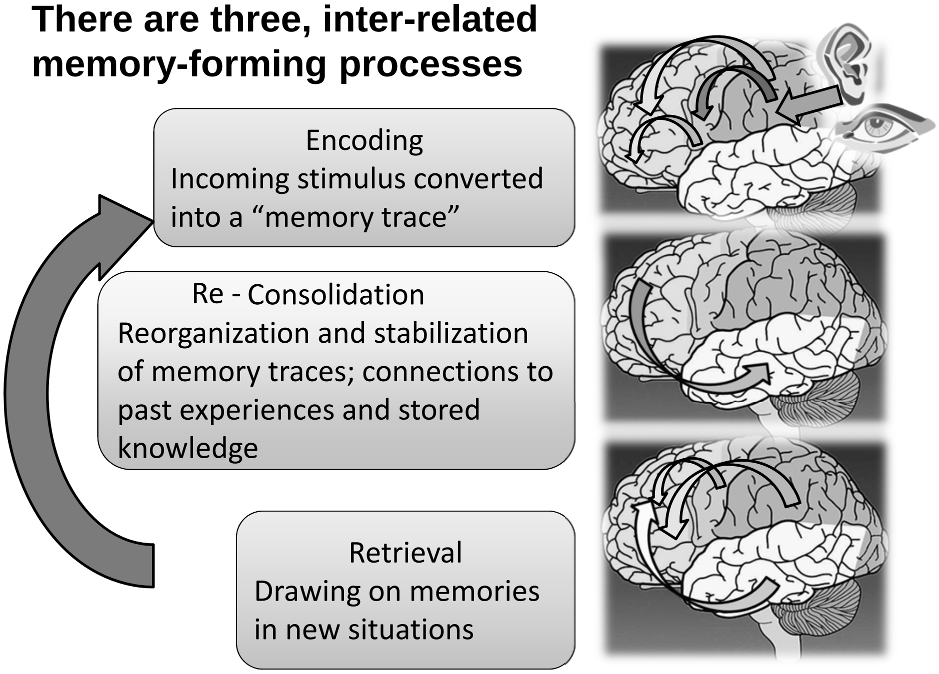
- Lecture accompanied by PowerPoint slides to present content and example problems
- Demonstrations
- “Clicker” questions (average 1.5 per class, range 0 to 5) were used for summative evaluation (which was characterized by individual testing without discussion or follow-up other than a summary of the correct answers).
- Students were instructed to read the relevant chapter in the textbook before class

<u>Novice teacher, interactive engagement</u>

- Pre-class reading assignments
- Pre-class reading quizzes
- In-class “clicker” questions with student-student discussion (peer instruction): typically 3 per class, with 3-8 minutes used for discussion, voting, and instructor feedback on each question
- Small-group active learning tasks; questions that required a written response
- No formal lecturing; however, guidance and explanations were provided by the instructor throughout the class. The instructor responded to student-generated questions, to results from the clicker responses, and to what the instructor heard by listening in on the student-students discussions.

How was the difference in learning related to the difference in teaching?

There are three, inter-related memory-forming processes



Encoding
Incoming stimulus converted into a “memory trace”

Re - Consolidation
Reorganization and stabilization of memory traces; connections to past experiences and stored knowledge

Retrieval
Drawing on memories in new situations

Cognitive Psychology Principles Relevant to Understanding Active Learning – Skeletal Notes

Active learning includes favorable encoding that is consolidated and retrievable

1. Selecting:

2. *Elaboration:*

3. Generation effect:

Consolidation (and re-consolidation) is affected by the timing of the encoding process

4. Spacing:

Retrieval is part of learning as well as testing

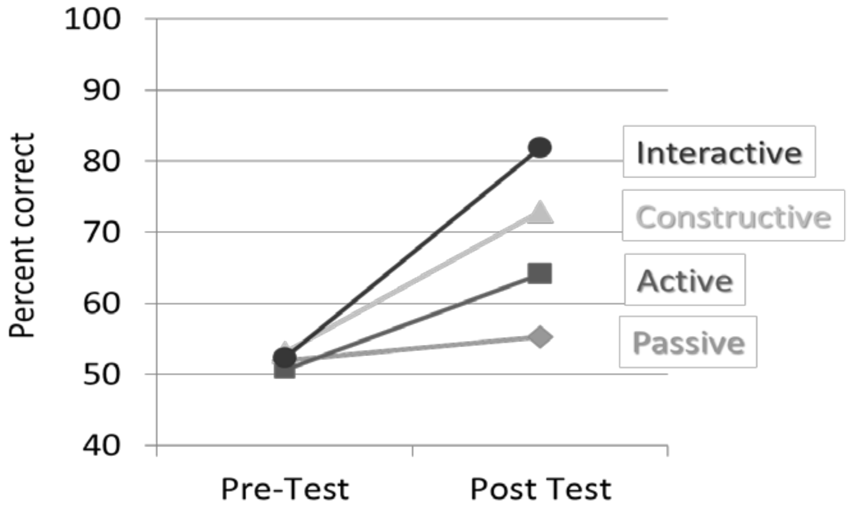
5. Testing effect:

Differentiated Learning Activities – The ICAP Framework

Overt behavior	**PASSIVE** Receiving	**ACTIVE** Selecting and/or manipulating	**CONSTRUCTIVE** Generating or producing	**INTERACTIVE** Collaborating constructively in dialogue
Knowledge-change processes	*Storing* new information directly in an isolated way without assimilating it with other relevant knowledge	*Integrating* activated prior knowledge with new information Assimilate and store new information with prior knowledge	*Infer* new knowledge through integration of activated prior knowledge and new knowledge. Repairing, revising, or reorganizing old knowledge in light of new learning Accommodate and store integrated knowledge	Co-infer new knowledge iteratively through new inputs from conversational partner(s); new knowledge is novel to the co-learners Build on each other's knowledge Resolve own conflicts based on partner's explanation/argument
Cognitive outcomes	*Recall*, in the same context	*Apply* manipulated and emphasized information to similar problems or situations	*Transfer* by applying knowledge in a novel context or to dissimilar problems; interpretation and explanation of new concepts	*Co-Creating* through inventing or discovering new solutions, procedures and explanations
Learning for later retrieval and use	Minimal understanding	Shallow understanding	Deep understanding; potential for transfer	Deepest understanding; potential to innovate new ideas
Example activities	Listening to explanations; watching a video	Taking verbatim notes; highlighting sentences	Self-explaining; comparing and contrasting; solving novel problems	Discussing with peers; solving problems or drawing diagrams with a partner.

(after Chi, 2009, *Topics in Cognitive Science*, 1(1): 73-105; Chi and Wylie, 2014, *Educational Psychologist*, 49(4): 219-243)

ICAP hypothesis is supported by learning-achievement data from an introductory materials science course



1. Each student reads a text or listens to a lecture explaining relations between bonding energy, elastic modulus, melting points, and coefficient of thermal expansion concepts. Passive	2. Each student reads a text that explains the relations between bonding energy, elastic modulus, melting points, and coefficient of thermal expansion concepts and is instructed to highlight the most important or critical sentences. Active
3. Each student examines graphs and figures that illustrate the properties of three metals in terms of elastic modulus, bond energy, and melting points, and then completes a 5-question worksheet to demonstrate relationships between these properties Constructive	4. Pairs of students examine graphs and figures that illustrate the properties of three metals in terms of elastic modulus, bond energy, and melting points, and then together complete a 5-question worksheet to demonstrate relationships between these properties. Interactive

Menekse et al., 2013, *J. of Engineering Education*, 102(3): 346-374

Criteria for recognizing ICAP levels during instructor-led instruction and active learning

	During instructor-led instruction	During active learning
Passive Receiving and storing new information without doing anything with it or connecting to existing knowledge	• Listening to speaker • Watching video/demonstration • Reading text	• Watching/listening to others
Active Selecting, manipulating to strengthen understanding and assimilate with existing knowledge	• Taking verbatim notes • Underlining/highlighting provided notes • Answering questions that seek repetition of what is presented	• Pointing and gesturing • Manipulating objects • Looking for information • Underlining/highlighting instructions • Answering/solving with a provided model; plug and chug • Copying another student's answer
Constructive Generating, producing, inferring something that was not presented and accommodating through integrated knowledge	• Asking questions • Taking notes in one's own words • Making notes that connect new information to prior knowledge • Answering questions that seek application of what is presented • Socratic dialogue with instructor	• Creating outputs beyond the information given (transfer) • Solving a novel or more difficult problem than has been presented • Drawing relationships between information • Generate inferences and relations for conceptual knowledge • Inducing hypotheses • Making predictions • Evaluating claims • Justifying/explaining methods/interpretations; self-explaining • Pair/group activity where not everyone is constructive *or* taking equal turns in dialogue
Interactive Collaborating in dialogue to actively build on each other's knowledge; co-inferring, co-creating	• Answering questions via interaction with peers that seek application of what is presented • Socratic dialogue or discussion that builds off of and engages statements by other learners	• Dialogue where all participants are constructive to generate ideas that were either not expressed initially or where members interject questions and provide clarifications to each other's statements.

ICAP each of the following activities that you have experienced as a part of the course redesign institute.

1. Each participant reads an article and answers accompanying guiding reading questions individually.	2. Each participant listens to a lecture and elaborates on the skeleton notes about *Selecting, Elaborating, Generation Effect, Spacing,* and *Testing Effect* provided in their workbook during the workshop.
3. Each participant listens to the facilitator explain where learning takes place in the brain, and the three components of memory formation.	4. Each participant answers a clicker question and then discusses and debates answers with colleagues. Answers are resubmitted via clickers. .

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Part VII: Where Does Learning Take Place?

After completing this session of the institute, course designers will be able to...

... sketch the learning-activity sequence as a framework for building a teachable unit

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To maximize our time, what could we provide as:

Preparation before class	Follow-up after class

The *learning activity sequence* structures what is learned both in and out of class

Learning Before Class → **Learning In Class** → **Learning After Class**

Learning Activity Sequence

Photo by Aurora Pun

Photo by Aurora Pun

Photo by UNM

First contact with content before *and* outside of class

Interactive learning during *and* inside class

Monitoring and elaborating on learning after *and* outside of class

Assessing learning

Some key references regarding active learning

Chi, Michelene T. H., and Ruth Wylie, ‘The ICAP framework: linking cognitive engagement to active learning outcomes’, *Educational Psychologist*, 49 (2014), 219–43

Deslauriers, L., E. Schelew, and C. Wieman, Improved learning in a large-enrollment physics class’, *Science*, 332 (2011), 862–64

Dunlosky, J., K. A. Rawson, E. J. Marsh, M. J. Nathan, and D. T. Willingham, Improving students’ learning with effective learning techniques: Promising directions from cognitive and educational psychology, *Psychological Science in the Public Interest*, 14 (2013), 4–58

Freeman, S., S. L. Eddy, M. McDonough, M. K. Smith, N. Okoroafor, H. Jordt, and others, Active learning increases student performance in science, engineering, and mathematics, *Proceedings of the National Academy of Sciences*, 111 (2014), 8410–15

Friedlander, Michael J, L. Andrews, E. G. Armstrong, C. Aschenbrenner, J. S. Kass, P. Ogden, and others, What can medical education learn from the neurobiology of learning?, *Academic Medicine*, 86 (2011), 415–20

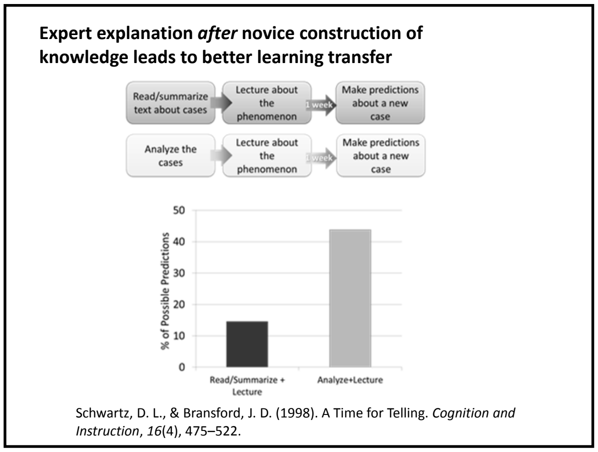
Graffam, B., Active learning in medical education: Strategies for beginning implementation, *Medical Teacher*, 29 (2007), 38–42

Haak, D. C., J. HilleRisLambers, E. Pitre, and S. Freeman, Increased structure and active learning reduce the achievement gap in introductory biology. *Science*, 332 (2011), 1213–16

Smith, M. K., Wood, W. B., Adams, C. K., Wieman, C. E., & Knight, J. K. (2009). Why peer discussion improves student performance on in-class concept questions. *Science*, *323*, 122–124.

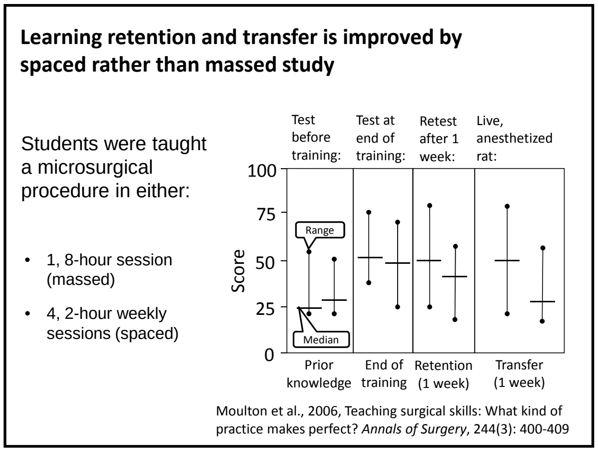
Van der Vleuten, C P M, and E W Driessen, What would happen to education if we take education evidence seriously?’, *Perspectives on Medical Education*, 3 (2014), 222–32

Wieman, Carl, Why not try a scientific approach to science education? *Change*, 39 (2007), 9–15



Expert explanation *after* novice construction of knowledge leads to better learning transfer

Schwartz, D. L., & Bransford, J. D. (1998). A Time for Telling. *Cognition and Instruction*, *16*(4), 475–522.

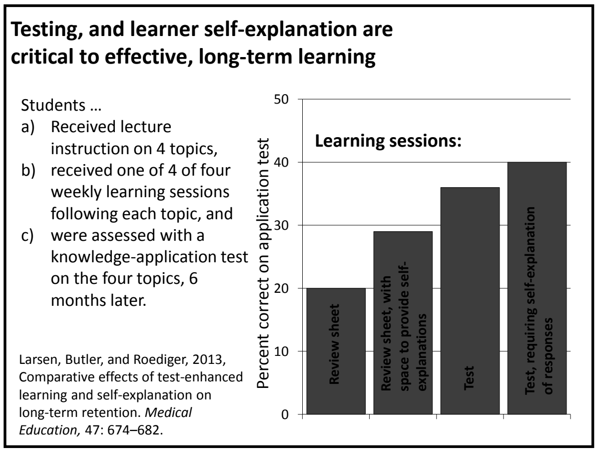


Learning retention and transfer is improved by spaced rather than massed study

Students were taught a microsurgical procedure in either:

- 1, 8-hour session (massed)
- 4, 2-hour weekly sessions (spaced)

Moulton et al., 2006, Teaching surgical skills: What kind of practice makes perfect? *Annals of Surgery*, 244(3): 400-409



Testing, and learner self-explanation are critical to effective, long-term learning

Students …

a) Received lecture instruction on 4 topics,
b) received one of 4 of four weekly learning sessions following each topic, and
c) were assessed with a knowledge-application test on the four topics, 6 months later.

Larsen, Butler, and Roediger, 2013, Comparative effects of test-enhanced learning and self-explanation on long-term retention. *Medical Education,* 47: 674–682.

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Day 2
May 15th, 2015

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TPI TEACHING PERSPECTIVES INVENTORY

Each of the paragraphs below represents a different perspective on 'good teaching,' as indicated by the large bars on your profile sheet.

Together, they will help you understand and interpret your profile. Keep in mind that these five are not mutually exclusive perspectives. In our research involving thousands of teachers, the vast majority hold one or (sometimes) two dominant perspectives. Many hold an additional 'back-up' perspective that is high, although not dominant. This combination of dominant and back-up perspectives allows teachers to accommodate changes in context, content, and learners. Common sense requires that no one can operate from all five simultaneously, since they represent contrasting and sometimes competing views of teaching.

On your profile sheet you also have sub-scores for Beliefs (B), Intention (I), and Actions (A) within each perspective. These sub-scores scores will further help to identify your philosophy of teaching by highlighting whether your views within a perspective are grounded (differentially or equally) in what you believe, what you intend to accomplish, or what educational actions you undertake in your teaching settings.

Transmission	Effective teaching requires a substantial commitment to the content or subject matter. Good teaching means having mastery of the subject matter or content. Teachers' primary responsibilities are to represent the content accurately and efficiently. Learner's responsibilities are to learn that content in its authorized or legitimate forms. Good teachers take learners systematically through tasks leading to content mastery: providing clear objectives, adjusting the pace of lecturing, making efficient use of class time, clarifying misunderstandings, answering questions, providing timely feedback, correcting errors, providing reviews, summarizing what has been presented, directing students to appropriate resources, setting high standards for achievement and developing objective means of assessing learning. Good teachers are enthusiastic about their content and convey that enthusiasm to their students. For many learners, good transmission teachers are memorable presenters of their content.

Apprenticeship	**Effective teaching is a process of socializing students into new behavioral norms and ways of working.** Good teachers are highly skilled practitioners of what they teach. Whether in classrooms or at work sites, they are recognized for their expertise. Teachers must reveal the inner workings of skilled performance and must translate it into accessible language and an ordered set of tasks which usually proceed from simple to complex, allowing for different points of entry depending upon the learner's capability. Good teachers know what their learners can do on their own and where they need guidance and direction; they engage learners within their 'zone of development'. As learners mature and become more competent, the teacher's role changes; they offer less direction and give more responsibility as students progress from dependent learners to independent workers.
Developmental	**Effective teaching must be planned and conducted "from the learner's point of view."** Good teachers must understand how their learners think and reason about the content. The primary goal is to help learners develop increasingly complex and sophisticated cognitive structures for comprehending the content. The key to changing those structures lies in a combination of two skills: (1) effective questioning that challenges learners to move from relatively simple to more complex forms of thinking, and (2) 'bridging knowledge' which provides examples that are meaningful to the learner. Questions, problems, cases, and examples form these bridges that teachers use to transport learners from simpler ways of thinking and reasoning to new, more complex and sophisticated forms of reasoning. Good teachers adapt their knowledge to learners' levels of understanding and ways of thinking.

Nurturing	**Effective teaching assumes that long-term, hard, persistent effort to achieve comes from the heart, not the head.** People become motivated and productive learners when they are working on issues or problems without fear of failure. Learners are nurtured in knowing that (a) they can succeed at learning if they give it a good try; (b) their achievement is a product of their own effort and ability, rather than the benevolence of a teacher; and (c) their learning efforts will be supported by both teacher and peers. Good teachers care about their students and understand that some have histories of failure resulting in lowered self-confidence. However they make no excuses for learners. Rather, they encourage their efforts while challenging students to do their very best by promoting a climate of caring and trust, helping people set challenging but achievable goals, and supporting effort as well as achievement. Good teachers provide encouragement and support, along with clear expectations and reasonable goals for all learners but do not sacrifice self-efficacy or self-esteem for achievement. Their assessments of learning consider individual growth as well as absolute achievement.
Social Reform	**Effective teaching seeks to change society in substantive ways.** From the Social Reform point of view, the object of teaching is the collective rather than the individual. Good teachers awaken students to values and ideologies that are embedded in texts and common practices within their disciplines. Good teachers challenge the status quo and encourage students to consider how learners are positioned and constructed in particular discourses and practices. To do so, they analyze and deconstruct common practices for ways in which such practices perpetuate conditions that are unacceptable. Class discussion is focused less on how knowledge has been created, and more by whom and for what purposes. Texts are interrogated for what is said and what is not said; what is included and what is excluded; who is represented and who is omitted from the dominant discourse. Students are encouraged to take critical stances to give them power to take social action to improve their own lives and the lives of others. Critical deconstruction, though central to this view, is not an end in itself.

Descriptions from: http://www.teachingperspectives.com/tpi/

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Part VIII: Building A Teachable Unit- Selecting Pedagogy and Content for Student Success

After completing this session of the institute, course designers will be able to …

… draft peer instruction Q & A prompts
… create teachable units for their redesigned course using the learning activity sequence
… analyze a teachable unit to assure alignment of learning activities with learning outcomes

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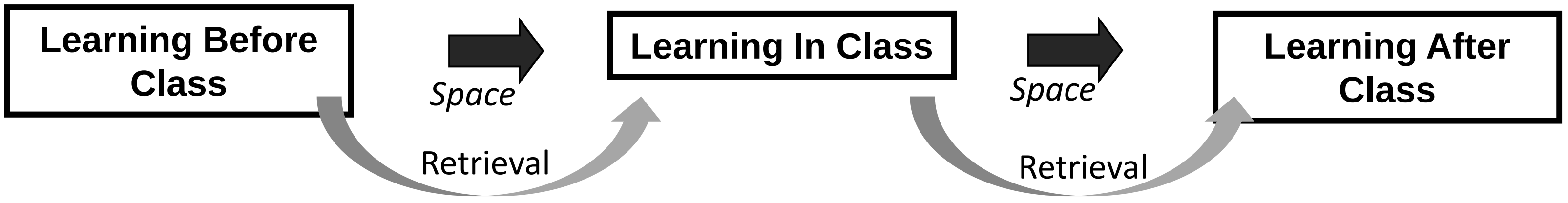


Increasing learning potential

Learning Before Class

- ☐ 5. Reading/video/simulation, with a written application or analysis exercise submitted before/at beginning of class – C; *G,T*
- ☐ 4. Reading/video, with warm-up quiz (low-level questions) at beginning of class (closed book) – A; *T*
- ☐ 3. Reading/video, with warm-up quiz (low-level questions) online before class (open book) – A; *S, (E-depending on questions)*
- ☐ 2. Reading/video, with guiding questions – A; *S, (E-depending on questions)*
- ☐ 1. Reading/video – P(A)
- ☐ 0. No pre-class preparation expected

Learning In Class

- ☐ 6. Small-group assignment or activity – I(C); *E, G*
- ☐ 5. Lecture; peer instruction with clickers – C(I); E,G,T
- ☐ *4.* Individual writing assignment to elaborate and self-explain problems/cases – C; *E (G)*
- ☐ 3. Lecture; asking clicker questions – A; *S, T, (E – depending on questions),*
- ☐ 2. Lecture; asking questions– P(A); *S, (E-depending on questions)*
- ☐ 1. Lecture P(A); *S*

Learning After Class

- ☐ 4. Group assignment/project – I(C); *E,G,T*
- ☐ 3. Unstructured study in groups – C(I); *E,G,(T – if students quiz one another)*
- ☐ 2. Learning assessment quiz applying in-class learning (online) – C; *T,(E,G – depending on questions)*
- ☐ 1. Unstructured study alone – A(C); *E,G,(T-if students self test)*

Potential ICAP levels: **I**nteractive / **C**onstructive / **A**ctive / **P**assive
Potential memory builders: ***S***electing / ***E***laboration / ***G***eneration effect / **T**esting effect

Instructions:

1. Place an × in the box that is most representative of each learning-sequence stage in your *current* teaching sessions
2. Place a ✓ in the box that represents your goal for each learning-sequence stage in your *future* teaching

From Questions to Concepts - Debrief

How is the learning activity sequence being applied?

How are students' misconceptions and prior knowledge being addressed?

Why is it important to make learning “visible”?

Where does pre-class work plot on the ICAP framework?

Where does in-class work plot on the ICAP framework?

What was the role of peer instruction for both promoting and assessing learning?

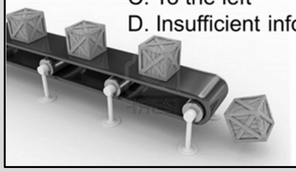
Peer instruction is a research-based use of clickers to both promote and formatively assess learning

1 Lecture is interrupted with the projection of a conceptual multiple-choice question related to the topic (*ConcepTest*). Students respond with their clicker.

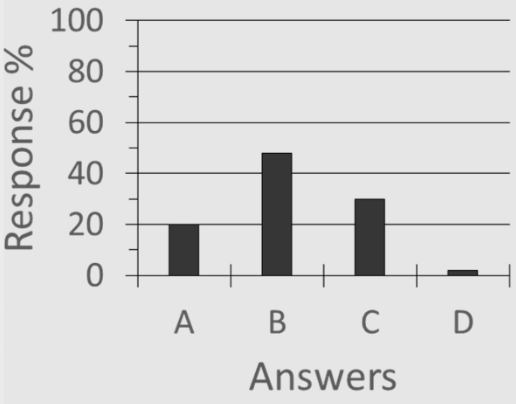
Example of peer instruction:

A crate is moving to the right on a conveyor belt without slipping. The conveyor belt maintains a constant speed. The force of friction on the crate is:

A. To the right
B. Zero
C. To the left
D. Insufficient information to answer



Instructor examines response histogram from program:

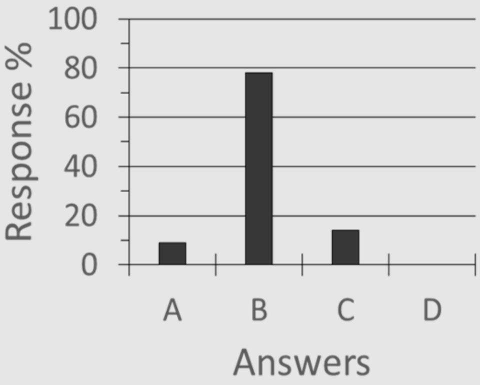


2 Students discuss their competing answers with one another.

Students enter a second response to the question.

3

After discussing with peers:



Photos by Aurora Pun

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Resources for Teaching with Clickers

Websites:

http://cte.unm.edu/resources/teaching/teaching-with-clickers.html
http://cft.vanderbilt.edu/guides-sub-pages/clickers/

Methods for teaching with clickers:

Bruff, D. (2009). *Teaching with Classroom Response Systems. Creating Active Lea*rning Environments. Jossey-Bass/Wiley.

Mazur, E. (1997). *Peer instruction: a user's manual*. Upper Saddle River: Prentice Hall.

Beatty, I. D., Gerace, W. J., Leonard, W. J., & Dufresne, R. J. (2006). Designing effective questions for classroom response system teaching. *American Journal of Physics*, 74(1), 31. doi:10.1119/1.2121753

Mazur, E. (2009). Farewell, Lecture? *Science*, 323, 50–51.

Perez, K. E., Strauss, E. A., Downey, N., Galbraith, A., Jeanne, R., Cooper, S., & Madison, W. (2010). Does Displaying the Class Results Affect Student Discussion during Peer Instruction ? *CBE—Life Sciences Education*, 9, 133–140.

Turpen, C., & Finkelstein, N. D. (2010). The construction of different classroom norms during Peer Instruction: Students perceive differences. *Physical Review Special Topics - Physics Education Research*, 6(2), 020123. doi:10.1103/PhysRevSTPER.6.020123

Research on learning efficacy of clickers:

Crouch, C. H., & Mazur, E. (2001). Peer Instruction: Ten years of experience and results. *American Journal of Physics*, *69*(9), 970. doi:10.1119/1.1374249

Knight, J. K., Wise, S. B., & Southard, K. M. (2013). Understanding clicker discussions: student reasoning and the impact of instructional cues. *CBE Life Sciences Education*, *12*(4), 645–54. doi:10.1187/cbe.13-05-0090

Mayer, R. E., Stull, A., DeLeeuw, K., Almeroth, K., Bimber, B., Chun, D., … Zhang, H. (2009). Clickers in college classrooms: Fostering learning with questioning methods in large lecture classes. *Contemporary Educational Psychology*, *34*(1), 51–57. doi:10.1016/j.cedpsych.2008.04.002

Smith, M. K., Wood, W. B., Adams, C. K., Wieman, C. E., & Knight, J. K. (2009). Why Peer Discussion Improves Student Performance on In-Class Concept Questions. *Science*, *323 ,* 122–124.

See it in action:

Audience Response Systems (Merlot)

http://elixr.merlot.org/case-stories/technology--learning/audience-response-systems?noCache=724:1307404573

Wieman Science Education Initiative, UBC
http://www.cwsei.ubc.ca/resources/SEI_video.html

Eric Mazur interactive physics lecture at Harvard
https://www.youtube.com/watch?v=wont2v_LZ1E

The *learning activity sequence* structures what is learned both in and out of class

Learning Before Class ➡ **Learning In Class** ➡ **Learning After Class**

Learning Activity Sequence

Photo by Aurora Pun

First contact with content before *and* outside of class

Photo by Aurora Pun

Interactive learning during *and* inside class

Photo by UNM

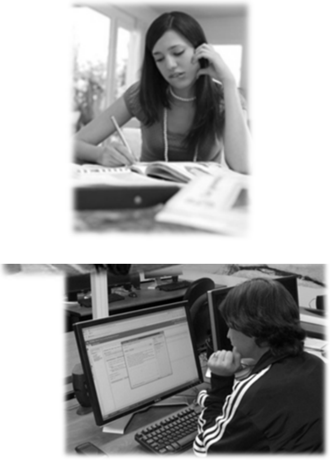
Monitoring and elaborating on learning after *and* outside of class

Assessing learning

Within the learning activity sequence…

… students engage with learning the content during class time with peer and instructor influence, …

… which means that students must be prepared by making **first contact with (and thinking about) content prior to class**.



You may have of heard these concepts as “flipped learning”

In Class

Out of Class

“Traditional” course structure

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Part IX: Assessing What Students Are Learning

After completing this session of the institute, course designers will be able to…

… develop formative and summative assessments of learning outcomes
… analyze assessments to assure alignment with learning outcomes and learning activities

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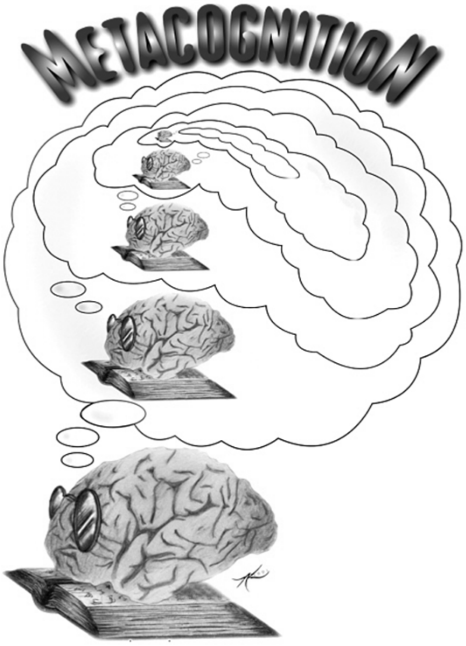
Is it the responsibility of *students* or *instructors* to monitor and assess learning?

"It sort of makes you stop and think, doesn't it."

Cartoon by Sam Gross



- Knowledge about one's own cognition
- Thinking about one's own thinking
- What do I know and what don't I know?
- Regulating how we go about learning

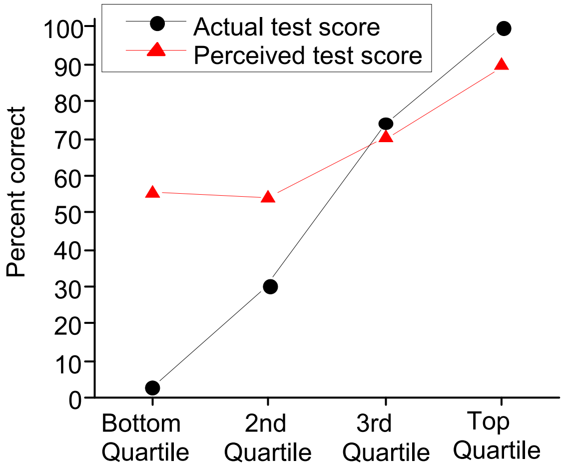
N. Kremenek

Knowing What You Do and Do Not Know

"I can't believe that I got a D on this test; I really understand all of this stuff." How many times have you heard this statement from a student? Can it really be possible that learners don't know that they do not know?

Students who obtain high grades tend to possess strong metacognition. That means that they are able to determine what they know and what they don't know, and adjust their study and questioning habits to focus on perceived weaknesses in understanding. Low-performing students, on the other hand, tend to over-estimate their abilities and knowledge and score much worse than they expected on learning assessments. Most of these latter students, arguably, are capable of succeeding if they only knew that their perceptions of learning were incorrect.

The graph below comes from a classic study by Kruger and Dunning[1]. A group of students at Cornell University completed a test of logical reasoning ability. After the test, but before the results were released, the students were each asked to estimate their grade on the test. On average, no quartile group felt that they had missed more than half the points. Students who scored in the top quartile slightly underestimated their test score but in the successively lower quartile groups, the negative disparity between test score and perceived score increases.



Answer the following questions. When you have finished, partner with a person beside you and discuss your answers.

1. What is the take away point of this study?

2. Name 2 ways you can improve students' metacognition in your course.

---

[1] J. Kruger and D. Dunning, 1999, *J. of Personality and Social Psychology*, 77(6), 1121-1134

How can you help your students to be more metacognitive?

Model metacognition

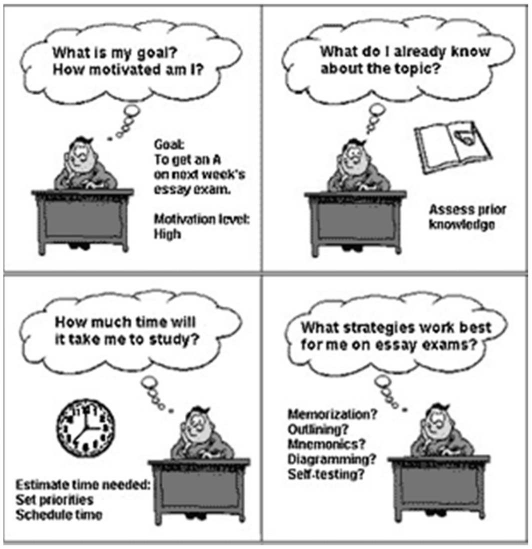


Image at: http://ambertraining.org.uk/wp-content/uploads/2012/12/Student-comic.jpg

Provide assignments or discussion opportunities that initiate metacognition

Muddy-point question: What seems murky and unclear and is slowing down your learning progress? What is your plan for clearing up this concern?

Photo at: http://www.sowetanlive.co.za/incoming/2011/09/06/mud.jpg/RESIZED/mediumRectangle/mud.jpg

Two-minute paper: Before leaving, write down the most important thing you learned today and why it is important.

Image at: http://images.pensfatales.com/uploaded_images/clock-cartoon-798489.jpg

Assessing Student Learning

Assessment is…

Collecting data about what learners understand and can do, evaluating those data, and **making decisions** based on that evaluation.

Program assessment asks, *"Is our department preparing our majors well?"*

A. **Analyzing whether the department curriculum is meeting the intended learning goals**
B. Giving a final exam to students
C. Ongoing two-way communication with students regarding where they are at in a given class

Summative course assessment asks, *"What learning has taken place with each student?*

A. Analyzing whether the department curriculum is meeting the intended learning goals
B. **Giving a final exam to students**
C. Ongoing two-way communication with students regarding where they are at in a given class

Formative course assessment asks, *"What learning is taking place with each student?*

A. Analyzing whether the department curriculum is meeting the intended learning goals
B. Giving a final exam to students
C. **Ongoing two-way communication with students regarding where they are at in a given class**

Summative assessments are high stakes but if they are not carefully constructed they will produce grades that do not relate to what students learned.

Are your questions valid for measuring the outcomes that you expect students to learn?

Are tests constructed properly? *One study found that flawed multiple-choice test items accounted for as much as 41% (median 20%) of the variance in test scores; 10-15% of students who failed the tests arguably should have received passing grades.*

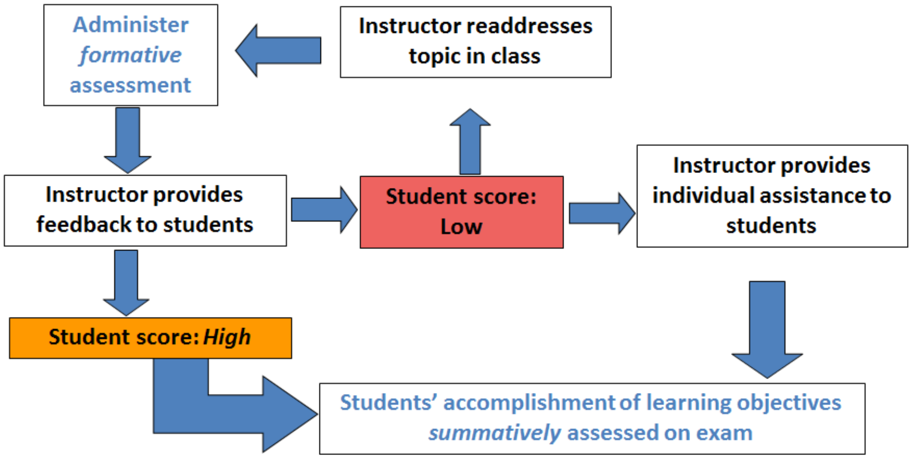
Have students received formative feedback on the types of learning that will be summatively assessed?

Formative assessment is all about feedback …

… to whom?
… for what reason?
… when?

Always designed with outcomes in mind

Formative and summative assessment should be related in order to promote learning



How often should we do formative assessment?

Formative assessment need not add another layer of instructor work

Make the most of your assignments: *In-class-learning assignments can also serve as formative learning assessments.*

Administer online assessments using Blackboard Learn.

But – you do need to review student work and adjust instruction, otherwise formative assessment is incomplete and useless.

Links on writing exam questions, with an emphasis on multiple-choice tests

Writing good multiple choice exams, by Dawn M. Zimmaro,
http://www.utexas.edu/academic/mec/research/pdf/writingmcexamshandout.pdf

Designing and Managing Multiple Choice Questions,
http://web.uct.ac.za/projects/cbe/mcqman/mcqman01.html

How Can We Construct Good Multiple-Choice Items? by Derek Cheung and Robert Bucat
http://www3.fed.cuhk.edu.hk/chemistry/files/constructMC.pdf

To How to Prepare Better Multiple-Choice Test Items: for University Faculty by Steven J. Burton, Richard R. Sudweeks, Paul F. Merrill and Bud Wood
http://testing.byu.edu/info/handbooks/betteritems.pdf

To How to Prepare Better Tests: Guidelines for University Faculty by Beverly B. Zimmerman, Richard R. Sudweeks, Monte F. Shelley and Bud Wood
http://testing.byu.edu/info/handbooks/bettertests.pdf

Improving Multiple Choice Tests by Klegg and Cashin
http://www.theideacenter.org/sites/default/files/Idea_Paper_16.pdf

Authentic Assessment Toolbox
http://jonathan.mueller.faculty.noctrl.edu/toolbox/index.htm

Preparing Effective Essay Questions: A Self-Directed Workbook for Educators,
https://testing.byu.edu/info/handbooks/WritingEffectiveEssayQuestions.pdf

Writing Exam Questions, http://depts.washington.edu/cidrweb/resources/exams.html

Resources for Concept Inventories and Knowledge Surveys

General information about Concept Inventories

Libarkin, J. (2008). *Concept Inventories in Science:* Manuscript prepared for the National Research Council. http://sites.nationalacademies.org/cs/groups/dbassesite/documents/webpage/dbasse_072624.pdf

Richardson, J. (2005). Concept Inventories : Tools For Uncovering STEM Students ’ Misconceptions. In*vention and Impact: Building Excellence in Undergraduate Science, Technology, Engineering and Mathematics (STEM) Education* (pp. 19–26). Washington D.C.: American Association for the Advancement of Science. http://www.unc.edu/opt-ed/eval/bp_res_eval/richardson.pdf

Biology Concept Inventories

There are more than a dozen concept inventories in biological science, some of which are specifically for sub-disciplines. For an insightful bibliography, please consult:

Fisher, K.M. and K.S. Williams. (2011). Concept Inventories and Conceptual Assessments in Biology (CABs): An annotated list. http://www.sci.sdsu.edu/CRMSE/files/Concept_Inventories_in_Biology_20110325.pdf

Physics Concept Inventories

Halloun–Hestenes Mechanics Diagnostic Test

Halloun, I.A., and D. Hestenes, D. (1985). The initial knowledge state of college physics students, *Am. J. Phys*. 53, 1043–1055

Halloun, I.A., and D. Hestenes, D. (1987) Modeling instruction in mechanics, *Am. J. Phys.* 55, 455–462.

Force Concept Inventory

Hestenes, D., Wells, M., and Swackhamer, G.‘ (1992). Force Concept Inventory, *Phys. Teach.* 30, 141–158.

Mazur, E. (1997) *Peer Instruction: A User’s Manual*. Prentice-Hall, Engelwood Cliffs, [contains the 1995 Revised FCI]

Mechanics Baseline Test

Hestenes, D., Wells, M., (1992) A Mechanics Baseline Test. *Phys. Teach*. 30, 159–166.

Geoscience Concept Inventory

Libarkin, J. C., & Anderson, S. W. (2005). Assessment of Learning in Entry-Level Geoscience Courses: Results from the Geoscience Concept Inventory. *Journal of Geoscience Education*, 53, 394-401.

Libarkin, J. C., & Anderson, S. W. (2006). The Geoscience Concept Inventory: Application of Rasch Analysis to Concept Inventory Development in Higher Education. In X. Liu & W. Boone (Eds.), Applications of Rasch Measurement in Science Education (pp. 45-73): JAM Publishers.

Chemistry Concept Inventory

Mulford, D. R. (1996). An Inventory for Measuring College Students' Level Of Misconceptions in First Semester Chemistry., Purdue University.

Chemical Concepts Inventory available from Journal of Chemical Education: http://www.jce.divched.org/jcedlib/qbank/collection/CQandChP/CQs/ConceptsInventory/CCIIntro.html

Barbera, J., (2013). A Psychometric Analysis of the Chemical Concepts Inventory. *J. Chem. Educ.*, *90* (5), 546–553.

Knowledge Surveys

Nuhfer, E.B., and Knipp, D. (2003) The knowledge survey: A tool for all reasons: *To Improve the Academy*, *21*, 59-78.

Wirth, K. (2006) Knowledge Surveys. Science Education Resource Center. (accessed 5/6/2015) http://serc.carleton.edu/NAGTWorkshops/assess/knowledgesurvey/index.html

STEM Gateway
Course Redesign Institute

Part X: Aligning and Evaluating the Teachable Unit

After completing this session of the institute, course designers will be able to…

… align the outcomes, activities, and assessments that your built for your TU

… evaluate the strengths and weaknesses of a teachable unit

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Table. 5.2 Review Rubric for Teachable Units

Criteria	Levels of Completion		
	Comprehensive	**Intermediate**	**Cursory/Absent**
Learning Goals and Outcomes Goals—What students will know, understand, or be able to do Outcomes—What performances or behaviors will indicate accomplishment of the goals	**Overall: Students will experience the nature of science in this unit and know what is expected of them.** It is clear what students will know, understand, and be able to do after they have completed this unit. The goals are challenging, interesting, and appropriate for the intended students. It is clear what knowledge (concepts, topics, theories, facts, and terminology) students are expected to learn and what behaviors and performances typify understanding.	The goals are clear, but they do not entirely represent the nature of science. Students need more information to know what is expected of them. The prior knowledge that students are expected to have is somewhat inaccurate; this unit may therefore be too challenging or simple.	The goals do not represent the nature of science, or they are otherwise inadequate. For example, they may be too vague, ambiguous, broad, ambitious, detailed, or focused. There are no descriptions of expected student performances or behaviors; students will not know what is expected of them.
Active Learning How students will engage actively in learning	**Overall: Students will be actively engaged in learning.** The activities follow a logical progression within a unit and will effectively engage students. It is clear how the activities elicit students' prior knowledge and address common misconceptions.	Activities should be more clearly tied to the learning goals, interesting, or student-centered. There are not enough student-centered activities in this unit to elicit prior knowledge, to construct new knowledge, or address common misconceptions.	Activities are exclusively teacher-centered. It is not clear how the activities will engage students in learning, how they build on students' prior knowledge, or how they address misconceptions.
Assessment How instructors will measure student learning How students will self-assess learning	**Overall: Students will know what is expected of them and will receive regular feedback about learning.** The assessments provide instructors and students with useful feedback about student learning throughout the unit and at the end of the unit. Assessments are designed to drive student learning toward the goals. Criteria for evaluation and grading are clear.	The assessments will measure student learning at some key points, but students will need more feedback during the unit. Alternatively, students will need more opportunities to evaluate their own learning during the unit. Rubrics could provide more clear descriptions of the expected performances and the consequences of each performance.	There are no formative assessments in this unit. The assessments do not adequately measure progress toward or achievement of the learning goals. The assessments do not provide useful feedback to students about learning.

Diversity How all students will be included in learning	**Overall: All students will be included in learning.** It is clear that the unit is designed to enable students to construct their own learning in the context of their own minds and to engage diverse students. It is clear that the unit addresses multiple aspects of student diversity, such as race, gender, and abilities. Varied teaching methods are used to address different learning goals and engage a diversity of students. A diversityo fcontent, examples, or metaphors is used that are not offensive.	The unit offers some opportunity for students to construct their own learning, but could include more diverse or effective teaching methods.The unit could use more examples that reflect student diversity in cultural b ackground, g ender, learning skills, or physical abilities.The unit includes diverse teaching methods, but otherwise does not address student diversity.	The unit is teacher-centered and does not foster student responsibility for learning. The unit does not address diversity or includes potentially off-putting examples.
Alignment How the unit aligns with learning goals	**Overall: The unit's activities will help students achieve the learning goals. The assessments will measure stduent achievment of the goals and provide regular feedback about learning.** It is clear how the unit's activities and assessments are aligned with the goals. It is clear how the unit addresses the themes of diversity, assessment, and active learning.	In some cases, it is not clear how the activities help students meet the learning goals, or how the assessments provide feedback about the goals. Certain goals are over- or under-assessed through activities or assessments, which will give students the wrong idea about what is important to learn. There are too many activities for the time period; students will likely feel this unit is "busywork."	The activities and assessments do not align with the learning goals. Students will be confused about which learning goals are important.
Teaching Plan What the instructor and students will do	**Overall: Instructors will understand the schedule of events.** The plan includes a clear schedule of events for activities and assessments for both the instructor and the students. The sequence of events is logical and aligned with goals. Detailed instructions are provided so that another instructor could easily implement the unit, including guiding questions, tips, and supporting materials. Detailed instructions are provided for students.	The schedule of activities is described broadly, but more detailed instructions are needed for another instructor to implement. The order of events is somewhat logical, but more information is needed to be useful to other instructors. Some minor factual information is inaccurate and should be corrected.	The schedule of activities is vague, not logical, or omitted. Detailed instructions are not included for instructors or students. There are so many inaccuracies in factual information that this unit should not be taught.

Excerpted from: Handelsman J., S. Miller, C. Pfund. 2007. *Scientific Teaching*. W.H. Freeman and Company, New York.

Creating a culture of sharing, communicating, and working together to improve STEM student success

Dialogue about teaching within a social network (communities of practice) that diffuses and supports innovation within and across departments.

Image at: http://cvjointchamber.com/uploads/images/networking.jpg

STEM Gateway
Course Redesign Institute

Day 3
May 18th, 2015

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Reflect and Choose….*Read the quotations below and choose one that particularly resonates with you or that inspires your curiosity to better understand what the writer is saying.*

Learning takes place in the minds of students and nowhere else, and the effectiveness of teachers lies in what they can induce students to do. The beginning of the design of any educational procedure is dreaming up experiences for students: things that we want students to do because these are the activities that will help them to learn this kind of information and skill. And then we can back off and ask what we have to do to get students to carry out these activities.

Simon, H. A. (1998). What We Know About Learning.
Journal of Engineering Education, 87(4), 343-348.

The most influential cause of the failure of science education is that science has been so frequently presented just as so much ready-made knowledge, so much subject-matter of fact and law, rather than as the effective method of inquiry into any subject-matter.

-John Dewey

Research has taught us a great deal about effective teaching and learning in recent years, and scientists should be no more willing to fly blind in their teaching than they are in scientific research

Bruce Alberts, President, National Academy of Sciences

...most introductory courses rely on "transmission-of-information" lectures and "cookbook" laboratory exercises — techniques that are not highly effective in fostering conceptual understanding or scientific reasoning. There is mounting evidence that supplementing or replacing lectures with active learning strategies and engaging students in discovery and scientific process improves learning and knowledge retention.

Handelsman et al., 2004, "Scientific Teaching," *Science*, 304, 521-522.

If college students are encouraged to learn only the facts and details and aren't required to comprehend the information, they're left with superficial, nonenduring knowledge. Understanding, not facts, is what education is all about. It's understanding that's left after you've forgotten all the details.

Thomas Lord
President Society of College Science Teachers

Who will do science? That depends on who is included in the talent pool. The old rules do not work in the new reality. It's time for a different game plan that brings new players in off the bench.

Shirley M. Malcom
Head, AAAS Directorate for Education and Human Resources Programs
"Who Will Do Science in the 21st Century", *Scientific American*, Feb. 1990

STEM Gateway
Course Redesign Institute

Part XI: Planning and Rolling Out the Redesign

After completing this session of the institute, course designers will be able to…

… create a work plan for redesigning the course
… create an implementation plan for new course components

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Real Course – ***Where we are now***	**Pathway**	**Ideal Course** – ***Our vision for the redesigned course***

Planning a SMART Redesign Project

"If you don't know where you're going, chances are you will end up somewhere else." -Yogi Berra

When planning for a successful redesign, s tart with the end in mind. The following prompts are provided to help you construct a plan that includes a goal, milestones, and a timeline for partial to full implementation of the redesign. Your plan should also include additional STEM Gateway consultation and other resource needs. You can use the timeline on the next page to help you plot the activities sequentially. Anticipate that timelines may shift and goals may be revised as you make progress. As you respond to the prompts

1. **S**pecific Goals. What goal are you trying to accomplish? What are you trying to achieve by redesigning the course? What are your goals for summer '15, fall '15, spring '16 and summer '16?

2. **M**ilestones. List all milestones or sub-goals that will need to occur in order to reach your goal. **M**easurable. How will you measure whether or not the goal has been reached (list at least two indicators)?

3. **A**ction items. What are the specific action items that need to be accomplished to meet each milestone/ sub-goal?

4. **R**esources. Do you have the necessary knowledge, skills, abilities, and resources to accomplish the goal? What resources do you have? What resources do you need? What resources can STEM G provide? Who will be responsible for accomplishing each activity listed?

5. **T**ime-bound. What is the established completion date and does that completion date create a practical sense of urgency? Write tentative due dates for each activity, milestone, and goal.

Remember to consider the following while planning a successful redesign:

***Develop*:** What materials, tools, assignments, and learning assessments will need to be created or found?

***Implement*:** How will the changes be implemented – in stages, with a pilot, all at once? Why? What professional development is needed? What additional resources are required?

Evaluate: How will you know that the redesign is working? Are the stated learning outcomes being achieved?

Improve*:* What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course? How will new instructors be brought up to speed?

Redesign Planner

Summer 2015

Goal-	**Responsible Party**	**Due Date**	**Resources (have/need)**
Sub-Goal 1- *Action Step1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 2- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 3- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			

Redesign Planner

Fall 2015

Goal-	**Responsible Party**	**Due Date**	**Resources (have/need)**
Sub-Goal 1- *Action Step1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 2- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 3- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			

Redesign Planner

Spring 2016

Goal-	**Responsible Party**	**Due Date**	**Resources (have/need)**
Sub-Goal 1- *Action Step1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 2- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 3- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			

Redesign Planner

Summer 2016

Goal-	**Responsible Party**	**Due Date**	**Resources (have/need)**
Sub-Goal 1- *Action Step1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 2- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			
Sub Goal 3- *Action Step 1-* *Action Step 2-* *Action Step 3-* *Action Step 4-* *Action Step 5-*			

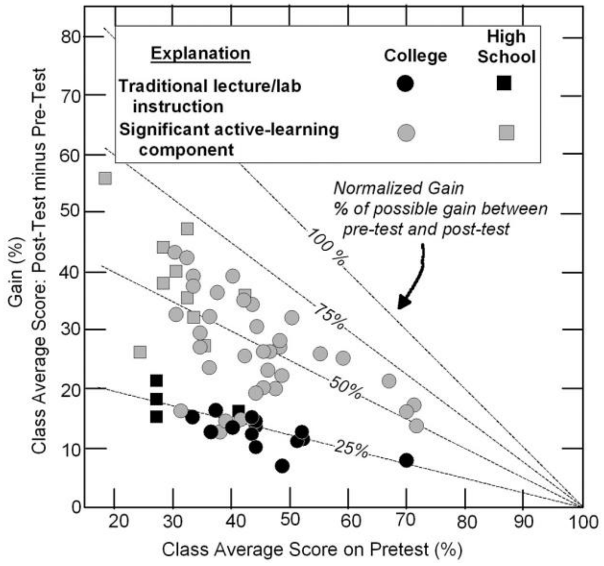
Lessons in Learning from Gateway STEM Courses

An Example from Physics

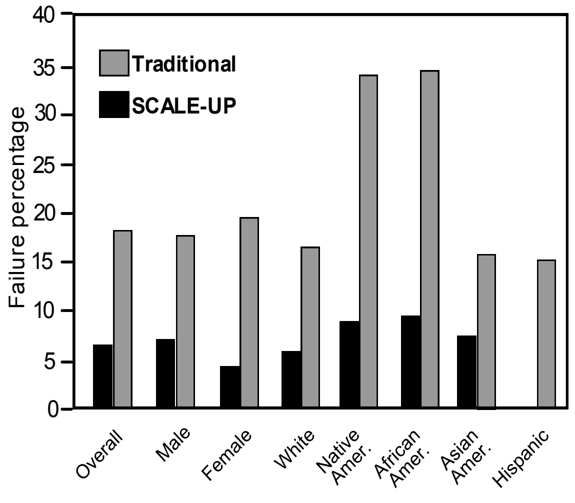
Many studies have addressed the effect of instruction on the depth of student learning. The largest data set addresses conceptual learning in first-semester physics based on pre- and post-term testing of more than 6500 students in 62 classes[1]. The test consisted of nationally validated questions that assess conceptual, qualitative understanding of the fundamental laws of motion that are the focus of the first-semester course. Although instructional approaches varied, the learning environments could be generalized as either traditional lecture plus lab, or class sessions with a significant component of active learning. In the latter classes, students engaged in small-group discussion or problem solving that forced retrieval and use of knowledge rather than passive absorption through listening. In some cases the active learning focused on use of peer-instruction with clickers, whereas other instructors had pairs of students work with in-class worksheets (lecture tutorials) or devoted significant class time for students to test predictions with simple experiments.

The different learning gains based on instruction are dramatic, as indicated in the graph at top right. The dashed lines show normalized gain, which is the amount of gain possible between pre- and post-tests. For example, if a student scored 20% on the pretest and 40% on the post-test, they gained 20 percentage points out of a possible 80, for a normalized gain of 25%. For most active-learning classrooms, the normalized learning gains were two to three times greater than in the traditional classrooms.

One of the more interesting approaches to interactively engage students with learning physics blends traditional lecture and laboratory time in classrooms that are specifically designed to foster teamwork and cooperative learning. The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) originated at North Carolina State University and has now spread to many campuses and moved to disciplines other than physics.



Not only do SCALE-UP students demonstrate greater conceptual understanding of physics but they also achieve better grades. As shown in the graph below[2], North Carolina State students in many demographic groups achieved higher grades in the SCALE-UP classes. In addition, well-known achievement gaps between white males and other students are substantially reduced.



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[1] Hake, R.R., 1998, *Am. J. Phys.,* 66(1), 64-74.

[2] Beichner, Saul, et al., 2007, *Rev. of Physics Ed. Res.* 1

STEM GATEWAY

Lessons in Learning from Gateway STEM Courses

An Example from Geology

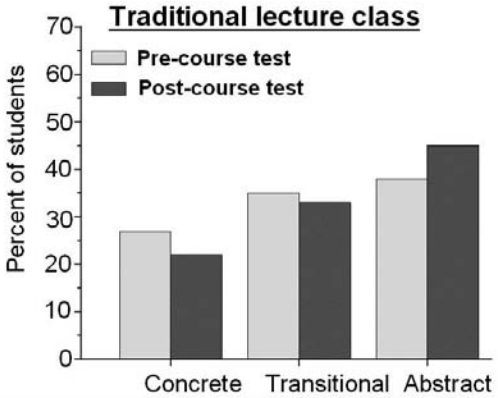
STEM faculty commonly complain that students learn course subjects and problem-solving strategies by rote rather than understanding underlying concepts, principles, and theories and integrating this deeper understanding for transfer to other courses. To a large extent, this disparity between teacher expectation and student behavior and performance is rooted in how reasoning develops from childhood to adulthood[1]. Teacher experts appreciate, through practice and experience, that conceptual understanding of abstract principles provides a framework for deductive reasoning that predicts or permits derivation of new ideas and facts. So, they tend to expect this reasoning in their students. However, novices – not only to a discipline but to complex reasoning – are much more likely to build understanding inductively from concrete, sensed experiences. Ultimately, if we want students to truly understand scientific disciplines and to think scientifically, we need to help them develop more expert reasoning abilities.

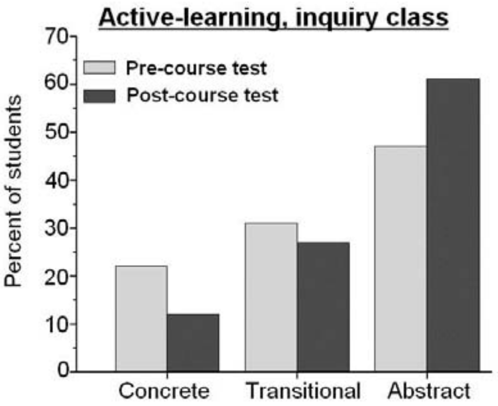
This was the objective of geology faculty at the University of Akron[2]. They examined the role of instruction in transforming students from concrete operational thinkers (who do not simultaneously manage multiple concepts, use induction exclusively, rely on information within a question as the only source of evidence for their brief and incomplete answers) to abstract operational thinkers. Concrete operational students typically seek a single, correct solution and have difficulty constructing responses for open-ended questions – a tendency to answer questions by "finding" answers in text or sample solutions rather than reasoning and "constructing" answers. Concrete operational thinkers are not only novices to the discipline but are novice thinkers. Abstract operational thinkers can make predictions in hypothetical situations that require going beyond their experiences to build conclusions on logic and inferences or to design solutions to new problems. With deeper working memory, these thinkers keep the questions, key concepts, and their inter-relationships in mind together while constructing answers that show recognition of how variables influence each other and show evidence of deduction to explain specific concepts in relation to a general rule that may not be discussed in the question.

The Akron professors adopted a goal to foster the development of higher order thinking skills of the abstract operational thinker so as to encourage student conceptual understanding of the geosciences. They measured reasoning ability by administering a validated assessment of competence in proportional reasoning, controlling variables, combinational reasoning, probabilistic reasoning, and correlational reasoning as a pre- and post-test in multiple sections of experimental (active, inquiry-based learning) and control (passive lecture) courses taught by several instructors teaching in similar classrooms

The active, inquiry based classes emphasized processes such as making observations, posing questions, analyzing data, making predictions, and communicating ideas. Students in these classes worked together in groups to complete learning exercises that included conceptual multiple-choice questions (conceptests), Venn diagrams, evaluation rubrics, concept maps, and open-ended questions. The learning was structured to scaffold learning by beginning with exercises that employed concrete examples and later moved students toward more abstract reasoning.

As the graphs below show, traditional lecture instruction had no significant impact on transforming concrete thinkers, whereas the number of students functioning as abstract thinkers increased by 28% and concrete thinkers decreased by 50% in active-learning classrooms. The study suggests, therefore, that reasoning capacity is affected by how students learn science content.





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[1] Felder and Brent, 2005, *J. Engineer. Ed.*, 94(1): 57-72

[2] McConnell et al, 2005, *J. Geosci. Ed.*, 54(3): 462-470

Lessons in Learning from Gateway STEM Courses

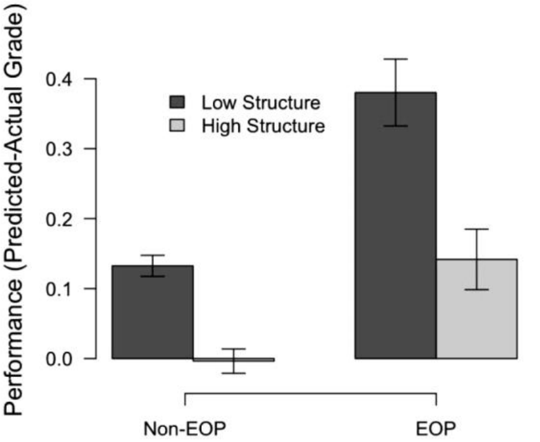
An Example from Biology

For more than 30 years, policy makers and professional organizations have been calling for an increase in the number of underrepresented minority groups within the STEM disciplines. Nonetheless, even when successfully recruiting minority students into the undergraduate gateway STEM courses, achievement gaps remain large and these students have lower persistence rates, especially when also identified as first-generation-to-college and from low-income families. Many universities respond with interventions that enhance tutoring, mentoring, research, and financial-aid opportunities for targeted students. Although these programs point to short-term successes, they have largely relied on external funds and are rarely sustained.

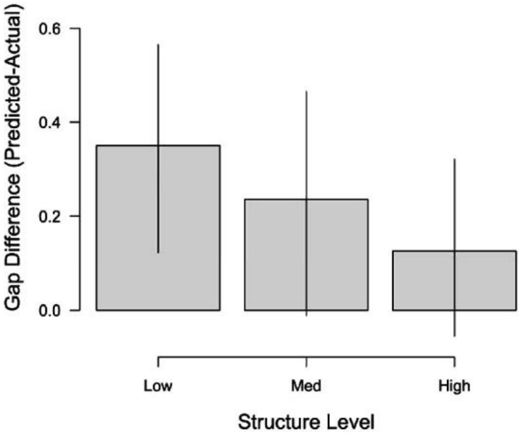
The University of Washington encouraged more sustainable approaches to diminish the achievement gap. The Biology Department examined the impact of instructional strategies in the gateway course for majors[1]. Faculty identified 3 course structures: *Low*: Emphasis on lecturing; inclusion of questions with answers solicited from students who voluntarily raised their hands or responded using clickers; occasional use of ungraded think-pair-share questions, minute papers, or question sets completed by informal groups. *Medium*: Lectures supplemented with daily graded clicker questions that elicited interactivity through peer instruction; weekly peer-graded short-answer questions completed and graded with a strict time limit. *High*: "Lecture-free" with the elements of medium-structure classes plus weekly class note summaries; reading quizzes testing understanding of basic vocabulary and concepts prior to each class; daily in-class questions addressed to groups.

The biology researchers assessed the impact of these classroom structures by using previous analyses showing that a student's course grade could be predicted from SAT-Verbal score and college GPA at the time of course enrollment. The impact on the achievement gap was assessed by separately tracking students in the university's Educational Opportunity Program (EOP); EOP participants are from educationally or economically disadvantaged backgrounds and most are first generation to college. About 76% of EOP students are from under-represented minorities, and the majors-Biology course typically includes 15-20% EOP students.

The first graph at right shows how high-structured course experiences improved grade achievement, relative to predicted grade, for both EOP and non-EOP students. The vertical scale is the difference of predicted and actual grade on a 4-point scale. Differences in predicted and actual grade ("performance" on the graph) between EOP and non-EOP students indicates an achievement gap related to course attributes rather than preparation measured by SAT or GPA. This gap is smaller in the high structure course and the overall performance of EOP students relative to the prediction in the high-structured courses matches the achievement for non-EOP students in the low-structured courses, i.e., the larger achievement gap in the low-structure courses primarily relates to the course structure not to EOP-student ability.



The second graph shows the impact of course structures implemented by a single instructor. In this case, the vertical scale shows the achievement gap between EOP and non-EOP students. In the low-structured classes, however, this gap is about 1/3rd of a grade whereas in the high-structured classes this disparity is minimal (bars are 95% confidence intervals).



The study shows, therefore, that replacing lecture with active, student engagement in learning improves overall course performance regardless of preparation and diminishes achievement gaps through incorporation of more inclusive pedagogy.

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[1] Haak et al., 2011, *Science* 332:1213-1216

Lessons in Learning from Gateway STEM Courses

An Example from Mathematics

Universities across the country have been paying increased attention to improving student outcomes in mathematics. Decreased levels of student preparation for college-level mathematics have negatively impacted development of quantitative skills and progress into mathematically rigorous disciplines, such as the STEM fields. Black Hills State University addressed this problem through a systematic, assessment-driven course redesign of College Algebra[1].

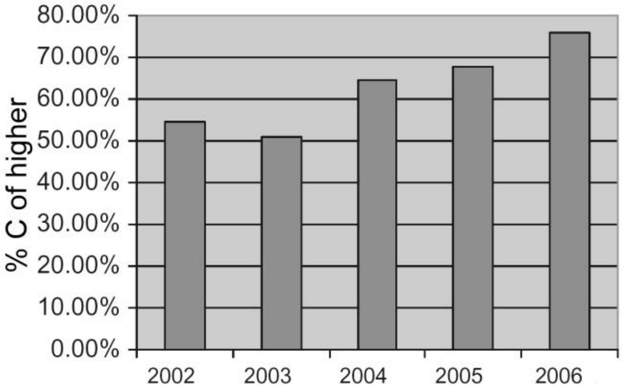
The Black Hills State faculty started with surveys of faculty and students that identified two problems: First, calculus instructors felt that a major reason for failure in calculus was a lack of understanding of algebraic and trigonometric processes. Many of the calculus students were able to complete problems only when the steps involving algebraic or trigonometric prior knowledge were isolated. Therefore, one project goal was to assure that students understood the processes of algebra to the point of automaticity if they were going to become more effective problem solvers in subsequent classes. Second, surveys of students showed low self-efficacy — self-judgment of one's capabilities to organize and execute the courses of action required to attain designated performance. Successes build self-efficacy and failures undermine it. However, if success is too easily attained, then students do not learn that sustained effort is necessary to overcome the difficulties that they may encounter later. Therefore, the project emphasized a component of mastery learning where students learn that they can struggle, and then organize and execute plans to succeed. The hypothesis was that if students do not learn that they can succeed when they are challenged, then they might change their major if they do not think that they can succeed in subsequent math and quantitative science courses.

The college-algebra faculty systematically and incrementally implemented and assessed each intervention in steps. They started with incorporating a computer-based mastery-learning program where students did self-paced, online homework and spent one class period in a computer lab with the instructor to get assistance on the most challenging topics. Other class periods were reconstituted to progressively replace most lectures with modules on the historical development of concepts, whole-class discussions, and cooperative problem solving activities with an emphasis on relevant applications. Rather than presenting lectures, instructors tracked their time answering questions, modeling the processes for solving a problem, discussing with students the theoretical aspects of math within an historical, human-interest perspective, applying mathematics to potential applications, and discussing the relevancy of mathematics to other disciplines and the real world.

The project progressed in an iterative process of changes, assessment of learning and self efficacy, consultation of the research literature on learning for guidance, and a process of adjusting in the face of what these efforts revealed. Throughout the process, the faculty focused on why students needed college algebra. To be successful in other courses outside of the department, students needed to understand both the concepts (i.e., solving equations, statistical analysis procedures, and logarithmic and exponential functions) and the processes (i.e., modeling, problem-solving, communication, and analysis) of college algebra.

Over the 5 years of incremental implementation and improvement, the passing rate (C or higher) rose from 54% to 75%, there was a 300% increase in enrollment in the next mathematics course (trigonometry), a 25% improvement in attendance, and a statistically significant increase in competency as measured by a nationally normed proficiency test. Surveys implied that improved attendance and progress to additional math classes was a consequence of improved self-efficacy resulting from mastery-learning strategies and an emphasis on the relevance of learning mathematics at the deep, conceptual level rather than memorizing problem-solving steps.

As the graph below shows, these changes were not instantaneous. The greatest gains were achieved after all components were deliberately set in motion, assessed and revised. There was also a "learning curve" for the faculty to most effectively implement and integrate all components of the new curriculum and pedagogy.



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[1] Hagerty et al., 2010, *Primus*, 20(5): 418–437

Teachable Unit Guide

STEM GATEWAY

Project for Inclusive
Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

Building a Teachable Unit

The term "teachable unit" is borrowed from work in the instructional design of college science courses by Jo Handelsman and colleagues at the University of Wisconsin. A teachable unit contains the instructional materials that enclose the activities, assignments, and assessments intended to achieve learner mastery of an essential concept (or a course-level learning outcome). A teachable unit may be a plan for one class period, one week, or some other part of the whole course. The teachable unit (a) is built backwards from assessable outcomes, (b) incorporates evidence-based and research-informed pedagogical strategies, and (c) facilitates dissemination of the curriculum design by containing all of the information that *another instructor* would need to teach the unit in order to. An effectively designed (redesigned) course consists of a collection of teachable units.

Define the Teachable Unit

1. Give the teachable unit a title that reflects the essential course concept (or course outcome):

2. How long will it take to complete the unit (e.g., number of class periods, days...)?

State the Student Learning Outcomes of the Teachable Unit *(What should students learn?)*

3. What is(are) the essential learning outcome(s) for the *unit*? How do these outcomes connect to (or scaffold to) one or more learning outcomes for the *course*?

Teachable Unit Outcome	*Related Course Outcome (number)*
A.	
B.	
C.	
D.	
E.	
F.	

Before moving on: "Bloom" each unit-level outcome and related course-level outcome on your Bloom poster.

The Implications of Learners' Prior Knowledge

4. What previous experiences do students have with the content, methods, analysis, etc. that you wish to include in this unit? Be sure to consider these experiences, which you anticipate from previous courses or earlier in the current course, as jumping-off points when you design the unit (start where the learner is situated.

5. What are the students' bottlenecks to learning this content and outcomes? In other words (if you've had experience teaching this material), what do students repeatedly fail to learn and/or what misconceptions are difficult to change? Keep these bottlenecks in mind for special consideration as you design learning activities.

Developing Questions for Peer Instruction with Clickers*

Research shows student grades, accomplishment of learning outcomes, and interest in subject matter all increase when clickers are effectively used, especially in large lecture classes (Center for Effective Teaching). Peer instruction with clickers is one of the most accessible ways of transforming a lecture presentation into an interactive presentation instruction and provides immediate feedback to the instructor on whether or not students are understanding the material.

In the space below, develop at least **3** peer-instruction questions. For each question include 3-5 potential answers. Well written questions and answer options should be: 1) clear, 2) connect to the content and learning outcomes of the class, 3) be of the appropriate difficulty, and 4) stimulate thoughtful discussion among students because the question (and distractor answers) address common misunderstandings, misconceptions, and errors so that 30-70% of initial answers are incorrect (Peter Newbury, Center for Teaching Development, University of California, San Diego).

1.

2.

3.

*Even if not using peer instruction, these questions can be used for think-pair-share and other interactive learning approaches.

Constructing the Learning Activity Sequence *(How should students learn?)*

__Pre-class__: Actively and constructively preparing students individually for classroom learning

__In-Class:__ Interactive learning (with or without lecture); a collaborative classroom learning experience that substantially does not duplicate pre-class learning and takes advantage of peer and instructor influences on learning

__Post-class (post-unit):__ Actively and constructively monitoring and elaborating learning

In-Class Learning. What must students do during class time in order to accomplish the outcomes of the unit?

6. Consider this questionnaire before digging into the details:

What proportion of class time will be allocated for lecture?	
Will peer instruction, think-pair-share, write-pair-share, etc. be used during lecture?	
What proportion of class time will be allocated for constructive learning activities?	
What proportion of class time will be allocated for interactive learning activities?	
What is the highest intended level of cognitive processing (Bloom's taxonomy) for in-class activities?	
Will the instructor explore students' existing knowledge?	

7. List and briefly explain what students will experience in class and connect it to the learning objective of the experience; *be sure that these objectives link to the unit and course outcomes*. Remember that class time is an opportunity to focus on *interactive learning* with judicious use of instructor explanation (Provide the *ICAP* identity for each experience).

   Place these activities and experiences in chronological order *or* number them after you list them to show the intended sequence. Each experience (middle column) should have a clear objective (left column) that forms part of a pathway to meeting the learning outcomes (#3). If your teachable unit is longer than one class day, be sure to indicate which activities and experiences belong to each day of class.

What students need to learn, and …	***… the experience where they will learn it.***	***I, C, A, or P***

In-Class Learning (continued)

What students need to learn, and …	*… the experience where they will learn it.*	*I, C, A, or P*

Before moving on: "Bloom" each activity on your Bloom poster.

Pre-Class Learning Assignment. What do students need to know or do *before* coming to class in order to achieve the expectations you have for class time each day; i.e., *what do students need to do to individually activate learning prior to class?*

8. Consider this questionnaire before digging into the details:

What, if anything, will students do before class?	
How much time do we expect the “typical” student to spend on pre-class preparation?	
Will we guide the pre-class work (e.g., expected learning outcomes, guiding questions, muddy-point question)?	
How, if at all, will pre-class learning be assessed?	
What is the highest intended ICAP level for pre-class activities?	
What is the highest intended level of cognitive processing (Bloom’s taxonomy) for pre-class activities?	
Will the instructor explore students’ existing knowledge?	
Will the instructor use information about students’ pre-class learning during in-class instruction?	

9. Each experience (middle column) should have a clear objective (left column) that prepares students for in-class learning (#7). Remember that pre-class learning will be better retained if it includes more than passive engagement with text or media (Provide the *ICAP* identity for each experience).

   If your teachable unit encloses more than one-day of class, be sure to break down this list for each day to assure preparation for the upcoming day of in-class learning. For each assignment component (e.g., reading, video, simulation) write the guiding questions that will provide the roadmap for student achievement.

What students need to learn, and …	***… the experience where they will learn it.***	***I, C, A, or P***

10. Pre-Class Learning Accountability. How will you hold students accountable for pre-class learning that is necessary for successful in-class learning? Briefly explain your strategy here and then go back to items 7 and 9 and be sure that you have included these accountability plans in your unit design.

Post-Unit (Class) Learning. What do students need to do outside of class after the unit (or at key points within a long unit) in order to solidify their learning?

11. Consider this questionnaire before digging into the details:

Will there be post-class assignments?	
How much time do we expect the "typical" student to spend on post-class assignments?	
Will students receive feedback on their post-class learning?	
How, if at all, will post-class learning be assessed?	
What is the highest intended ICAP level for post-class activities?	
What is the highest intended level of cognitive processing (Bloom's taxonomy) for post-class activities?	
Will the instructor use information about students' post-class learning during in-class instruction?	

12. What do you plan to assign students to do (middle column) and how will each learning outcome (#3) be included (left column)? Remember that post-class learning will be better retained if it includes more than passive engagement with text, media, or notes (Provide the *ICAP* identity for each experience).

What students need to learn, and …	***… the experience where they will learn it.***	***I, C, A, or P***

Assessing Student Learning Achievement ***(How will we know that students learned?)***

Each learning outcome for the unit should be *formatively* assessed at least once and also *summatively* assessed.

13. Formative Assessment. For each lettered teachable unit outcome (left column), describe (middle column) the formative assessment tools (e.g., clicker question, in-class assignment response, reflective writing, low-stakes quiz) for checking knowledge gain and where in the learning activity sequence each formative assessment will occur (right column)

Teachable Unit Outcome	***Formative Assessment Tool***	***Pre-, In, Post-Class?***
A.		
B.		
C.		
D.		
E.		
F.		

14. Summative Assessment. For each lettered teachable unit outcome (left column), describe (middle column) the summative assessment tools (e.g., exam question, project rubric, report rubric) for checking knowledge gain, and how that assessment will also, if applicable, assess course-level outcomes (right column)

    Although only course-level outcomes technically need to be summatively assessed it is usually beneficial for guiding student studying for high-stakes exams and preparation of other high-stakes reports, if they see the scaffolding steps of the unit-level outcomes within their assessments. You can also work this table backwards by including the summative assessment tool for a course-level outcome and then determining how it simultaneously assesses one or more unit-level outcomes.

Teachable Unit Outcome	***Summative Assessment Tool***	***Also assesses course-level outcome? Which one?***
A.		
B.		
C.		
D.		
E.		
F.		

Before moving on: "Bloom" each formative and summative assessment on your Bloom poster.

Alignment

Are all of the ...
... learning outcomes,
... learning experiences, and
... assessments *aligned*?!!

15. The first way to check alignment is to be sure that you have included learning activities, formative assessments, and summative assessments for each teachable-unit learning outcome. Fill out the table below by utilizing (i.e., copying/pasting) your previous responses. *This table will serve as a summary, at-a-glance view (teaching plan) of the components of your teachable unit.*

Teachable Unit Learning Outcome	Learning Activities	Assessment of Learning
A.	Pre-class: In-class: Post-class	Formative: Summative:

Teachable Unit Learning Outcome	Learning Activities	Assessment of Learning
B.	Pre-class: In-class: Post-class	Formative: Summative:
C.	Pre-class: In-class: Post-class	Formative: Summative:

Teachable Unit Learning Outcome	Learning Activities	Assessment of Learning
D.	Pre-class: In-class: Post-class	Formative: Summative:
E.	Pre-class: In-class: Post-class	Formative: Summative:
F.		

16. Look at your Bloom's Taxonomy Poster and answer these questions. If any answer is "no", make a note for how you can adjust the teachable unit in order to better align the levels of thinking and types of knowledge that will be constructed.

	Yes	No	How to adjust
Are the teachable-unit learning outcomes at the same level as the related course learning outcome(s), or are the teachable-unit learning outcomes an appropriate, scaffolded path toward eventual achievement of the related course learning outcome(s)?			
Do the learning activities (pre-, in-, post-class) include the same levels of thinking and type of knowledge as the intended teachable-unit learning outcomes?			
Do the formative assessments include the same levels of thinking and type of knowledge as the intended teachable-unit learning outcomes?			
Do the summative assessments include the same levels of thinking and type of knowledge as the intended teachable-unit learning outcomes?			
Do the summative assessments match the levels of thinking and type of knowledge that students have experienced through learning activities and formative assessment?			

Evaluating the Teachable Unit

Apply the” Review Rubric for Teachable Units” (from Handelsman et al., *Scientific Teaching*) to rate your teachable unit and identify possible changes that would improve the rating.

Criterion	Comprehensive	Intermediate	Cursory/ Absent	Changes
Learning Goals and Outcomes	☐	☐	☐	
Active Learning	☐	☐	☐	
Assessment	☐	☐	☐	
Diversity	☐	☐	☐	
Alignment	☐	☐	☐	
Teaching Plan	☐	☐	☐	

STEM GATEWAY

http://unmstemgateway.blogspot.com/p/welcome.html

Seven Principles for Good Practice in Undergraduate Education

(excerpt from, Seven Principles for Good Practice in Undergraduate Education, by Arthur W. Chickering and Zelda F. Gamson *AAHE Bulletin,* Mar 1987)

Good practice in undergraduate education:

1. **Encourages Contact Between Students and Faculty** Frequent student-faculty contact in and out of classes is the most important factor in student motivation and involvement. Faculty concern helps students get through rough times and keep on working. Knowing a few faculty members well enhances students' intellectual commitment and encourages them to think about their own values and future plans.
2. **Develops Reciprocity and Cooperation Among Students** Learning is enhanced when it is more like a team effort than a solo race. Good learning, like good work, is collaborative and social, not competitive and isolated. Working with others often increases involvement in learning. Sharing one's own ideas and responding to others' reactions sharpens thinking and deepens understanding.
3. **Encourages Active Learning** Learning is not a spectator sport. Students do not learn much just by sitting in classes listening to teachers, memorizing pre-packaged assignments, and spitting out answers. They must talk about what they are learning, write about it, relate it to past experiences and apply it to their daily lives. They must make what they learn part of themselves.
4. **Gives Prompt Feedback** Knowing what you know and don't know focuses learning. Students need appropriate feedback on performance to benefit from courses. When getting started, students need help in assessing existing knowledge and competence. In classes, students need frequent opportunities to perform and receive suggestions for improvement. At various points during college, and at the end, students need chances to reflect on what they have learned, what they still need to know, and how to assess themselves.
5. **Emphasizes Time on Task** Time plus energy equals learning. There is no substitute for time on task. Learning to use one's time well is critical for students and professionals alike. Students need help in learning effective time management. Allocating realistic amounts of time means effective learning for students and effective teaching for faculty. How an institution defines time expectations for students, faculty, administrators, and other professional staff can establish the basis of high performance for all.
6. **Communicates High Expectations** Expect more and you will get more. High expectations are important for everyone -- for the poorly prepared, for those unwilling to exert themselves, and for the bright and well-motivated. Expecting students to perform well becomes a self-fulfilling prophecy when teachers and institutions hold high expectations for themselves and make extra efforts.
7. **Respects Diverse Talents and Ways of Learning** There are many roads to learning. People bring different talents and styles of learning to college. Brilliant students in the seminar room may be all thumbs in the lab or art studio. Students rich in hands-on experience may not do so well with theory. Students need the opportunity to show their talents and learn in ways that work for them. Then they can be pushed to learn in new ways that do not come so easily.

STEM Gateway
Course Redesign Teaching Professional Development Program:

Teaching that Supports Diverse Learners

- What is *inclusive pedagogy*?
- How can we easily adjust instruction to embrace diverse learner experiences and approaches to learning that improve student success?
- What do the data show about culture-based differences in learning and about instruction that reduces achievement gaps?

STEM GATEWAY

Project for Inclusive Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

Teaching that Supports Diverse Learners

Gary Smith and Audriana Stark
June 2015

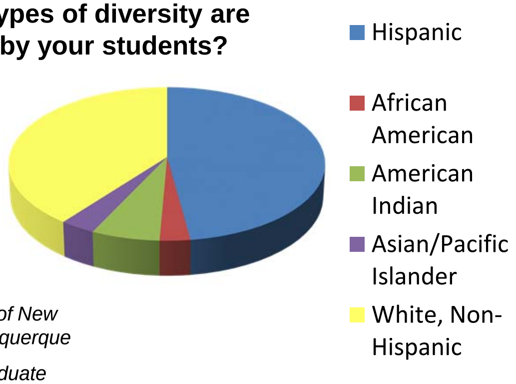
Outcomes:

You will be able to:

1. Describe some of the demographic/socioeconomic characteristics of UNM students that impact teaching and learning.
2. Evaluate yourself and your course in terms of cultural constructs of teaching and learning
    a) Describe the cultural constructs of teaching and learning
    b) Plot your teaching approach, course, and students on the cultural constructs spectrum.
    c) Determine ways of adjusting instruction across the spectrum and for helping students to “swing” across the spectrum.
3. Evaluate your classroom climate
    a) Self-assess the inclusiveness of your course
    b) List ways to make the course more inclusive

What are the implications of cultural and ethnic diversity for how you teach your course?

What other types of diversity are represented by your students?



University of New Mexico-Albuquerque

Undergraduate enrollment, Fall 2013

STEM Gateway research shows that some populations are less likely to persist in STEM majors at UNM

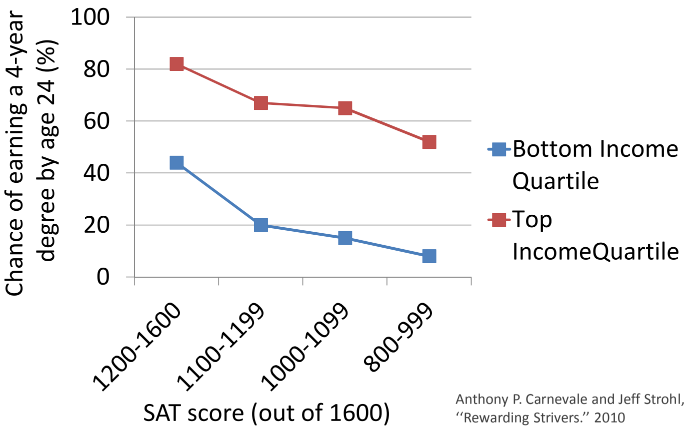
1503 first-time full-time freshmen entered UNM in the fall semesters of 2005, 2006, and 2007 with the intention of completing a STEM degree

Hispanic STEM students are 0.65 times as likely to graduate with STEM degrees than non-Hispanic students

Female STEM students are 1.36 times as likely to switch majors out of STEM than male students. (And, incoming freshmen women are only about half as likely as men to be interested in pursuing STEM)

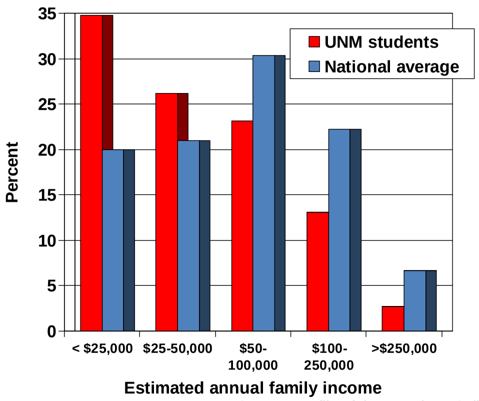
STEM GATEWAY ***Research***

Socioeconomic status matters more than SAT/ACT score for determining student persistence to graduation.



Anthony P. Carnevale and Jeff Strohl, ''Rewarding Strivers.'' 2010

UNM students are, compared to the national college-student population, more likely to be financially under-resourced



Source: Profile of the American College Student, 2008; UNM-OIR

New Mexico ranks 42nd in median family income.

37% of UNM undergraduates received Pell Grants in Fall 2009 (more than any other public flagship university, which average ~20%)

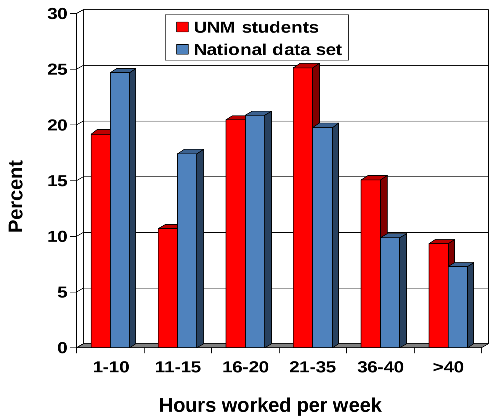
Socioeconomic status affects STEM degree completion at UNM

Pell-Eligible STEM students are 1.43 times as likely to stop attending UNM and are .46 times as likely to graduate than non-Pell-eligible students.

First Generation STEM students are 1.62 times as likely to stop attending UNM and are .42 times as likely to graduate than non-First Generation students.

Research

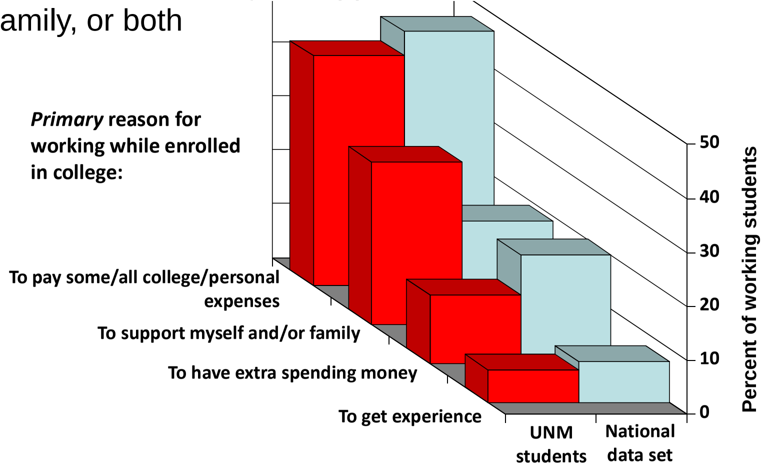
UNM students work more hours (primarily off campus) than the average US college student



Source: Profile of the American College Student, 2008

UNM students are more likely than their national peers to be working to support themselves, their family, or both

Primary **reason for working while enrolled in college:**

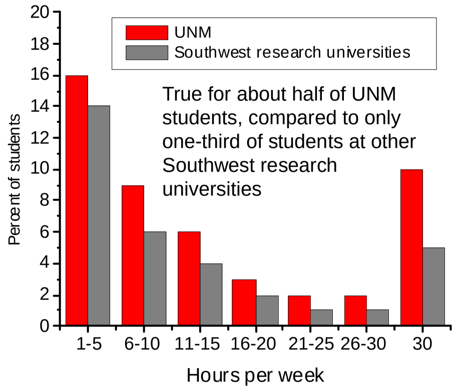


Source: Profile of the American College Student, 2008

UNM students are more likely to be care givers in their families

About 40% of UNM freshmen and 50% of seniors provide care to parents, children, and /or siblings (16% of seniors commit >30 hrs/wk to this obligation).

Providing care for dependents living with you (parents, children, spouse, etc.)



True for about half of UNM students, compared to only one-third of students at other Southwest research universities

Source: 2009 NSSE

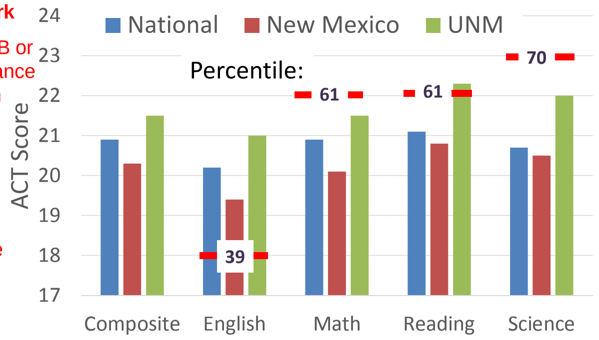
UNM student preparation compares well with national data (based on ACT scores) …

… but student preparation for science and math courses lags other fields

ACT Benchmark

50% chance of B or higher; 75% chance of C or higher in entry level:

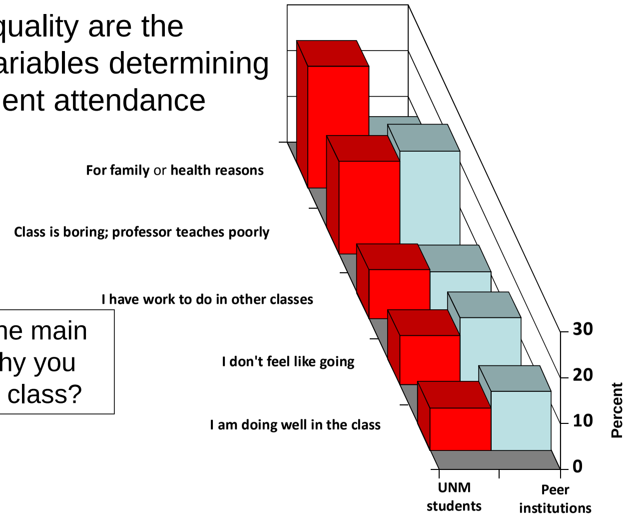
- English Composition
- Algebra
- Social Science
- Biology



Source: ACT, 2013, The Condition of College and Career Readiness, 2013

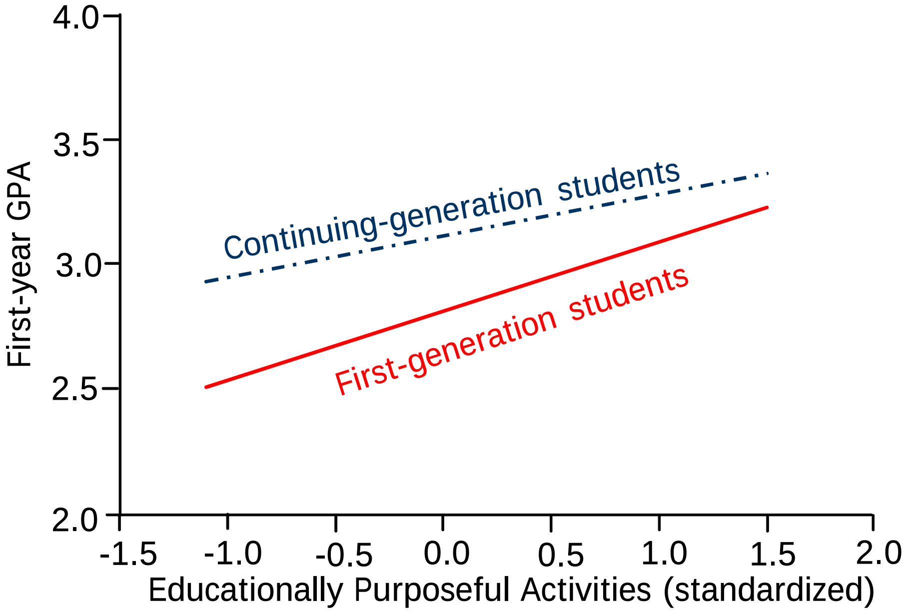
Personal concerns and teaching quality are the primary variables determining UNM student attendance

What is the main reason why you miss/skip class?



Source: Profile of the American College Student, 2008

UNM’s first-generation students benefit disproportionately from engaging pedagogy



A combined score of 19 NSSE response items that include
a number of best practices in undergraduate education

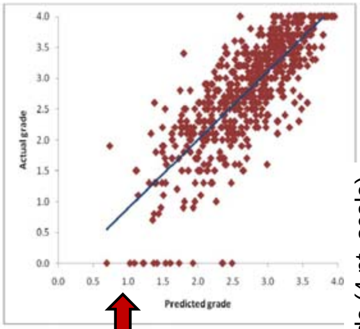
UNM Data – National Survey of Student Engagement

Approximately 44% of UNM undergraduates are first-generation college students; at least 25% are first in their family to attend college.

Educationally Purposeful Activities:

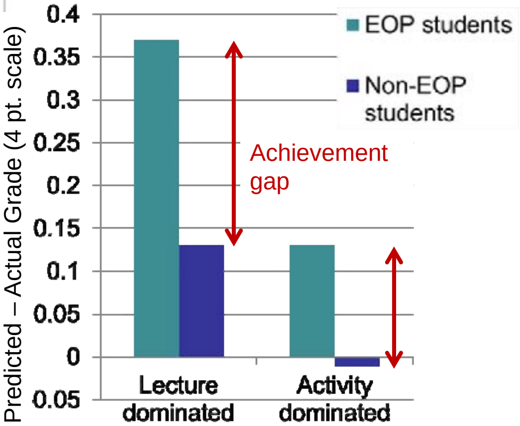
- ✓ Asked questions in class or contributed to class discussions
- ✓ Made a class presentation
- ✓ Prepared two or more drafts of a paper or assignment before turning it in
- ✓ Come to class unprepared (reverse coded)
- ✓ Worked with other students on projects DURING CLASS
- ✓ Worked with classmates OUTSIDE OF CLASS to prepare class assignments
- ✓ Tutored or taught other students (paid or voluntary)
- ✓ Participated in a community-based project (e.g., service learning) as part of a regular course
- ✓ Used an electronic medium (listserv, chat group, Internet, instant messaging, etc.) to discuss or complete an assignment
- ✓ Used e-mail to communicate with an instructor
- ✓ Discussed grades or assignments with an instructor
- ✓ Talked about career plans with a faculty member or advisor
- ✓ Discussed ideas from your readings or classes with faculty members outside of class
- ✓ Received prompt written or oral feedback from faculty on your academic performance
- ✓ Worked harder than you thought you could to meet an instructor's standards or expectations
- ✓ Worked with faculty members on activities other than coursework (committees, orientation, student life activities, etc.)
- ✓ Discussed ideas from your readings or classes with others outside of class (students, family members, co-workers, etc.)
- ✓ Had serious conversations with students of a different race or ethnicity than your own
- ✓ Had serious conversations with students who are very different from you in terms of their religious beliefs, political opinions, or personal values

Active learning increases student learning and decreases achievement gap



Regression of all students' incoming GPA and SAT verbal score predicts course grade

Educational Opportunity Program (EOP) students are from educationally or economically disadvantaged backgrounds; most are first generation to college; 76% are from under-represented minorities



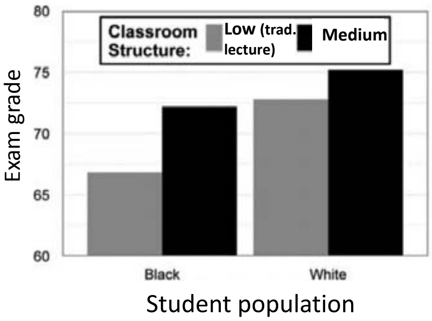
Instructional format (same instructor) affects actual learning

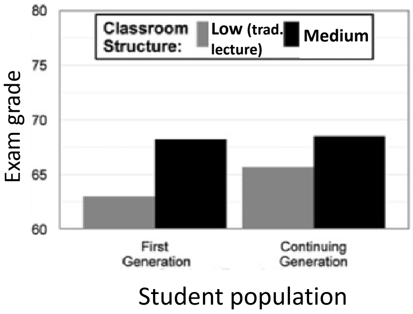
Haak et al., Increased structure and active learning reduce the achievement gap in introductory biology, *Science*, June 3, 2011

Active learning increases student learning and decreases achievement gap

	Graded preparatory assignments (example: reading quiz)	Student in-class engagement (example: clicker questions, worksheets, case studies)	Graded review assignments (example: practice exam problems)
▩ Low (traditional lecture)	None or <1 per week	Talk <15% of course time	None or <1 per week
■ Moderate	Optional[a]: 1 per week	Talk 15–40% of course time	Optional[a]: 1 per week
High	≥1 per week	Talk >40% of course time	≥1 per week

[a]Need either a preparatory or review assignment once per week, but not both.





Eddy et al., Getting Under the Hood: How and for Whom Does Increasing Course Structure Work?, *CBE-Life Sci. Ed.*, Fall 2014

HOW DO YOU ENTER THE LEARNING PROCESS?
WHERE DO YOU FALL IN THIS TABLE?

Ways of knowing, sources of knowledge, styles of learning, roles of teacher and learner and other aspects of the learning process vary among people and, in part, relate to life experiences and cultural context and identity of the learner. For each of the rows in this table, mark an X where you think you fall. Notice, this isn't "black and white", so you may decide your preference for some items lies somewhere between the two extremes. That's normal! Just mark an X using the two sides of the central column as the ends of the spectrum and note where you are within this spectrum. *Then*, mark an 'O' where your experiences of how STEM-gateway courses are taught fall on the spectrum in each applicable row.

Cultural Constructs of Teaching and Learning		
Individuated In a culturally individuated worldview or epistemology, a compartmentalized, private, contextually independent conception of the world is common, assumed, and valued.	⟷	**Integrated** In a culturally integrated worldview or epistemology, an interconnected, mutual, contextually dependent conception of the world is common, assumed, and valued.
Knowledge, individual competence	**Purpose**	Wisdom, betterment of the lives of those with whom we are connected
Mind	**Ways of Knowing / Taking in information**	Mind, Body, Spirit/Intuition, emotions, through relationships
Verbal/linguistic, logical, mathematical, spatial	**Ways of Making Sense / Leaning styles ' processing information and knowledge**	Visual, intuitive/spiritual, natural interpersonal, intrapersonal, body/kinesthetic, musical/rhythmic
Compartmentalized and separate; belief that understanding how the parts work separately, abstractly, and in isolation will lead to the greatest understanding	**Interconnectedness of what is being learned**	Contextualized and connected, belief that understanding how things affect each other within the whole, pragmatically, and within community will lead to understanding
Learning is a private, individual activity. Responsible for one's own learning, personal space is private	**Space/Privacy/Responsibility**	Learning is a collective, shared activity. Responsible for one's own and others' learning, personal space is shared
Unconscious of cultural traits related to teaching and learning	**Cultural Consciousness**	Conscious of cultural traits related to teaching and learning
Linear, task oriented, can be measured and used, to be on time shows respect	**Time**	Circular/seasonal, process oriented, dependent on relationships, awareness and context; to allow for enough time shows respect
Provider and evaluator of knowledge – a few best perspectives and ways of learning, predetermined/bounded	**Role of teacher / control**	Facilitator of learning experience – multiple perspectives and ways of learning; emergent / constructivist
Primarily between teacher and students, primarily rely on explicit verbal messages	**Interactions and Communications**	Involving a wide variety of interactions between students and between teacher and students; High use of nonverbal and multiple streams of communication
Based on the work of Alicia Chavez ,UNM, (Chávez, Ke & Herrera,2009) adapted from Burton (2009); Cajete (1994); Chávez (2008); Guido-DiBrito and Chávez; Ibarra (2001); and Rendón (2009)		

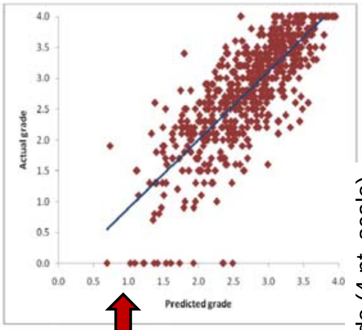
THE CLASSROOM CLIMATE

Choices in how to organize class time, design learning experiences, and assess learning range widely among instructors but typically vary little for a single instructor. But classes consist of students who bring diverse backgrounds, capabilities, and traditions of learning that may not be wholly compatible with the narrow range of instructional choices used by a teacher. How teachers intend learning to occur and how that learning is assessed can be viewed as being more or less inclusive of different types of students and more or less accessible for all learners, while also minimizing or maximizing the opportunities for students to learn from their diverse peers. For each of the rows in this table, mark an X where you think you plot on the inclusivity spectrum.

Less Inclusive	⟷	**More Inclusive**
Lectures primarily use verbal explanation along with writing on board or text-rich PowerPoint.		Lectures include a mixture of visual representation of data, images, and/or pictures along with verbal explanation and text.
Students apply concepts through individually completed homework.		Students apply concepts collaboratively during in-class assignments.
Instructor uses one type of teaching method (lecture).		Instructor integrates a variety of active learning exercises and assessment tools regularly into class and homework.
Instructor uses one type of exam question format (eg. all multiple-choice).		Exams include multiple question formats.
Grading is done without explanation or a rubric.		Grading schemes are explained and/or graded according to a rubric.
Grades are assigned by curving.		Grades are assigned according to achievement of stated outcomes.
Grades are based mostly on a few individually completed high-stakes exams/assignments.		Grades are based on a variety of learning measures ranging from low-stakes, formative assessments to high-stakes exams/assignments, and work completed both collaboratively and individually
Instructor's questions always have a "right" answer.		Answers to questions have many correct answers, require consensus among the group, or require the class's collective knowledge to be answered.
It is undesirable for students to work together on questions or problems in class; individual work is required.		Substantial class time is provided for students to purposefully work to collaboratively construct answers to questions and problems.

Underrepresented minority students are all grouped together or completely separated.		Groups are ethnically and gender diverse.
Presentations, assignments, and assessments focus on mastery of theory and general principles of the field.		Presentations, assignments, and assessments focus on mastery of practical applications of theory and general principles of the field.
Students are told how to interpret illustrations, data tables, photographs.		Students are provided opportunities to make sense of illustrations, data tables, photographs on their own and/or with others.
Lessons focus on learning from examples and experiences selected by the teacher.		Lessons provide opportunities for students to relate the content to examples and experiences from their lives.
Feedback may not be provided promptly or at all on student work.		Feedback is provided promptly (within a few days at most) on student work.
Narratives of how people (including the instructor and former students) used or developed concepts learned in the course *are not* included in the instruction.		Narratives of how people (including the instructor and former students) used or developed concepts learned in the course *are* included in the instruction.
Scientists in the examples are all men.		Examples include important contributors to science who represent various ethnicities, races, and genders.
Students are “cold called” to answer questions in class.		Students are provided the opportunity to reflect and discuss questions with peers before answering.
The same few students volunteer or are called upon to answer questions in class.		A safe environment is provided for requesting and encouraging answers and contributions from all students.
Many of the analogies are drawn from limited subject areas such as sports-, military-, or construction-related.		A broad range of analogies are used.
Adapted from Handelsman, Miller, and Pfund, 2007, Scientific Teaching; Sanchez, I., 2000, Motivating and Maximizing Learning in Minority Classrooms; Wodkowski and Ginsberg, 2003, Diversity and Motivation: Culturally Responsive Teaching.		

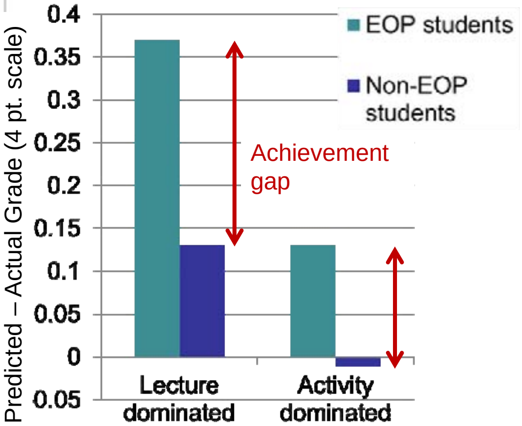
Active learning increases student learning and decreases achievement gap



Regression of all students' incoming GPA and SAT verbal score predicts course grade

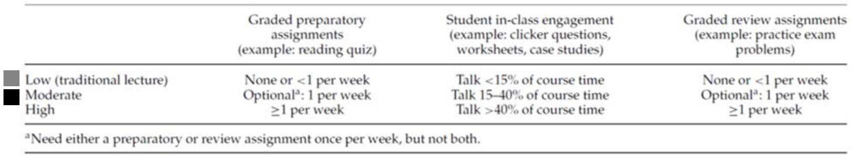
Educational Opportunity Program (EOP) students are from educationally or economically disadvantaged backgrounds; most are first generation to college; 76% are from under-represented minorities

Instructional format (same instructor) affects actual learning



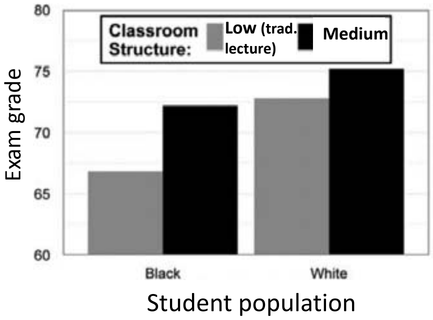
Haak et al., Increased structure and active learning reduce the achievement gap in introductory biology, *Science*, June 3, 2011

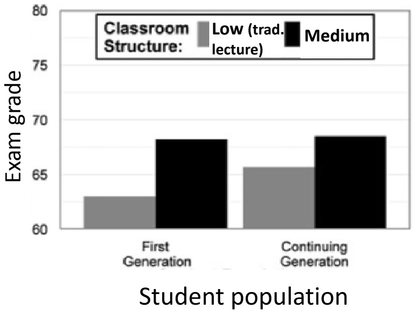
Active learning increases student learning and decreases achievement gap



	Graded preparatory assignments (example: reading quiz)	Student in-class engagement (example: clicker questions, worksheets, case studies)	Graded review assignments (example: practice exam problems)
▨ Low (traditional lecture)	None or <1 per week	Talk <15% of course time	None or <1 per week
■ Moderate	Optional[a]: 1 per week	Talk 15–40% of course time	Optional[a]: 1 per week
High	≥1 per week	Talk >40% of course time	≥1 per week

[a]Need either a preparatory or review assignment once per week, but not both.





Eddy et al., Getting Under the Hood: How and for Whom Does Increasing Course Structure Work?, *CBE-Life Sci. Ed.*, Fall 2014

STEM Gateway
Course Redesign Teaching Professional Development Program:

Building Learning-to-Learn Habits of Mind into your Curriculum

- Do your students know how to develop competency in your course?
- How can you develop exercises and activities that improve your students’ metacognition and reasoning abilities to become better learners?

STEM GATEWAY

Project for Inclusive
Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

Building Learning to Learn Habits of Mind into Your Curriculum

Gary Smith and Audriana Stark

Outcomes:

You will be able to:

- Use evidence to support why students may struggle to demonstrate their learning in your course
- Describe an assignment for helping your students learn about learning
- Integrate a learning-to-learn strategy with existing course content into one or more "teachable units"

"From my experiences in my first year in college, we all have difficulties learning how to properly learn." - UNM Student

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Do you know what approaches to studying are most effective for learning?

Activity

Learning approach	Effectiveness for learning – *(High, Medium, Low)*
Self-explanation	
Summarization	
Highlighting/underlining	
Rereading	
Practice testing	
Distributed practice	

Do you know what approaches to studying are most effective for learning?

Calculate your score:

- For each category that you matched exactly: 2 pts.
- For each category that you chose the adjacent category: 1 pt.
- For each category that you chose the opposite extreme: 0 pt.

Learning approach	Research result on learning effectiveness
Self-explanation	M
Summarization	L
Highlighting/underlining	L
Rereading	L
Practice testing	H
Distributed practice	H

Dunlosky et al., 2013, *Psychological Science in the Public Interest*, *14*(1), 4–58.

Do your students, and you, know what approaches to studying are most effective for learning?

What do you think are the strategies most used by students?

How can our instructional strategies improve student learning?

Learning approach	Research result on learning effectiveness
Self-explanation	M
Summarization	L
Highlighting/underlining	L
Rereading	L
Practice testing	H
Distributed practice	H

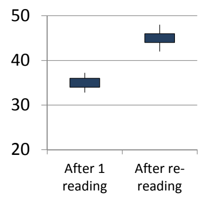
Dunlosky et al., 2013, *Psychological Science in the Public Interest*, *14*(1), 4–58.

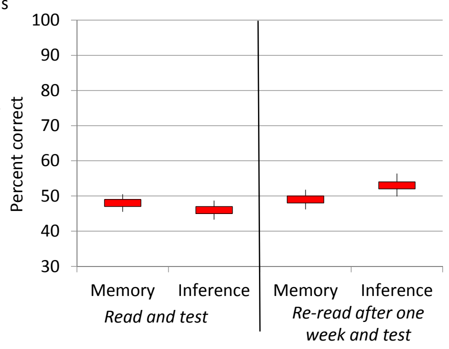
Misconceptions about learning impede student success

Re-reading does not significantly increase learning although students perceive that their learning increases

"How well do you think you will be able to answer test questions over this material?

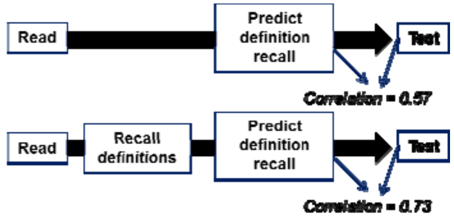
0 (*definitely won't be able*), 20 (*20% sure I will be able*), 40 … , 60 … , 80 … , 100 (*definitely will be able*)."





Dunlosky and Rawson, 2005, Why Does Rereading Improve Metacomprehension Accuracy?...*Discourse Processes*, 40(1): 37–55

Could it be that students lack adequate comprehension of written text or how to learn from text?



Students don't spontaneously self-quiz in order to evaluate their learning and, as a result, are overconfident of learning from text.

(Dunlosky, et al., 2002, in Perfect and Schwartz, eds., *Applied Metacognition*)

Brainstorm

Considering what was presented,
what can you do to improve student learning?

Image at:http://getmespark.com/wp-content/uploads/brainstorming.jpg

“There seemed to be a mystifying universal conspiracy among textbook authors to make certain the material they dealt with never strayed too near the realm of the mildly interesting . . .”

– *A Short History of Nearly Everything,*
Bill Bryson

Do students know what is important when they read technical text?

Faculty, seniors, and freshmen read a 100-sentence genetics research article and were instructed to highlight sentences containing important information.

Faculty *unanimously* agreed that …

… 11 sentences were important

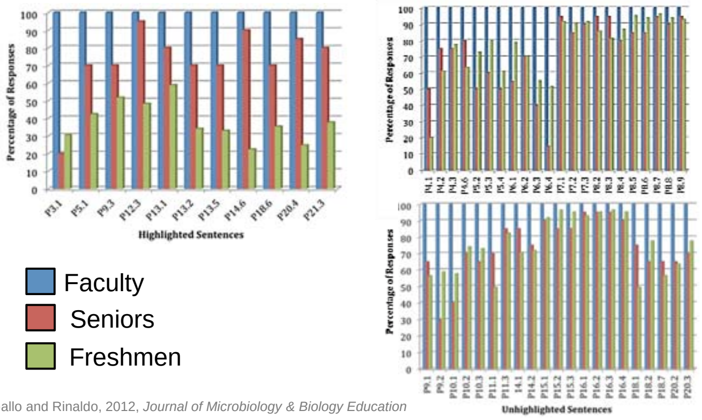
… 43 sentences were unimportant

What did the students think?

Students have difficulty determining what is important when reading

Important sentences

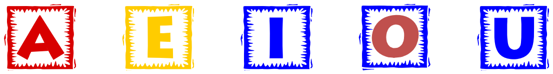
Unimportant sentences



Gallo and Rinaldo, 2012, *Journal of Microbiology & Biology Education*

Preparing the learner enhances use of memory

Count all of the vowels in the words on the next slide in 45 seconds.

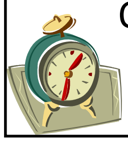


45 seconds

Activity from Saundra McGuire,
Louisiana State University.

Dollar Bill
Dice
Tricycle
Four-leaf Clover
Hand
Six-Pack
Seven-Up
Octopus

Cat Lives
Bowling Pins
Football Team
Dozen Eggs
Unlucky Friday
Valentine's Day
Quarter Hour



45 seconds

How many *words* or *phrases* do you remember?

- **A. 15**
- **B. 10-14**
- **C. 5-9**
- **D. 1-4**
- **E. 0**

Let's look at the words again…

What is the scheme for the order of the items?

Dollar Bill
Dice
Tricycle
Four-leaf Clover
Hand
Six-Pack
Seven-Up
Octopus

Cat Lives
Bowling Pins
Football Team
Dozen Eggs
Unlucky Friday
Valentine's Day
Quarter Hour

Dollar Bill
Dice
Tricycle
Four-leaf Clover
Hand
Six-Pack
Seven-Up
Octopus

Cat Lives
Bowling Pins
Football Team
Dozen Eggs
Unlucky Friday
Valentine's Day
Quarter Hour

45 seconds

NOW, How many *words* or *phrases* do you remember?

- **A. 15**
- **B. 10-14**
- **C. 5-9**
- **D. 1-4**
- **E. 0**

What were two major *differences* between the two attempts?

1. **We knew what the task was**
2. **We knew how the information was organized**

Activity inspired by Saundra McGuire, Louisiana State University

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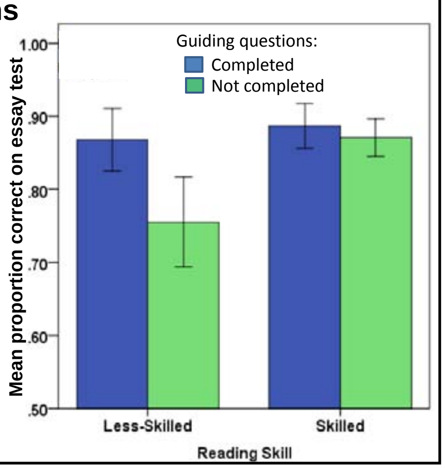
Consider the benefits of providing structured reading assignments and guiding questions



Stiegler-Balfour and Benassi, 2012

Improving Academic Success: Guiding Questions in Advancing Reading Comprehension

http://unh.edu/teaching-excellence/events/SoLConfDocs.html

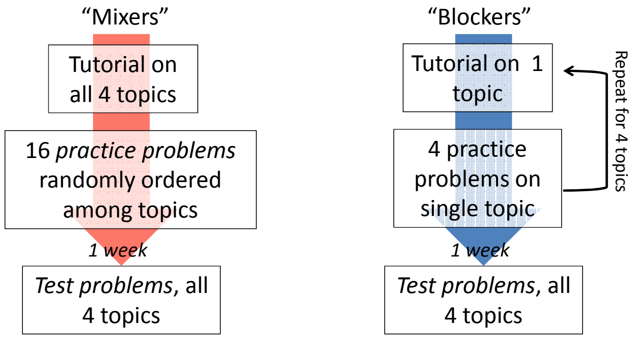
Brainstorm

Considering what was presented,
what can you do to improve student learning?

Long-term learning benefits from interleaving learning topics

Example from mathematics:

Tutorial/Practice/Test on problem types



"Mixers"

Tutorial on all 4 topics

16 *practice problems* randomly ordered among topics

1 week

Test problems, all 4 topics

"Blockers"

Tutorial on 1 topic

4 practice problems on single topic

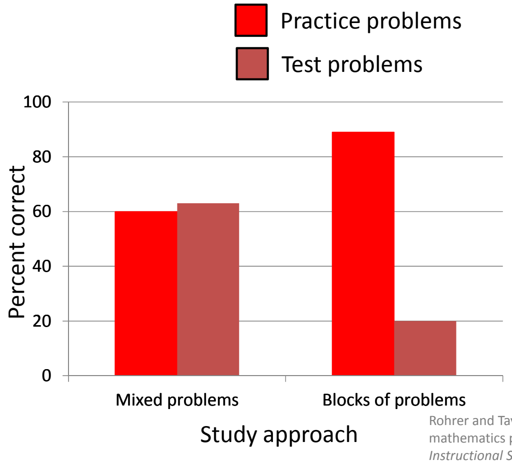
Repeat for 4 topics

1 week

Test problems, all 4 topics

Rohrer and Taylor, 2007, Shuffling of mathematics problems improves learning. *Instructional Science* 35(6): 481-498

Long-term learning benefits from interleaving learning topics



Rohrer and Taylor, 2007, Shuffling of mathematics problems improves learning. *Instructional Science* 35(6): 481-498

Brainstorm

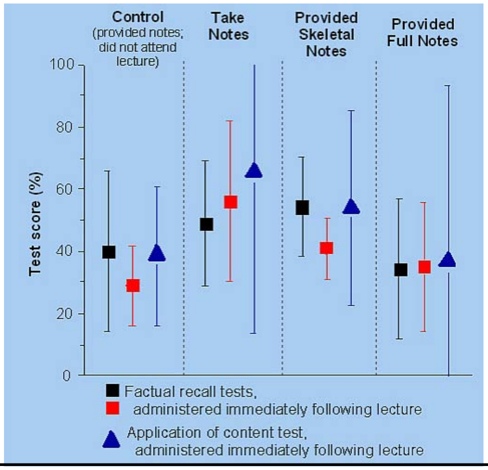
Considering what was presented,
what can you do to improve student learning?

Students are not necessarily experienced, or skilled at taking notes

In national surveys, 66.5 % of incoming freshmen indicate that they frequently took notes in class during the past year.

Studies show that student notes during lectures generally record no more than half of the key presented concepts.

Providing *skeletal notes* supports more learning than posting full notes



Students are not necessarily accustomed to asking for help

Speaking up in public requires confidence. In polls, Americans generally rank fear of “speaking in front of many people” on par with “dying” and “losing all of my money.”

In national surveys, only 59% of incoming freshmen indicate that they frequently asked questions in class during the past year. During the freshman year, this falls to 34%

.

Source: The American Freshman, National Norms 2009; HERI, UCLA

Students are not necessarily accustomed to asking for help

In a 2010 survey of 2650 UNM undergraduates, 60% never met with the instructor outside of class and 19% only did once.

Source: Title V-OSET survey data

All questions are *not* created equal

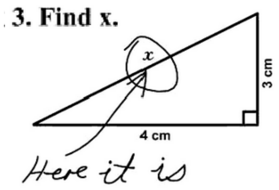


Image at: https://s-media-cache-ak0.pinimg.com/originals/80/92/2a/80922a6f47d8f06e02433f53a38332af.jpg

Bloom's taxonomy describes the types of thinking and learning we want to achieve.

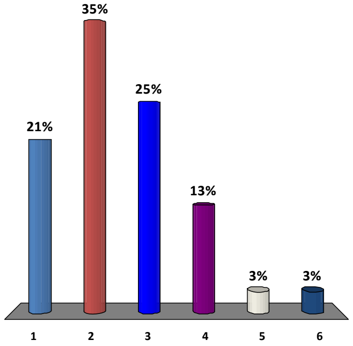
Cognitive process:	**What the learner does:**
1. Remember	Recalls or recognizes information: facts, definitions, generalizations
2. Understand	Constructs meaning by interpretation, classification, comparing, explaining, summarizing
3. Apply	Use methods, concepts, principles, theories in new situations; solve realistic problems that require the identification of issues and use of appropriate generalizations and skills.
4. Analyze	Identifies how parts relate to one another or to a larger structure or purpose; considers available evidence to reach a conclusion, inference or generalization
5. Evaluate	Judges the value of something by application of criteria, processes, or standards.
6. Create	Brings together parts to form a new whole or solve a problem that requires new creative thinking.

Anderson & Krathwohl, 2001, A Taxonomy for learning, teaching, and assessing. Longman Publishing Group.

How students answered

At what level of Bloom's did you have to operate to make A's or B's in high school?

1. Remember
2. Understand
3. Apply
4. Analyze
5. Evaluate
6. Create

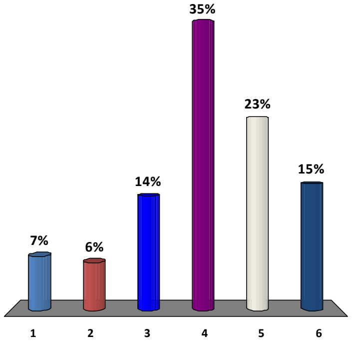


Saundra McGuire, LSU

How students answered

At what level of Bloom's do you think you'll need to be to make an A in Chemistry I?

1. Remember
2. Understand
3. Apply
4. Analyze
5. Evaluate
6. Create



Saundra McGuire, LSU

Write Pair Share

How can you help students recognize the type of thinking required to solve the problems?

An example from Biology; provided by Angela Hung

“Effective faculty members understand that students learn in very different ways.”

- Higher Learning Commission, 2003, *The Handbook of Accreditation*

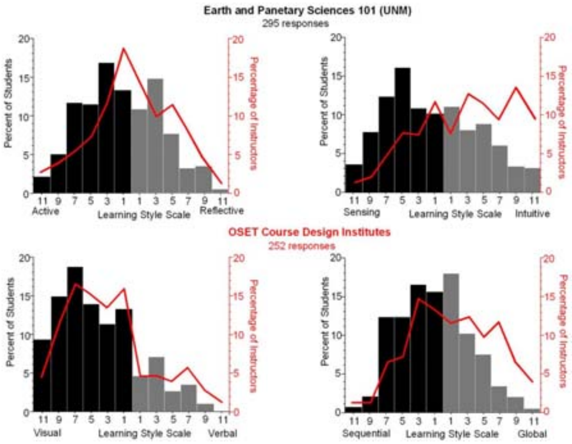
Three things that you should know about “learning styles”

Learning preferences *are* reliably and validly measured by *some* instruments

Students are not necessarily disadvantaged by instructional strategies that are contrary to their learning-style preference

There *is* evidence that *some* learning-style preferences are rooted in cultural experience and *may*, therefore have an affective impact on learning

Felder-Silverman Index of Learning Styles



Brainstorm

Considering what was presented,
what can you do to improve student learning?

Learning-preference diversity has implications for your teaching

Your students may not prefer to learn, or think, the same way that you do. Some of these differences are likely rooted in cultural experience.

No single instructional approach engages learning equally for all of your students.

Adopt multiple methods, where appropriate, to enhance learning *and* to provide variety that maintains student interest.

I anticipate that students will readily understand how to maximize their learning within the structure of the redesigned course (e.g., pre-class, in-class, post-class learning opportunities and expectations)

- **A. Strongly agree**
- **B. Agree more than disagree**
- **C. Disagree more than agree**
- **D. Strongly disagree**

Learning process flow chart used in G. Smith's geology classes

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Returning to the workshop outcomes:

After completing this workshop, participants will be able to:

- Use evidence to support why students may struggle to demonstrate their learning in your course
- Describe an assignment for helping your students learn about learning
- Integrate a learning-to-learn strategy with existing course content into at least one "teachable unit"

Choose ***one*** outcome and briefly summarize how one or more activities during this workshop have helped you achieve, or progress toward achieving, this outcome.

Learning Outcome Log (LOL) – Chris Burnham, NMSU

Do your students, and you, know what approaches to studying are most effective for learning?

Learning approach	Effectiveness for learning – *(high, medium, low)*	Research result on learning effectiveness	Your learning strategy knowledge score
Self-explanation: Explaining how new information is related to known information, or explaining steps taken during problem solving			
Summarization: Writing summaries (of various lengths) of to-be-learned texts			
Highlighting/underlining: Marking potentially important portions of to-be-learned materials while reading			
Rereading: Reading text material again after an initial reading			
Practice testing: Self-testing or taking practice tests over to-be-learned material			
Distributed practice: Implementing a schedule of practice that spreads out study and learning activities over time			

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology. *Psychological Science in the Public Interest*, *14*(1), 4–58.

Assignment for Monday's Class: Introduction to Ground Water Contamination

Objectives: This is the first of several class sessions where you will develop an understanding for how harmful contaminants, of natural or human origin, move through aquifers and cause potential risk to drinking-water supplies. Each topic builds on its predecessors and integrates your previous learning about methods for determining the direction and velocity of fluid flow in aquifers. After this class session you will be able to explain (a) why contaminant concentrations vary from place to place and (b) one method for remediating contamination. *(Related to mastery of student learning outcomes 2 and 4 for the course)*

Before starting to read: "Wake up" your brain to what you already know; the most important determinant of learning is what you already know.

- Jot down on a sheet of paper the ideas and concepts that you already know about how contaminants get into ground water and move in ground water.
- Now, write down questions that you have about ground water contamination. Be watchful to learn the answers to these questions over the next week.

Reading resources:

Smith, G.A., 2013, *Some concepts of chemical transport in ground water,* unpublished, 5 p. [Note: This short reading will be used frequently in coming weeks, including considerably during completion of Research Problem 2 – read it carefully for understanding!]

Excerpts (14 pages) about contaminant transport in ground water from L. W. Lundgren, 1998, *Environmental geology* (2nd ed.): Prentice Hall.

Class Preparation Assignment: Understand - Know the answers to these questions before coming to class

- What geological characteristics of an aquifer affect the distribution of contaminants in the environment?
- The terms *contaminate* and *contaminant* are commonly misused in student writing for this course. Start working now on your thinking about these terms so that you don't lose points on upcoming assignments! Write out your own definitions of each term.
- Define *dispersion* and *retardation*.
- What is *point-source contamination* as opposed to *nonpoint-source contamination*?
- What is *remediation*?
- Explain *ground-water-flow reversal* as part of a remediation effort.
- Outline how you might apply the ground-water-flow reversal technique to the Babylon landfill site (Lundgren, p. 386-388).

View these short (30-60 seconds) animations, which are available on the "Presentations" page within "Online Library."

"Contaminant Transport"

"Contaminant Breakthrough"

"Dispersion"

"Retardation"

In-Class Learning

· Short discussion to explore your understanding of contaminant transport principles

· Group exercise (in My Groups) to use these principles to explain characteristics of a real contaminant plume *(InClass 5-Understanding and remediating ground-water contamination)*

An example of how Bloom's Taxonomy was integrated into a Biology course - Angela Hung, UNM Biology

Instructions to students:

Module: Problem Solving- Recognizing the Required Thinking and Learning Using Bloom's Taxonomy

Objective: Not all questions are alike. Some questions are what we call "find the answer" others are "make the answer". Understanding the type of question being asked and the required thinking to answer the question is critical not only to assure that you answer the question correctly but also to assure that you achieve the learning that was intended by asking the question in the first place.

Pre-Class Assignment:

1. *Part One – Basics of Learning; Chapter #4 – Cognitive Domain—Not All Challenges Are Alike*. This short reading introduces you to Bloom's Taxonomy, a classification of the types of thinking that are required to achieve learning that is progressively more demanding and sophisticated. The reading includes short exercises to familiarize you with Bloom's Taxonomy.

2. Print, read, and bring to class: "Discovery of Photosynthesis." We will use this illustrated reading to complete an exercise during class, so you'll need to read and think about it in advance.

During Class:

- We will discuss the reading about how biologists discovered photosynthesis and reflect on the cognitive processes (the levels of Bloom's Taxonomy) that you would use if you had to learn this topic for a test. We will also see how the scientists engaged in the scientific method and used Bloom's cognitive processes in order to discover photosynthesis.

Procedure for In-Class Assignment:

- A PowerPoint presentation (a version of the student handout on the Discovery of Photosynthesis) highlights four major experiments that contributed to understanding photosynthesis.
- Go through each major experiment one at a time.
  - For each experiment, have the students identify the question, hypothesis and predictions of that study.
  - Then have students interpret the results and state their conclusions
  - Show the class what the scientist concluded from their results. Do they match?
- At the end of the slideshow, remind students of each of the cognitive processes identified by Bloom's Taxonomy.
- In small groups, students fill out a blank Bloom's Taxonomy table in which they come up with questions and answers about the discovery of photosynthesis that fit each level of the taxonomy (example answers on next page)

Questions for Student Reflection:

1. How does your understanding Bloom's Taxonomy of Learning impact the way you approach answering questions or solving problems?

2. Educators commonly talk about the importance of "critical thinking." What does this term mean to you and what levels of Bloom's taxonomy challenge a learner to think critically?

Guide to Using Bloom's Taxonomy of Learning

Example from Angela Hung, UNM Biology TA.
Objective: To have students analyze a reading about the history of experiments that defined the process of photosynthesis as an opportunity to (1) explore scientific method and to (2) understand different levels of thinking with the content

Cognitive Process	What the Learner Does	Sample Questions that Apply to Course Material
Remember	Recalls or recognizes information: facts, definitions, generalizations	What is the formula for photosynthesis? What year did Joseph Priestly do his mint experiment?
Understand	Constructs meaning by interpretation, classification, comparing, explaining, summarizing	What was John Woodward testing? Why did the mouse survive in a jar when there was a plant present, but not without a plant?
Apply	Use methods, concepts, principles, theories in new situations; solve realistic problems that require the identification of issues and use of appropriate generalizations and skills.	Based on the experiments, what materials would you gather to start your own garden? Suppose you were locked in an airtight greenhouse. When would you begin to worry about your well-being?
Analyze	Identifies how parts relate to one another or to a larger structure or purpose; considers available evidence to reach a conclusion, inference or generalization	Was Van Helmont's conclusion supported by his data? Why is photosynthesis important? What are the products used for? In 1796, Senebier made two conclusions and Ingenhausz formed a hypothesis. What cognitive processes were they using?
Evaluate	Judges the value of something by application of criteria, processes, or standards.	Which component in photosynthesis is the most important? Why? Whose experiment was most important in discovering photosynthesis? Why?
Create	Brings together parts to form a new whole or solve a problem that requires new creative thinking.	Outline the design of an experiment to test the hypothesis that the O_2 is from the splitting of the CO_2 molecule.

Journal Prompt about Using Bloom's Taxonomy in a Chemistry Course: *Describe how you would use Bloom's Taxonomy when you study for a topic in chemistry. Give a specific topic. Feel free to include example questions and answers.*

An example student response:

"Bloom's taxonomy can be applied to just about anything. A person would use Bloom's taxonomy to help them study and/or better understand the material that they are trying to learn. It would help the learner gain a better understanding of the concepts behind the material.

"A chemistry student could use Bloom's taxonomy when learning about pressure. The first step in Bloom's taxonomy would be to remember. This would mean that the student would remember that the definition of pressure is 'the force exerted per unit area by gas molecules as they strike the surfaces around them.' They would also learn the formulas related to pressure such as pressure = force/area.

"Next the student would use the step understand. This would be something such as understanding how pressure works. An example of this would be 'as volume increases, concentration decreases.'

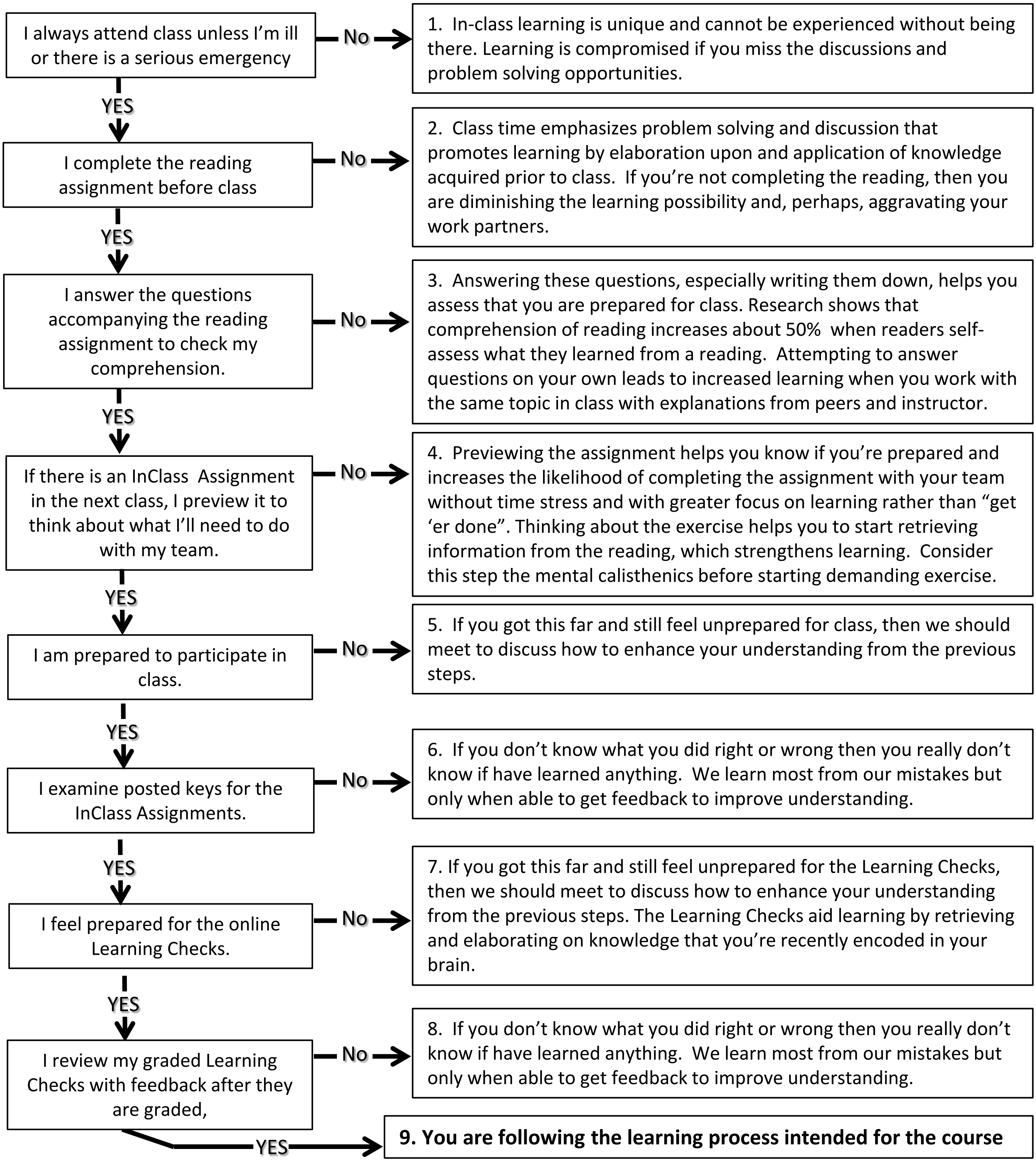
"Next would be the step apply. This could mean giving the student a word problem. The student would then have to pull out the relevant information and plug it into the equation. The student would then carry out the necessary calculations to obtain the correct answer.

"The next step is analyze. Through this step the student will break down what they know. The student could ask the question, 'Why do I have ear pain when flying on an airplane.' By analyzing the question, and what they already know about pressure they would conclude that the pressure from the altitude change can cause pressure in the ear.

"Next is the step of evaluation. The student could evaluate how what they learned about pressure measures up against how the world around them acts. For instance, if a person tried to blow up a balloon and it did not work, they could conclude that something that they were taught about pressure is incorrect.

"The last step is to create. The student could use what they have learned about pressure to create an experiment. This could be something along the lines of going up and down a mountain multiple times to see how it effects your ears. The first time the student would just drive to the top and back down. The next time the student could chew gum while going up and down. Next the student could drive very slowly. The next time drive very quickly and so on. This would help the student better understand the relationship of pressure to the altitude and their body.

"Bloom's taxonomy is a great tool for studying. It is a lot of work, but it creates a level of understanding not usually reached by a student. Utilizing this may be the key to college success."



I always attend class unless I'm ill or there is a serious emergency

1. In-class learning is unique and cannot be experienced without being there. Learning is compromised if you miss the discussions and problem solving opportunities.

I complete the reading assignment before class

2. Class time emphasizes problem solving and discussion that promotes learning by elaboration upon and application of knowledge acquired prior to class. If you're not completing the reading, then you are diminishing the learning possibility and, perhaps, aggravating your work partners.

I answer the questions accompanying the reading assignment to check my comprehension.

3. Answering these questions, especially writing them down, helps you assess that you are prepared for class. Research shows that comprehension of reading increases about 50% when readers self-assess what they learned from a reading. Attempting to answer questions on your own leads to increased learning when you work with the same topic in class with explanations from peers and instructor.

If there is an InClass Assignment in the next class, I preview it to think about what I'll need to do with my team.

4. Previewing the assignment helps you know if you're prepared and increases the likelihood of completing the assignment with your team without time stress and with greater focus on learning rather than "get 'er done". Thinking about the exercise helps you to start retrieving information from the reading, which strengthens learning. Consider this step the mental calisthenics before starting demanding exercise.

I am prepared to participate in class.

5. If you got this far and still feel unprepared for class, then we should meet to discuss how to enhance your understanding from the previous steps.

I examine posted keys for the InClass Assignments.

6. If you don't know what you did right or wrong then you really don't know if have learned anything. We learn most from our mistakes but only when able to get feedback to improve understanding.

I feel prepared for the online Learning Checks.

7. If you got this far and still feel unprepared for the Learning Checks, then we should meet to discuss how to enhance your understanding from the previous steps. The Learning Checks aid learning by retrieving and elaborating on knowledge that you're recently encoded in your brain.

I review my graded Learning Checks with feedback after they are graded,

8. If you don't know what you did right or wrong then you really don't know if have learned anything. We learn most from our mistakes but only when able to get feedback to improve understanding.

9. You are following the learning process intended for the course

Tear

Name: **Where did you end at (1-9)?**

What will you do differently in the future?

STEM Gateway
Course Redesign Teaching Professional
Development Program:

Starting the Semester- Making Sure Learners are on Board with your Redesign

- Are you ready to effectively introduce your redesigned course and expectations on the first day of class?
- How do you get students to value deep learning in your redesigned course?
- How do you get students to "buy into" the responsibility it takes to actively learn, not passively listen, in class?

STEM GATEWAY
Project for Inclusive
Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

Starting the Semester
Making Sure Learners are On Board with Your Redesign

Gary Smith and Audriana Stark

Outcomes:

Participants will be able to:

...describe why it is important to get students to buy into active learning and/or team work included in your redesign.

...be prepared to implement at least 2 activities using the Value Expectancy Model to get students invested in active learning and/or team work.

Connect Your Approach to What Learners Value

Answer this question, thinking of what you value in education

What is the most important goal of a college education and, therefore, individual college courses?

A. Acquiring information (facts, principles, concepts)
B. Learning how to use information and knowledge in new situations
C. Developing lifelong learning skills

How do you think undergraduate students answer this question?

What is the most important goal of your college education and, therefore, of this course?

A. Acquiring information (facts, principles, concepts)
B. Learning how to use information and knowledge in new situations
C. Developing lifelong learning skills

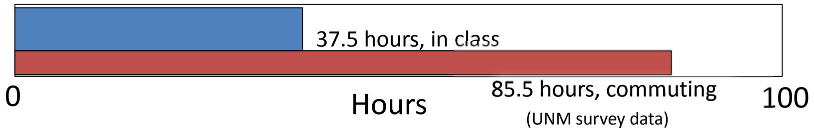
How students actually answer this question

What is the most important goal of your college education and, therefore, of this course?

A. Acquiring information (facts, principles, concepts) **7%**
B. Learning how to use information and knowledge in new situations **38%**
C. Developing skills to continue learning after college **55%**

(quantitative n = 1377)

If you have perfect attendance for one semester in this 3-credit course, how many classtime-learning hours will you experience in one semester?



Learning “venues”:


Learning on your own

Photo by Aurora Pun


Learning in class with others

Photo by: Gary Smith

Of the three goals, which do you think ***you can make headway on outside of class*** by your own reading and studying, and which do you think would be best achieved in class ***working with your classmates and me***?”

How do learners want to learn?

Attempt learning on their own, outside of class

A. Acquiring information (facts, principles, concepts)

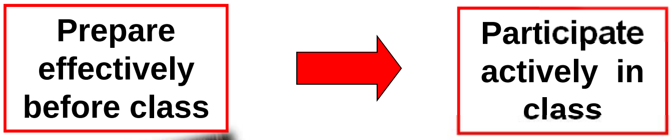
B. Learning how to use information and knowledge in new situations

C. Developing lifelong learning skills

Prefer learning in class, working with peers and instructor

First-day questions for the learner-centered classroom, G.A. Smith, *National Teaching and Learning Forum*, Sept. 2008

Why might it be potentially useful to conduct this exercise with your students on the ~~first day of class~~ ^ mid-point of the semester in an active learning classroom?



Prepare effectively before class → **Participate actively in class**

Right photo by Gary Smith

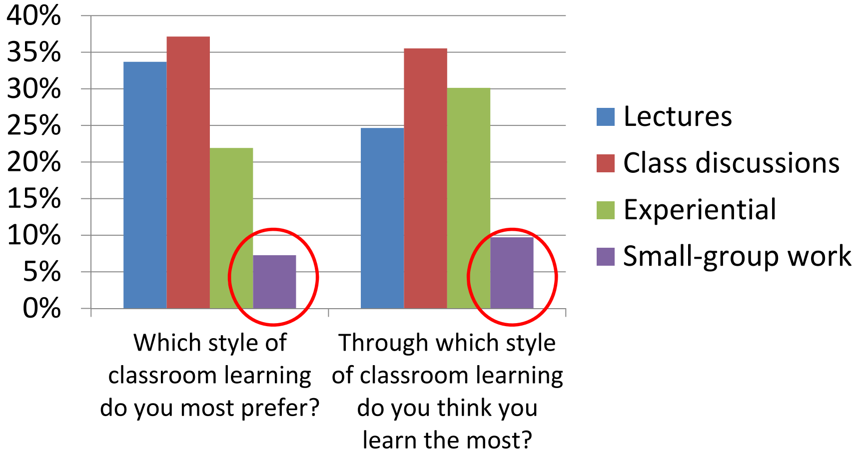
Photo by Aurora Pun

Where we're going

Provide a basis for your understanding of "student resistance" to active learning and group work

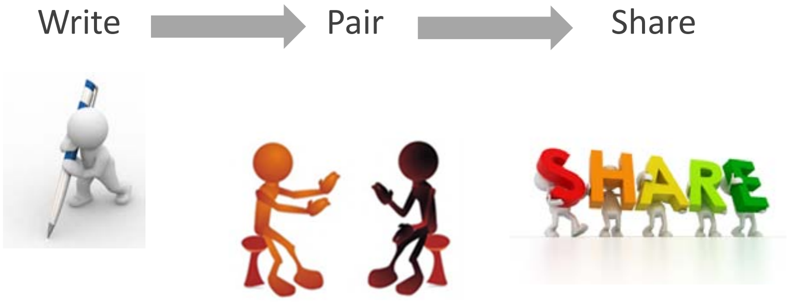
Provide more classroom-tested tactics for diminishing or removing resistance for your use.

So, although students admit that they learn best in ways that might not be preferred (easier?), small-group work is not highly regarded



Profile of the American College Student, Spring 2011

What aspects of active-learning classes do students dislike and *why*?



Write → Pair → Share

Left image at:http://www.blogotechblog.com/wp-content/uploads/2010/11/iStock_000002585519XSmall.jpg
Center image at:https://img.clipartfest.com/7ae29d851a10ec172a32bed9d47feb16_395855b08cea1c02d517adaae6ac04-two-people-talking-clip-art_649-495.jpeg
Right Image at : http://www.omgtop5.com/wp-content/uploads/2014/10/Share_Logo.jpg

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Students like interactivity of active-learning classes, but dislike added responsibility, including to groups

Changing Biology instruction at Georgetown University

Lecture course:

Liked:

- Traditional course materials: PowerPoint, videos, handouts, outlines
- Quality of instruction: enthusiasm, clarity, and organization

Disliked:

- Lecture not stimulating
- Exams: too hard, too specific, grading
- Subject matter not interesting

Active-learning course:

Liked:

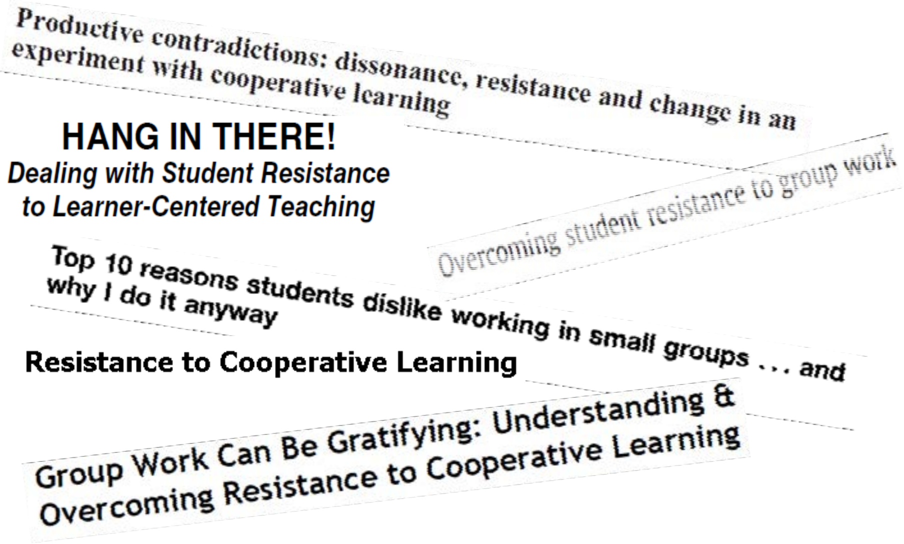
- Quality of instruction: organization, clarity, and interesting
- Additional course materials: learning goals, groups, quizzes
- Interaction in lecture: via group activities, clickers, multiple approaches to learning

Disliked:

- Group work
- Quizzes: points, stressful, too hard

Armbruster et al., 2009, *CBE—Life Sciences Education,* 8:203–213

Leading to a rich literature on overcoming student resistance working/learning in groups



Productive contradictions: dissonance, resistance and change in an experiment with cooperative learning

HANG IN THERE!

Dealing with Student Resistance to Learner-Centered Teaching

Overcoming student resistance to group work

Top 10 reasons students dislike working in small groups . . . and why I do it anyway

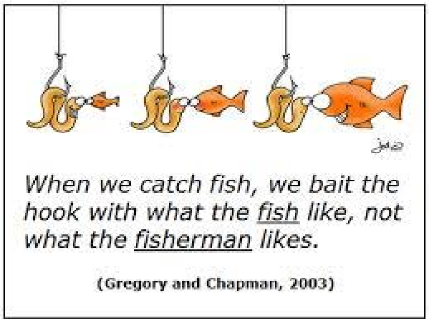
Resistance to Cooperative Learning

Group Work Can Be Gratifying: Understanding & Overcoming Resistance to Cooperative Learning

What to do?

"To counter students' resistance, try to persuade them that you are neither playing a game nor performing an experiment, but teaching in a way known to help students learn more and understand better."

Image at: http://www.sonofthesouth.net/uncle-sam/images/vegetables.jpg
Right image at: http://www.coolfunpics.com/wp-content/uploads/2016/04/26/Eat-Your-Vegetables.jpg



When we catch fish, we bait the hook with what the fish like, not what the fisherman likes.

(Gregory and Chapman, 2003)

Navigating the Bumpy Road to Student-Centered Instruction.
Richard M.Felder and Rebecca Brent, 1996, *College Teaching*

Achievement motivation relies on *value* and *expectancy*

A goal that I value …

… and a belief that I can make it!

Photo at : http://cdn.coresites.factorymedia.com/cooler_new/wp-content/uploads/2015/04/rock-climbing-almost-there-1.jpg

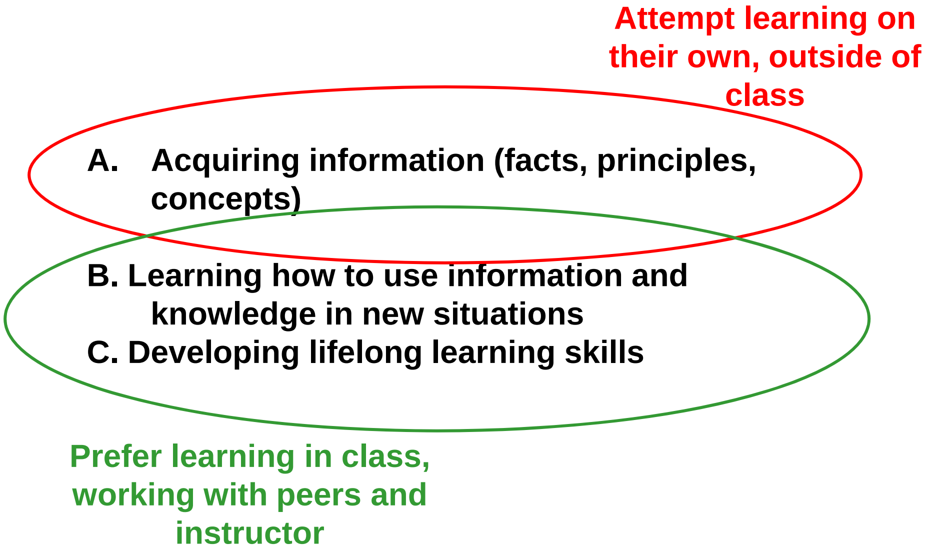
First-day questions … connect to what students value

What is the most important goal of your college education and, therefore, of this course?

A. Acquiring information (facts, principles, concepts) **7%**
B. Learning how to use information and knowledge in new situations **38%**
C. Developing skills to continue learning after college **55%**

First-day questions for the learner-centered classroom, G.A. Smith, *National Teaching and Learning Forum*, Sept. 2008

First-day questions … connect to expectancy



Attempt learning on their own, outside of class

A. Acquiring information (facts, principles, concepts)

B. Learning how to use information and knowledge in new situations

C. Developing lifelong learning skills

Prefer learning in class, working with peers and instructor

How important is it, to you, to develop skills in your coursework that will help you land a job when you graduate?

Can you pick which *four* in the following list are among the *top 5* most desired characteristics among recent college graduates as reported by hiring companies?

1. Creativity
2. Computer skills
3. GPA, cutoff above 3.0
4. Leadership skills
5. Problem-solving skills
6. Teamwork skills
7. Verbal communication skills
8. Written communication skills

Write the numbers for your four choices on the board

Photo by Gary Smith

1. Creativity
2. Computer skills
3. GPA, cutoff above 3.0
4. Leadership skills
5. Problem-solving skills
6. Teamwork skills
7. Verbal communication skills
8. Written communication skills

Source: *Job Outlook 2013*

Courtesy of the National Association of Colleges and Employers

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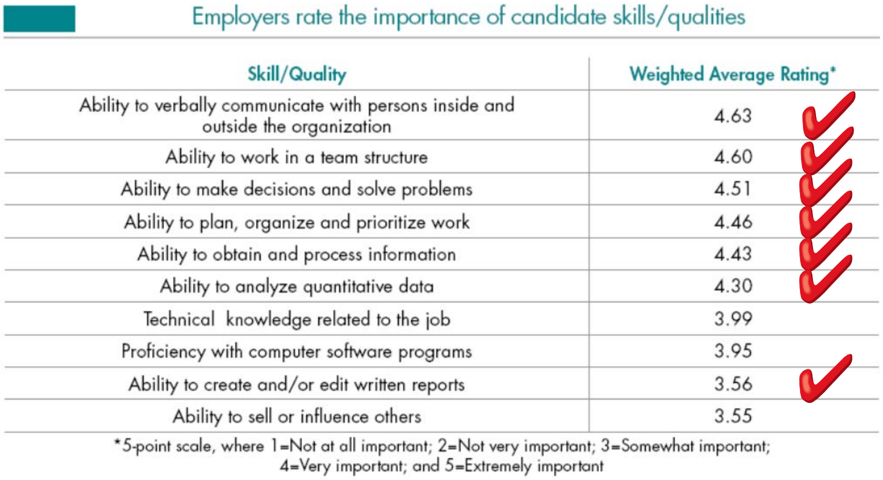


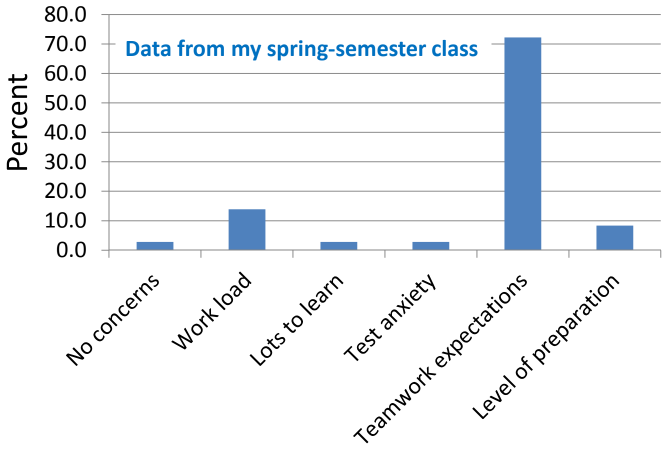
Employers rate the importance of candidate skills/qualities

Skill/Quality	Weighted Average Rating*	
Ability to verbally communicate with persons inside and outside the organization	4.63	✓
Ability to work in a team structure	4.60	✓
Ability to make decisions and solve problems	4.51	✓
Ability to plan, organize and prioritize work	4.46	✓
Ability to obtain and process information	4.43	✓
Ability to analyze quantitative data	4.30	✓
Technical knowledge related to the job	3.99	
Proficiency with computer software programs	3.95	
Ability to create and/or edit written reports	3.56	✓
Ability to sell or influence others	3.55	

*5-point scale, where 1=Not at all important; 2=Not very important; 3=Somewhat important; 4=Very important; and 5=Extremely important

✓ = **employer-desired skill that matches a learning outcome for this course**

Describe one or more aspects of this course that you feel might cause anxiety or stress during the semester.



Pick one aspect of working in small groups that is a concern for you. Explain why you have this concern.

No concerns about group work? <15%

Most common concern:
“Slackers” (60-80%)

Photo by Gary Smith

Then, skim through the three links that are listed at the top of the "Team information page" in Learn and seek information that is relevant to your concern.

Write a few sentences that explains how you can help alleviate your concern during the semester.

Resources provided to students:

“Top 10 reasons students dislike working in small groups … and why I do it anyway”

AnnTaylor
Biochemistry and Molecular Biology Education, v. 39 (3), 219-220 (2012)

“Coping with Hitchhikers and Couch Potatoes on Teams”

From, Turning Student Groups into Effective Teams, by B. Oakley, R. Felder, R. Brent, and I. Elhajj,. *J. Student Centered Learning, 2*(1), 9–34 (2004).

Fact and Fiction: Common Fears about Group Work

Writing@CSU

Think of something that you're "good at" other than being a student.

Jot down some thoughts in response to these questions:

How did you become "good at it?"
What role did other people play for you to develop expertise?

Image at: https://userscontent2.emaze.com/images/0db50308-79ec-4644-ae0f-04d9a98126bd/dbcbb381c551fae2cbbe285d8dec912f.gif

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Briefly share your answers with your tablemates.

Pay attention to processes and people that are mentioned most often.

List these "common denominators" on a whiteboard

(Inspired by R. Smilkstein, 1989, The natural process of learning and critical thinking: *Gamut*, 38:26-38)

All learning works the same

Repetition (practice) and elaboration (expanding understanding through sense-making)

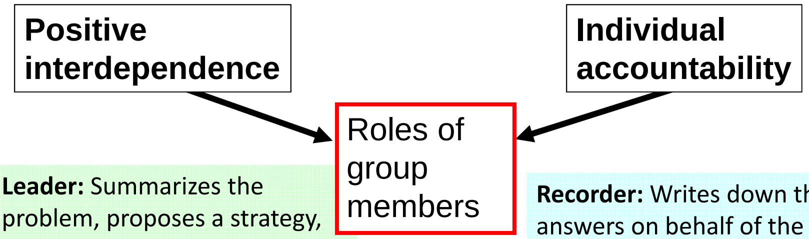
Image at: http://static.wixstatic.com/media/b7ad9b_c0fc19c1653942b99574eae31214cd3d.jpg

Coaches, mentors, parents, teachers, provide opportunity and give feedback – but the performance is up to the learner

Image at:https://joemull77.files.wordpress.com/2014/06/training-and-coaching.jpg

Where is the teacher "coaching" a learning process that includes practice and elaboration?

Photo by Gary Smith and Aurora Pun



Positive interdependence

Individual accountability

Roles of group members

Leader: Summarizes the problem, proposes a strategy, coordinates the conversations, keeps everyone on task, and keeps track of available time

Recorder: Writes down the answers on behalf of the group, frequently checks with teammates to assure accuracy

Monitor: Assures that *all* are participating and comfortable with the group consensus with responses; brings up alternative possibilities.

	Mon	Wed	Fri
Leader	Marie	John	Angel
Recorder	John	Angel	Marie
Monitor	Angel	Marie	John

Team Work Checkup:

What is the strongest aspect of our work as a team?

What is the weakest aspect of our work as a team?

What can we do to make our team work better for helping all of us learn?

Photo by Gary Smith

Connect Your Approach to What Learners Value

- Link active, collaborative learning to students' educational goals
- Make development of teamwork skills a learning outcome for the course
- Guide student reflection on good teamwork
- Be sure that group exercises foster positive interdependency and individual accountability

Photo by Gary Smith

Starting the Semester: Making Sure Learners are On Board with Your Redesign

http://www.elainebaileyinternational.com/wordpress/wp-content/uploads/2013/09/iStock_000003537689Large1.jpg

Connect Your Approach to What Learners Value

Gary Smith
Director, Office for Medical Educator Development
Professor, Organization, Information, & Learning Sciences
PI, STEM Gateway (Dept. of Ed. Title V)

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Summary: Shifting from teacher-centered to learner-centered pedagogy is high-risk for faculty. Adding to the common perceived risks of sacrificing course content and being ineffective with new techniques are concerns for student resistance and declining teaching-evaluation scores. Therefore, promoting pedagogical shift is incomplete unless instructors are empowered to assist learners to make the shift, too.

Student resistance to active learning and group work are well known. Resistance is attributed to students (a) not wanting – or knowing how – to take responsibility for their learning, (b) favoring an epistemology whereby knowledge is provided by experts rather than constructed by the learner, (c) not accepting a course structure that violates the expected norm, and (d) experiencing transition stresses comparable to psychological grief.

Most suggestions for confronting student resistance focus on the teacher's motivation. For example, instructors might explain their vision of the course and why it is being taught this way. Guidance to faculty for implementing group work typically focuses on team building and explaining the requirements for group operation.

This session instead emphasizes classroom-tested strategies that employ a learner-centered approach for obtaining student acceptance of their risks by focusing on (a) what they value for their education, and (b) their prior concrete learning experiences.

August 2014; rev 8/15

Activity Idea #1: The First Day Questions (In Class)

(For more information, see Smith, G.A., 2008, First-day questions for the learner-centered classroom; *National Teaching and Learning Forum*, 17(5), 1-4)

During the first day of class include a discussion that opens with you asking:

> *"Thinking of what you want to get out of your college education and this course, which of the following is most important to you?*
>
> 1. *Acquiring factual knowledge*
> 2. *Learning how to use knowledge in new situations*
> 3. *Developing skills to continue learning after college"*

Student voting usually emphasizes items 2 and 3. Therefore, learners typically place a high value on the types of thinking that faculty also have as primary goals for their students. However, this match does not necessarily mean that students understand how to achieve these goals. Next, ask:

> "*All three goals are clearly important; for instance you can't use knowledge without first obtaining it. But, let's think for a moment of how best to accomplish these goals. Learning is not a spectator sport – it takes work; that includes work in the classroom and work that you do outside of the classroom. So, of these three goals, which do you think you can make headway on outside of class by your own reading and studying, and which do you think would be best achieved in class working with your classmates and me?"*

Typically, most students respond that they can make progress with factual knowledge acquisition on their own and want assistance with the other two goals. This result leads to a discussion of how to pursue goals 2 and 3. Goals 2 and 3 are not achieved by reading or listening to a lecturer – students must actively do things in order to learn. Students learn best when they take an active role:

- When they discuss what they are reading
- When they practice what they are learning
- When they apply practices and ideas.

This expectation of active learning causes students to realize that in order to reach *their* just-stated goal they have must prepare for in- class learning by making first contact with content on their own (e.g., reading, online lectures and/or exercises). Then, students and instructors together use that content during class in active-learning activities (e.g., collaborative or cooperative learning, discussion, etc.) that, when effective, challenge students to reach for always higher but reachable bars of accomplishment. This discussion can also lead to the importance of feedback for learning and the need for frequent formative assessment. The focus is on learning, not simply performing for a grade.

Students may be inexperienced with active learning or the expectations placed upon them for their learning. This activity is designed for motivating students to value the active-learning strategies used in a course and the partnership responsibilities of instructor and student. Without this introductory dialogue, the expectation of coming to class prepared, the expectation to work with peers in class, and the expectation to complete frequent writing assignments and other formative assessments of learning can seem foreign to students. It may seem to them like too much work compared to listening to lectures and regurgitating facts on exams.

However, once students recognize the link between *their* goals and the implemented learning methods they have a new appreciation for *why you and they do the things that happen in the course*, and they come to value these methods so long as the methods are used effectively and students can measure their own learning.

Activity #2: Connecting Course Objectives to What Employers (and Students?) Want (In Class)

Faculty commonly feel that students only seek a job after graduation and view the college curriculum as a minefield to be navigated using a path of least resistance; students don't want to learn, they want a degree. A biology professor at the University of Michigan shares this comment written by one of his students: "Education is the only business where the consumer is satisfied with less product[1]."

You may find this view too cynical but it is supported by research into college student motivation. A Carnegie Council on Policy Studies in Higher Education survey shows that more than half of undergraduates believe the chief benefit of college is higher earning power, and more than one third admit they would drop out if they did not think that attending college was helping their job chances.

This activity, recommended for the first day of class, encourages students to link the *common expectations* of employers who hire college graduates with the opportunities for knowledge and skill development, including teamwork and leadership, in their classes.

Initiate the discussion with this question: *"How important is it, to you, to develop skills in your coursework that will help you land a job when you graduate?"* Usually, students respond that this should be an important goal.

Next ask, *"Can you pick which items in the following list are the top-5 most desired characteristics among recent college graduates as reported by hiring companies?"*

1. Creativity
2. Computer skills
3. GPA, cutoff above 3.0
4. Leadership skills
5. Problem-solving skills
6. Teamwork skills
7. Verbal communication skills
8. Written communication skills
9. Analytical/Quantitative skills

Students form discussion groups and each group writes its consensus five-item list on the board. Then, follow with the actual employer survey results (shown below). This activity is particularly effective for getting student buy in for courses requiring significant writing and team work.

1. Leadership (80.6%)
2. Problem-solving skills (75.3%)
3. Written communication skills (74.7%)
4. Ability to work in a team (74.2%)
5. Analytical/quantitative skills (73.0%)

(Cutoff at a GPA value above 3.0 was noted by only 20% of respondents).

(National Association of Colleges and Employers, 2012)

The importance of team work and leadership (which is fostered through team work) serves as a motivation for participating in courses where learning and working together in teams is a critical part of course design and included in the learning objectives.

(Inspired by a Calif. St. Univ Learning Across the Curriculum module: "Helping Ourselves by Helping Others – Working in Groups")

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[1] D.J. Klionsky, 2004, Talking Biology: Learning Outside the Book—and the Lecture *Cell Biology Education*, v. 3, p. 204–211

Activity #3 Connecting Expertise to Learning Approach (In Class)

This exercise is intended to connect students with how they learn outside of their academic experiences with how they should learn in college; learning is learning regardless of context.

Begin with this reflection prompt:

> *"Think of something that you consider yourself to be very good at, other than being a student of a school subject. For instance, examples might be athletic accomplishment, artistic ability, musical instrument talent, another creative ability (such as writing poetry or fiction). Now – think about the process that you went through to develop the expertise that you have acquired."*

After giving students a few minutes to come up with their personal lists, ask them to talk at their tables to derive common, generalized lists of "Processes for Developing Expertise". Have them write these short lists on the board. Then – guide students to see the most common listed items.

Usually, these lists include items such as:

- Hard work
- Lots of practice
- Getting instruction and feedback from parents, coaches, mentors, teachers, etc.
- Learning from mistakes; trying it and getting pointers for improvement from teachers, coaches, etc.

Then lead a discussion along these lines:

> *"Your brain treats all sorts of learning the same way. In fact, learning is a biological process involving the linking of neurons with synapses that permit you to retrieve and utilize information over and over again. When you learn something, your brain is physically changed. From a neuroscience standpoint, learning math or chemistry isn't really different from learning to create a sculpture or throw an accurate football pass. So, what implications for your learning in college can you derive from the lists you've written on the boards?"*

Expected ideas include:

- Hard, disciplined work
- Practice – by doing lots of sample problems and keeping up with homework
- Getting feedback from teachers and seeking assistance when progress seems unsatisfactory
- Being willing to accept mistakes as part of the learning process

Inspired by R. Smilkstein, 1989, The natural process of learning and critical thinking: *Gamut*, 38:26-38

Activity #4: Reflecting on How to Make Group Work, Work (Online)

This assignment is delivered as a reflective-writing prompt that students complete online at the end of the first or second week of class. The objective is for students to reflect on their perceptions of disadvantages of group work and design potential solutions to their concerns.

Prompt:

> *Working in teams is a significant part of the learning environment for [class name]. You will be placed in an assigned group for the semester. You will complete in-class assignments and ongoing projects as a team. Nearly everyone has some concerns or reservations about working as a part of a group. Pick one aspect of working in small groups that is a concern for you. Explain why you have this concern.*
>
> *Then, skim through the three provided links and seek information that is relevant to your concern. Write a few sentences that explains how you can help alleviate your concern during the semester.*

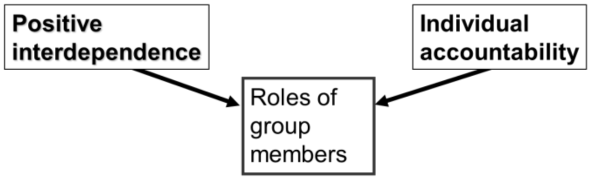
Provided references:

Top 10 Reasons Students Dislike Working in Small Groups … and Why I do it Anyway
AnnTaylor
Biochemistry and Molecular Biology Education, 39 (3), 219-220 (2012)

Coping with Hitchhikers and Couch Potatoes on Teams
From, Turning Student Groups into Effective Teams, by B. Oakley, R. Felder, R. Brent, and I. Elhajj,. *J. Student Centered Learning,* 2 (1), 9-34 (2004)

Fact and Fiction: Common Fears about Group Work
Writing@CSU, Colorado State University http://writing.colostate.edu/guides/page.cfm?pageid=849

Activity #5: Establish the Roles and Responsibilities for Teamwork (In Class)



Leader: Summarizes the problem, proposes a strategy, coordinates the conversations to assure even participation by all, keeps everyone on task, and keeps track of available time.

Recorder: Writes down the answers on behalf of the group, frequently checks with teammates to assure accuracy of what is written.

Monitor: Assures that *all* team members are participating and are comfortable with the group consensus with responses; brings up alternative possibilities. All team members respect the role of the monitor to ask dominating members to provide opportunities for other voices, to ask quiet members to share their insights, and to make sure that everyone understands the recorded answers.

Note: In four person teams, 2 people share the Monitor role. If only two people are present, the Recorder also serves as Monitor

Important: Rotate roles so that responsibilities change with each class period.

Activity #6: Team Work Check Up (In Class)

This exercise is intended as a quick writing response by each team. It should ideally be done several times a semester by having students respond to these prompts (shortened if necessary for time) as a team at the end of class. The objective is to generate conversations within groups about what is or is not working, and potentially activates previous reflection (Activity #3) and experience (Activity #4) to seek solutions and make suggestions.

What is the strongest aspect of our work as a team?

What is the weakest aspect of our work as a team?

What can we do to make our team work better for helping all of us learn?

Also see:

Framing the Interactive Engagement Classroom

http://www.colorado.edu/sei/fac-resources/framing.html

Instructor-written materials from a variety of disciplines for generating student buy-in to innovative classroom techniques.
The Science Education Initiative at the University of Colorado Boulder

STEM Gateway
Course Redesign Teaching Professional Development Program:

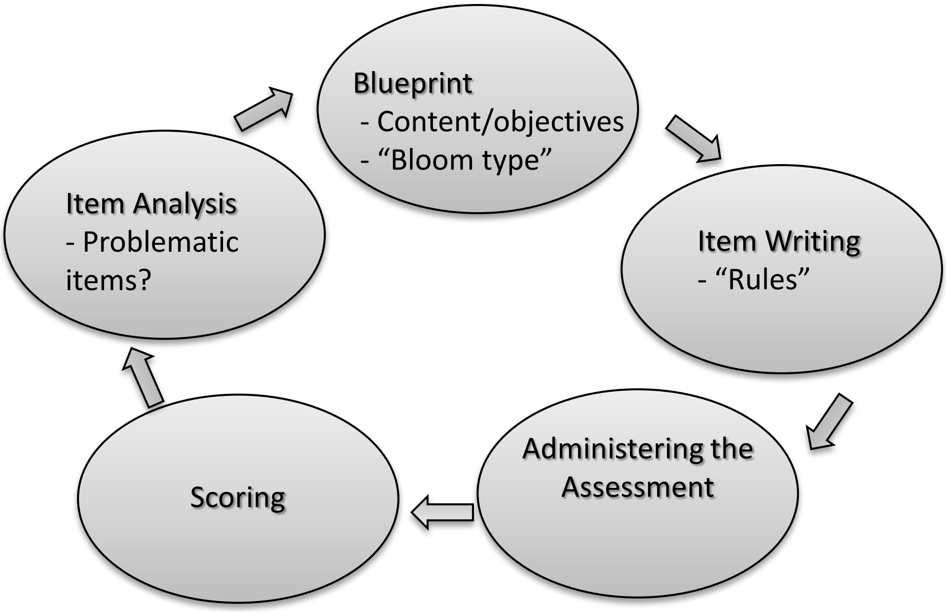
Constructing Effective Multiple Choice Tests

- Do you know that some studies conclude that most instructor-designed multiple-choice tests are flawed in ways that diminish student achievement regardless of their knowledge?
- Do you know the pitfalls to avoid when constructing a test?
- Do you want to improve formative and summative assessment of higher-order learning with your multiple-choice questions?

STEM GATEWAY
Project for Inclusive Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

Designing Multiple-Choice Assessments



Start with asking the question …

… *What is the test supposed to assess?*

Blueprint

- What content will be assessed, and with what weighting?
- What course learning objectives are being assessed?
- What types of *cognition* and *knowledge* are being assessed?

25 total questions

Topic X	5 questions
Topic Y	10 questions
Topic Z	10 questions

Learning objectives 1,3, and 4 need to included

The Effects of Violating Standard Item Writing Principles on Tests and Students: The Consequences of Using Flawed Test Items on Achievement Examinations in Medical Education

S. M. Downing, 2005, *Advances in Health Sciences Education*, 10: 133-143

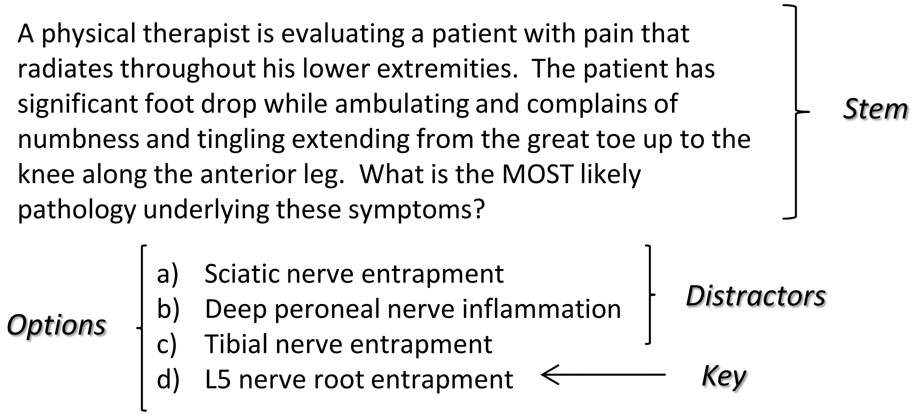
Compared student performance on “flawed” and “standard” items on four 1st and 2nd year medical school exams.

Questions with flawed item formats were 0 to 15 percentage points “more difficult” than standard, non-flawed item formats.

Flawed test questions contributed from 0 to 41% (median of 20%) of the variance in test scores.

“One can conclude that some students – perhaps as high as 10-15% of students tested – were incorrectly classified as failed when they should have been classified as passed, due solely to flawed item formats and the ineptitude of test item writers.”

The anatomy of a multiple-choice question:



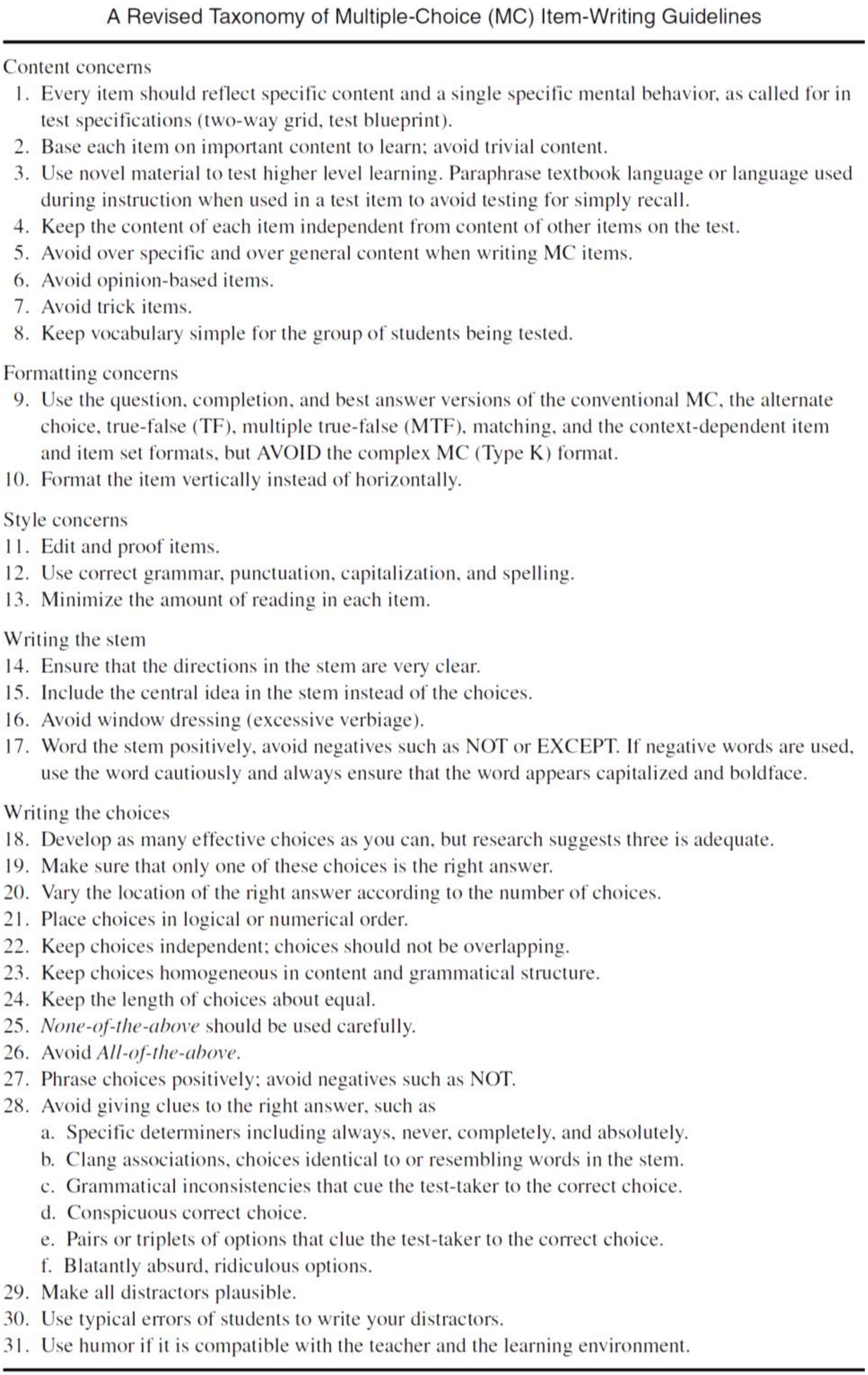
A physical therapist is evaluating a patient with pain that radiates throughout his lower extremities. The patient has significant foot drop while ambulating and complains of numbness and tingling extending from the great toe up to the knee along the anterior leg. What is the MOST likely pathology underlying these symptoms?

a) Sciatic nerve entrapment
b) Deep peroneal nerve inflammation
c) Tibial nerve entrapment
d) L5 nerve root entrapment

- Does the item assess important content?
- Does the item assess necessary cognitive processing and knowledge?
- Does the item contain only relevant information?

Cognitive load:

- Examinees shouldn’t have to think harder than the content requires
- Examinees should be focused on the content, not the testing process



A Revised Taxonomy of Multiple-Choice (MC) Item-Writing Guidelines

Content concerns

1. Every item should reflect specific content and a single specific mental behavior, as called for in test specifications (two-way grid, test blueprint).
2. Base each item on important content to learn; avoid trivial content.
3. Use novel material to test higher level learning. Paraphrase textbook language or language used during instruction when used in a test item to avoid testing for simply recall.
4. Keep the content of each item independent from content of other items on the test.
5. Avoid over specific and over general content when writing MC items.
6. Avoid opinion-based items.
7. Avoid trick items.
8. Keep vocabulary simple for the group of students being tested.

Formatting concerns

9. Use the question, completion, and best answer versions of the conventional MC, the alternate choice, true-false (TF), multiple true-false (MTF), matching, and the context-dependent item and item set formats, but AVOID the complex MC (Type K) format.
10. Format the item vertically instead of horizontally.

Style concerns

11. Edit and proof items.
12. Use correct grammar, punctuation, capitalization, and spelling.
13. Minimize the amount of reading in each item.

Writing the stem

14. Ensure that the directions in the stem are very clear.
15. Include the central idea in the stem instead of the choices.
16. Avoid window dressing (excessive verbiage).
17. Word the stem positively, avoid negatives such as NOT or EXCEPT. If negative words are used, use the word cautiously and always ensure that the word appears capitalized and boldface.

Writing the choices

18. Develop as many effective choices as you can, but research suggests three is adequate.
19. Make sure that only one of these choices is the right answer.
20. Vary the location of the right answer according to the number of choices.
21. Place choices in logical or numerical order.
22. Keep choices independent; choices should not be overlapping.
23. Keep choices homogeneous in content and grammatical structure.
24. Keep the length of choices about equal.
25. *None-of-the-above* should be used carefully.
26. Avoid *All-of-the-above*.
27. Phrase choices positively; avoid negatives such as NOT.
28. Avoid giving clues to the right answer, such as
    - a. Specific determiners including always, never, completely, and absolutely.
    - b. Clang associations, choices identical to or resembling words in the stem.
    - c. Grammatical inconsistencies that cue the test-taker to the correct choice.
    - d. Conspicuous correct choice.
    - e. Pairs or triplets of options that clue the test-taker to the correct choice.
    - f. Blatantly absurd, ridiculous options.
29. Make all distractors plausible.
30. Use typical errors of students to write your distractors.
31. Use humor if it is compatible with the teacher and the learning environment.

(Haladyna et al., 2002, A review of multiple-choice item-writing guidelines for classroom assessment: *Applied Measurement in Education*, 15(3): 309-334.

Bloom's Taxonomy of the Cognitive Domain

Anderson & Krathwohl, 2001, *A Taxonomy for Learning, Teaching, and Assessing:* Longman Publishing Group.

Cognitive process:	**What the learner does:**
6. Create	Brings together parts to form a new whole or solve a problem that requires new creative thinking.
5. Evaluate	Judges the value of something by application of criteria, processes, or standards.
4. Analyze	Identifies how parts relate to one another or to a larger structure or purpose; considers available evidence to reach a conclusion, inference or generalization
3. Apply	Use methods, concepts, principles, theories in new situations; solve realistic problems that require the identification of issues and use of appropriate generalizations and skills.
2. Understand	Constructs meaning by explaining, classifying, comparing,, summarizing
1. Remember	Recalls or recognizes information: facts, definitions, generalizations

Knowledge type:	**Knowledge gained:**
1. Factual	*Basic elements* (e.g., terms, people, formulas) that learners must know to be acquainted with a discipline or solve problems in the discipline.
2. Conceptual	The *interrelationships among the basic elements* within a larger structure that enables the elements to function together (e.g., classifications, principles, theories, models, structures).
3. Procedural	*How to do something* — methods of inquiry, algorithms, techniques — along with criteria for when to use appropriate procedures
4. Metacognitive	Knowledge of learning and awareness of one's own cognition – *"knowing what you do and do not know"*

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				

Determine the cognitive level in Bloom's taxonomy of each of the following questions

1. What is the first step in constructing an achievement test?
    a. Decide on test length.
    b. Identify the intended learning outcomes.
    c. Prepare a table of specifications.
    d. Select the stem types to use.

    Bloom level: ____

2. Which one of the following learning outcomes is properly stated in terms of student performance?
    a. Develops an appreciation of the importance of testing.
    b. Explains the purpose of test specifications.
    c. Learns how to write good test items.
    d. Realizes the importance of validity.

    Bloom level: ____

3. *Directions*: read the following test question and then indicate the best change to make to improve the question.

    Which one of the following types of learning outcomes is most difficult to evaluate objectively?
    a. A concept.
    b. An application.
    c. An appreciation.
    d. None of the above.

    The best change to make in the previous question would be to:
    a. Change the stem to incomplete-statement form.
    b. Use numbers instead of letters for each alternative.
    c. Remove the indefinite articles "a" and "an" from the alternatives.
    d. Replace "none of the above" with "an interpretation."

    Bloom level: ____

4. *Directions*: Read the following comments a teacher made about testing. Then answer the questions that follow by selecting the letter of the best answer.

    > "Students go to school to learn, not to take tests. In addition, tests cannot be used to indicate a student's absolute level of learning. All tests can do is rank students in order of achievement, and this relative ranking is influenced by guessing, bluffing, and the subjective opinions of the teacher doing the scoring. The teacher-learning process would benefit if we did away with tests and depended on student self-evaluation."

    Which one of the following unstated assumptions is this teacher making?
    a. Students go to school to learn.
    b. Teachers use essay tests primarily.
    c. Tests make no contribution to learning.
    d. Tests do not indicate a student's absolute level of learning.

    Which one of the following types of test is this teacher primarily talking about?
    a. Diagnostic test.
    b. Formative test.
    c. Pretest.
    d. Summative test.

    Bloom level: ____

(From: Gronlund, N. E., 1998. *Assessment of student achievement*. Boston: Allyn and Bacon)

Which question in each pair is the best question? Why?

1A. Which of the following is a category in the taxonomy of the cognitive domain?

a) Reasoning ability
b) Critical thinking
c) Rote learning
d) All of the above
e) None of the above

1B. What is the most complex level in the taxonomy of the cognitive domain?

a) Remember
b) Create
c) Evaluate
d) Analyze
e) Understand

Reason(s):

2A. A physical therapist is working with a patient who is aware that he is terminally ill. Which of the following courses of action is most appropriate when the patient wants to talk about his prognosis?

a) Patient is discouraged from talking about death and dying
b) Pastoral counseling
c) The therapist's experiences with terminally ill patients
d) Encouraging the patient's expression of feelings

2B. A patient who is terminally ill and knows the diagnosis wants to talk with the physical therapist about the diagnosis. Which of the following courses of action is **MOST** appropriate for the therapist?

a) Discourage discussion of death and dying
b) Refer the patient for pastoral counseling
c) Relate the therapist's experience with other patients
d) Encourage the patient's expression of feelings

Reason(s):

3A. The mean of a distribution of test scores is the:

a) Most frequently occurring score
b) Arithmetic average
c) 50th percentile
d) Measure of score range

3B. A university developed an aptitude test to use for admission to its Honors Program. The test was administered to a group of seven applicants who obtained the following scores: 70, 72, 72, 80, 89, 94, 98. The mean score on the aptitude test is:

a) 72
b) 80
c) 82
d) 90

Reason(s):

Which question in each pair is the best question? Why?

4A. Ribosomes are important for:

a) the nucleus
b) DNA
c) Cellulose
d) Protein synthesis

Reason(s):

4B. Suppose you thoroughly and adequately examined a particular type of cell, using the transmission electronic microscope, and discovered that it completely lacked ribosomes. You would then conclude that this cell also lacked:

a) A nucleus
b) DNA
c) Cellulose
d) Protein synthesis

5A. In what year did World War I begin?

a) 1714
b) 1814
c) 1914
d) 1614

Reason(s):

5B. In what year did World War I begin?

a) 1914
b) 1915
c) 1916
d) 1917

6A. Countries that made up the "Central Powers" in World War I included:

1. Germany
2. Austria-Hungary
3. United States
4. Russia

a) 1 and 2
b) 1, 2, and 3
c) 1, 2, and 4
d) 2 and 3

Reason(s):

6B. Which countries below were members of the "Central Powers" in World War I?

1. Germany
   a) member of Central Powers b) not a member
2. Austria-Hungary
   a) member of Central Powers b) not a member
3. United States
   a) member of Central Powers b) not a member
4. Russia
   a) member of Central Powers b) not a member

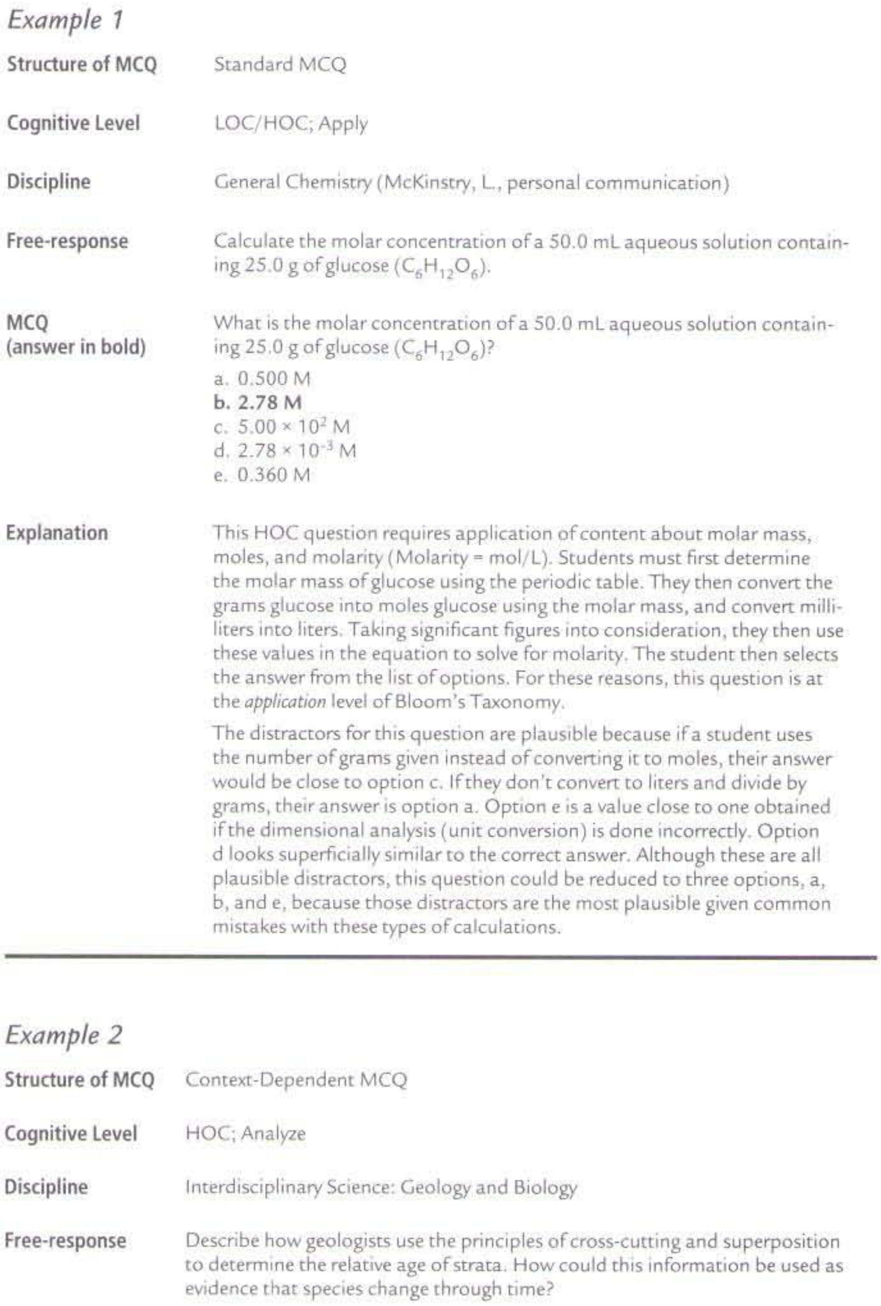
Use the space below to evaluate the example questions you brought. For each question answer:

1. Can you match this question to a couse-level or session-level objective?

2. Does the question violate any item writing guidelines? If so, how can it be adjusted?(See pages 3-4 for the Item Writing Guidelines)

3. What level of Bloom's taxonomy does the question plot on? Is there a way to alter the question so that it plots as a higher order question? (See page 5 for the Bloom's table)

Examples of converting "high-level" short-answer questions into multiple-choice questions.



Example 1

Structure of MCQ	Standard MCQ
Cognitive Level	LOC/HOC; Apply
Discipline	General Chemistry (McKinstry, L., personal communication)
Free-response	Calculate the molar concentration of a 50.0 mL aqueous solution containing 25.0 g of glucose ($C_6H_{12}O_6$).
MCQ **(answer in bold)**	What is the molar concentration of a 50.0 mL aqueous solution containing 25.0 g of glucose ($C_6H_{12}O_6$)? a. 0.500 M **b. 2.78 M** c. 5.00×10^2 M d. 2.78×10^{-3} M e. 0.360 M
Explanation	This HOC question requires application of content about molar mass, moles, and molarity (Molarity = mol/L). Students must first determine the molar mass of glucose using the periodic table. They then convert the grams glucose into moles glucose using the molar mass, and convert milliliters into liters. Taking significant figures into consideration, they then use these values in the equation to solve for molarity. The student then selects the answer from the list of options. For these reasons, this question is at the *application* level of Bloom's Taxonomy. The distractors for this question are plausible because if a student uses the number of grams given instead of converting it to moles, their answer would be close to option c. If they don't convert to liters and divide by grams, their answer is option a. Option e is a value close to one obtained if the dimensional analysis (unit conversion) is done incorrectly. Option d looks superficially similar to the correct answer. Although these are all plausible distractors, this question could be reduced to three options, a, b, and e, because those distractors are the most plausible given common mistakes with these types of calculations.

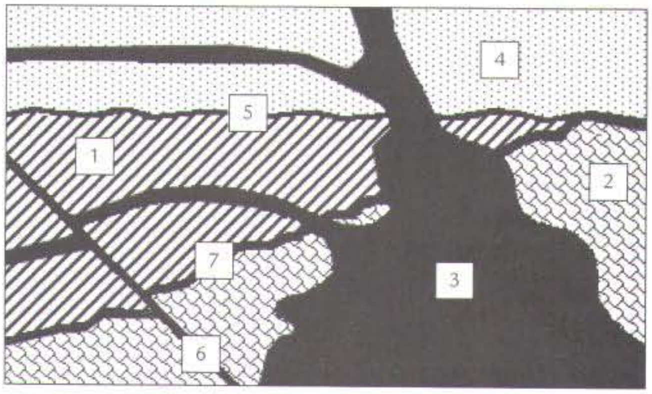
Example 2

Structure of MCQ	Context-Dependent MCQ
Cognitive Level	HOC; Analyze
Discipline	Interdisciplinary Science: Geology and Biology
Free-response	Describe how geologists use the principles of cross-cutting and superposition to determine the relative age of strata. How could this information be used as evidence that species change through time?

(from: Assessment in the College Science Classroom, by C. Dirks, et al.; 2014, W.H. Freeman)

MCQ
(answer in bold)

1. Using the principles of cross-cutting and superposition, place the sequence of depositional or structural events depicted in the figure from oldest to youngest.



   a. 2, 1, 7, 5, 4, 6, 3
   b. 7, 2, 1, 6, 3, 5, 4
   c. 2, 7, 1, 5, 4, 3, 6

2. If transitional fossils were found in layers 1, 2, and 4, which of the following is true of the fossils found in layer 1?
   a. fossils in layer 1 represent organisms from which the species in layer 4 evolved
   b. fossils in layer 1 represent organisms from which the species in layer 2 evolved
   c. fossils in layer 1 are not related to the species in layers 2 and 4

Explanation

This HOC question requires application of content, analysis of the diagram, and inference, and is at the *analysis* level of Bloom's Taxonomy. In the first part, students must apply the principles of superposition and cross-cutting to determine the relative dates of the strata. Strata deposited on top of other strata are younger; strata that cross-cut other strata are also younger. This question has two strong distractors because strata 2 and 7 are the oldest layers; it may appear that layer 7 cross-cuts layer 2, so some students might select this option. The students need only to compare three strata (1, 2, and 7) to make a selection.

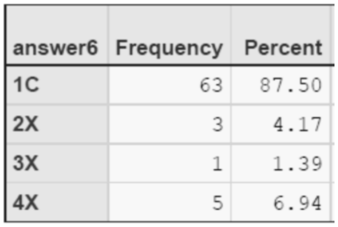
Although the second question also requires students to determine the relative dates of strata, the three strata selected are depositional and easier to date. Thus, the task is not as difficult as in question 1. However, question 2 requires students to understand that transitional fossils show common ancestry and to infer the ancestral relationships by comparing the strata in which they are found. This question is at the *analysis* level of Bloom's Taxonomy.

Example 3

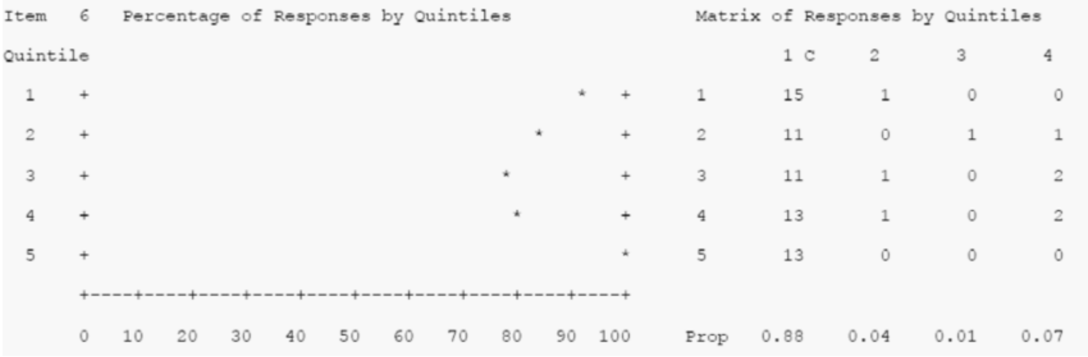
Structure of MCQ	True/False, Two-Tier Question
Cognitive Level	HOC; Apply or Analyze
Discipline	General Biology
Free-response	Explain how 2,4-dinitrophenol, an ionophore that transports protons across the inner mitochondrial membrane to the matrix, affects ATP synthesis.
MCQ (answer in bold)	1. The drug 2,4-dinitrophenol is an ionophore that transports protons across the inner mitochondrial membrane to the matrix. This drug would increase ATP synthesis. True or **False**? 2. Your selection is most closely associated with which of the following explanations? a. the drug directly increases the electrochemical gradient **b. the drug directly decreases the electrochemical gradient** c. the drug directly impacts ATP synthase and the reaction that makes ATP
Explanation	This HOC question requires application of content and inference of how 2,4-dinitrophenol impacts cellular respiration. To correctly answer the true/false question, students must know that the electron transport chain creates an electrochemical gradient, or proton force, by pumping protons from the matrix to the inner membrane space of the mitochondria. This gradient is then used to drive the reaction catalyzed by ATP synthase that makes ATP. Asking this question as a two-tiered question helps reduce the error associated with guessing the answer to the first question. Distractor "a" in question 2 is based on whether the student knows that the proton force is an electrochemical gradient and also the direction in which protons are pumped—from the matrix to the inner membrane space. Distractor "c" is based on a common misconception that the electron transport chain is directly connected to the production of ATP by ATP synthase. This drug would indirectly impact ATP synthase in catalyzing the reaction that makes ATP. This question is at the *analysis* level of Bloom's Taxonomy.

Item Analysis – What Teachers Learn from Administering a Test

1. Where would freeze-thaw weathering most likely occur?
   a. **At the top of the Sandia Mountains**
   b. In a rainforest
   c. Along a coastline
   d. Along the Rio Grande in Albuquerque



answer6	Frequency	Percent
1C	63	87.50
2X	3	4.17
3X	1	1.39
4X	5	6.94



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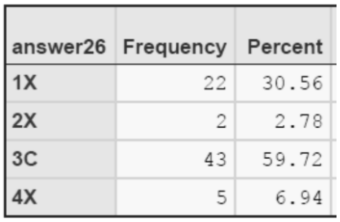
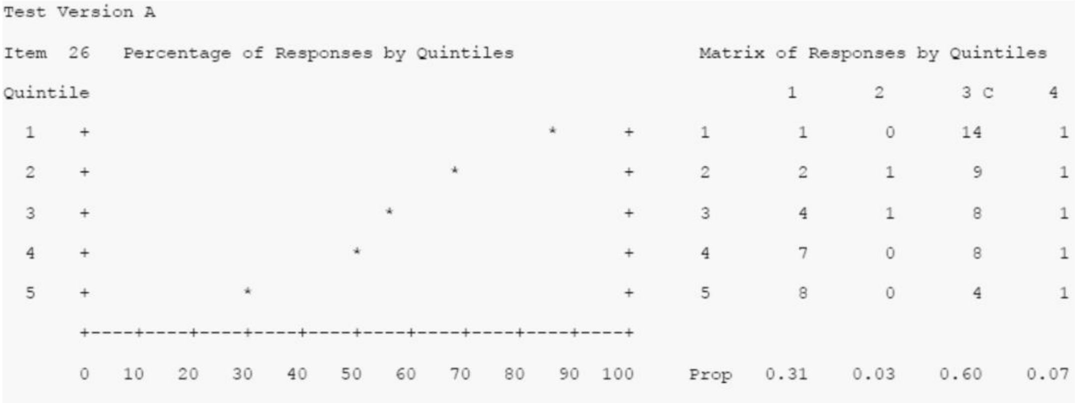
Item   6   Percentage of Responses by Quintiles                 Matrix of Responses by Quintiles
Quintile                                                                1 C      2       3       4
  1    +                                             *   +      1       15       1       0       0
  2    +                                         *       +      2       11       0       1       1
  3    +                                      *          +      3       11       1       0       2
  4    +                                       *         +      4       13       1       0       2
  5    +                                                 *      5       13       0       0       0
       +----+----+----+----+----+----+----+----+----+----+
       0   10   20   30   40   50   60   70   80   90  100     Prop   0.88    0.04    0.01    0.07
```

2. A feldspar is plucked from sandstone, analyzed at an isotope-dating lab, and determined to be 200 million year old. What does this tell you about the age of the sandstone?
   a. The sandstone is older than 200 million years old
   b. The sandstone is 200 million years old
   c. The sandstone is less than 200 million years old.
   d. Nothing. The sandstone could be any age.



answer26	Frequency	Percent
1X	22	30.56
2X	2	2.78
3C	43	59.72
4X	5	6.94



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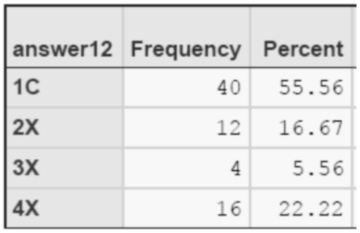
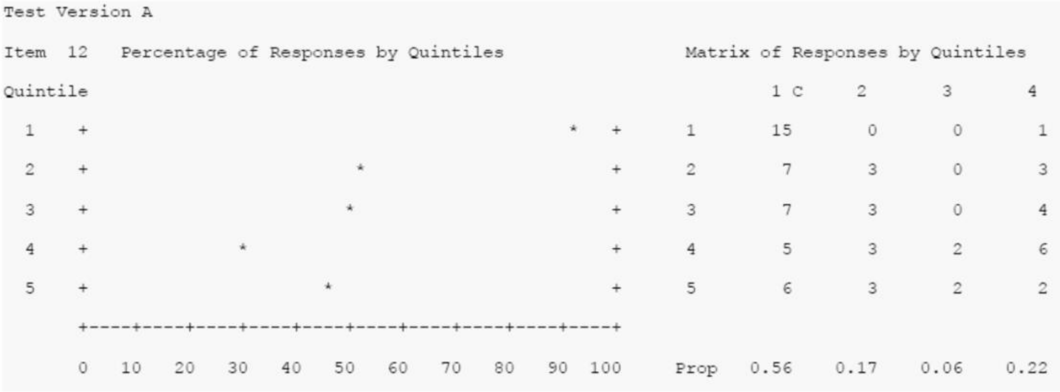
Test Version A
Item  26   Percentage of Responses by Quintiles                 Matrix of Responses by Quintiles
Quintile                                                                 1       2       3 C     4
  1    +                                          *      +      1        1       0      14       1
  2    +                                 *               +      2        2       1       9       1
  3    +                           *                     +      3        4       1       8       1
  4    +                        *                        +      4        7       0       8       1
  5    +              *                                  +      5        8       0       4       1
       +----+----+----+----+----+----+----+----+----+----+
       0   10   20   30   40   50   60   70   80   90  100     Prop   0.31    0.03    0.60    0.07
```

3. Which of the following factors does <u>not</u> determine the mineral composition and texture of a metamorphic rock?
   a. **Environment of deposition**
   b. Original rock composition
   c. Temperature and pressure
   d. Abundance and composition of fluid



answer12	Frequency	Percent
1C	40	55.56
2X	12	16.67
3X	4	5.56
4X	16	22.22



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Test Version A

Item  12   Percentage of Responses by Quintiles            Matrix of Responses by Quintiles

Quintile                                                           1 C      2       3       4

  1    +                                             *   +     1     15      0       0       1

  2    +                         *                       +     2      7      3       0       3

  3    +                        *                        +     3      7      3       0       4

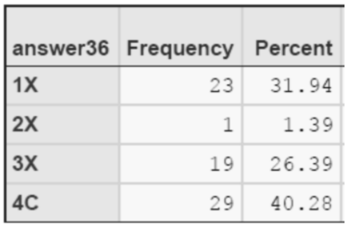
  4    +              *                                  +     4      5      3       2       6

  5    +                      *                          +     5      6      3       2       2

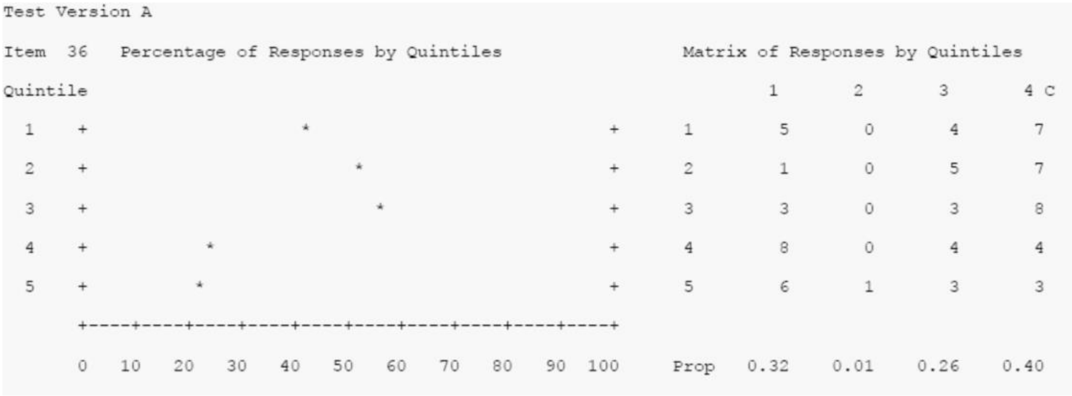
       +----+----+----+----+----+----+----+----+----+----+

       0    10   20   30   40   50   60   70   80   90  100    Prop  0.56    0.17    0.06    0.22
```

4. Which property of seismic waves has been most important to allow seismologists to identify the boundaries of the inner core/outer core boundary and the outer core/mantle boundary?
   a. Wave reflection
   b. Wave amplitude
   c. Wave velocity
   d. **Wave refraction**



answer36	Frequency	Percent
1X	23	31.94
2X	1	1.39
3X	19	26.39
4C	29	40.28



```
Test Version A

Item  36   Percentage of Responses by Quintiles            Matrix of Responses by Quintiles

Quintile                                                           1       2       3     4 C

  1    +                    *                            +     1      5      0       4       7

  2    +                         *                       +     2      1      0       5       7

  3    +                           *                     +     3      3      0       3       8

  4    +          *                                      +     4      8      0       4       4

  5    +         *                                       +     5      6      1       3       3

       +----+----+----+----+----+----+----+----+----+----+

       0    10   20   30   40   50   60   70   80   90  100    Prop  0.32    0.01    0.26    0.40
```

Some links for writing exam questions

Writing good multiple choice exams, by Dawn M. Zimmaro,
https://ctl.utexas.edu/sites/default/files/documents/Writing-Good-Multiple-Choice-Exams-04-28-10.pdf

Designing and Managing Multiple Choice Questions,
http://web.uct.ac.za/projects/cbe/mcqman/mcqman01.html (use Internet Explorer)

How Can We Construct Good Multiple-Choice Items? by Derek Cheung and Robert Bucat
http://www3.fed.cuhk.edu.hk/chemistry/files/constructMC.pdf

To How to Prepare Better Multiple-Choice Test Items: for University Faculty by Steven J. Burton, Richard R. Sudweeks, Paul F. Merrill and Bud Wood
https://testing.byu.edu/handbooks/betteritems.pdf

How to Prepare Better Tests: Guidelines for University Faculty by Beverly B. Zimmerman, Richard R. Sudweeks, Monte F. Shelley and Bud Wood
https://testing.byu.edu/handbooks/bettertests.pdf

Improving Multiple Choice Tests by Klegg and Cashin
http://www.theideacenter.org/sites/default/files/Idea_Paper_16.pdf

Authentic Assessment Toolbox
http://jonathan.mueller.faculty.noctrl.edu/toolbox/index.htm

Constructing Tests
http://www.washington.edu/teaching/constructing-tests/

STEM Gateway
Course Redesign Teaching Professional
Development Program:

Learning From Each Other- A Different Way to Think about Classroom Observation

- Have you ever considered visiting a colleague’s class to learn about teaching from observing how she or he teaches?
- How can your redesign effort be improved by learning from each other’s classroom practices?
- How can you maximize your learning during a classroom observation?

STEM GATEWAY
Project for Inclusive
Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

Learning from One Another Through Observations

A list of questions to contemplate when making classroom observations for the purpose of learning as an observer, rather than for evaluating the teacher. This draft was prepared collaboratively by members of the STEM Gateway course redesign teams on October 21, 2013.

In-Class Observation

Things to look for:

1. *Introducing the topic*
   - a. How are objectives addressed?
   - b. How is relevance of the class session addressed?
   - c. How are links to other course topics addressed?
   - d. How much time is allotted to introducing the topic?

2. *Implementing direct instruction and active learning*

   a. How is instructor transmission of knowledge to students occurring?

   b. How is instructor-to-student interaction occurring?

   c. How is student-to-student interaction occurring?

3. What are the students doing?

Reformed Teaching Observation Protocol (RTOP) Scoring Rubric

(From Classroom Observation Project, Science Education Resource Center, http://serc.carleton.edu/NAGTWorkshops/certop/index.html)

Lesson Design and Implementation (What Teacher Intended to Do)				
1) Instructional strategies and activities respected students' prior knowledge and the preconceptions inherent therein (what's happened before this class)				
Never occurred 0	Lesson is designed to remind students of what they already know and to make use of students' everyday knowledge Inform 1	Lesson is designed to use student input to assess their prior knowledge but not to adjust. Ask 2	Lesson is designed to activate student prior knowledge, assess and adjust content as needed, and makes use of students' input on their prior knowledge Act 3	Lesson is designed to activate student prior knowledge, assess and adjust content as needed, and makes use of students' input throughout the class Maximizes opportunity 4

Comments:

A cornerstone of reformed teaching is taking into consideration the prior knowledge that students bring with them. The term "respected" is pivotal in this item. It suggests an attitude of curiosity on the teacher's part, an active solicitation of student ideas, and an understanding that much of what a student brings to the mathematics or science classroom is strongly shaped and conditioned by their everyday experiences.

Prior knowledge includes both instruction from prior classes and knowledge from everyday experiences. Strategies for referencing prior knowledge include everyday analogies, references to learning from other courses, and references to previous classes in this course. A strong class will activate prior knowledge before initiating relevant instruction, will adjust to prior knowledge levels, and will activate prior knowledge in specific contexts throughout the lesson.

<table>
<tr><td colspan="5">2) The lesson was designed to engage students as members of a learning community</td></tr>
<tr><td>No evidence
0</td><td>Lesson has limited opportunities to engage students. (e.g., some clickers, rhetorical questions with shout out opportunities, clarification questions)
1</td><td>Lesson is designed for continual interaction between teacher and students
2</td><td>Lesson is designed to include both extensive teacher-student and student-student interactions
3</td><td>Lesson was designed for students to negotiate meaning of content primarily through student-student interaction
4</td></tr>
<tr><td colspan="5"><i>Comments:</i> Much knowledge is socially constructed. The setting within which this occurs has been called a “learning community.” The use of the term community in the phrase “the scientific community” (a “self-governing” body) is similar to the way it is intended in this item. Students participate actively, their participation is integral to the actions of the community, and knowledge is negotiated within the community. It is important to remember that a group of learners does not necessarily constitute a “learning community.</td></tr>
</table>

<table>
<tr><td colspan="5">3) In this lesson, student exploration preceded formal presentation (students asked to think or do something relevant to new content **prior to** introduction of concept or can come later and be with respect to details)</td></tr>
<tr>
<td>No exploration preceded explanation of new content (instructor provides answers, tells students how to work through a problem, gives the facts or solutions to a problem, or leads students on a step-by-step solution)
0</td>
<td>Exploration precedes new content that is limited in quality or quantity (e.g., students don't interact with each other, teacher intercepts some of their ability to draw conclusions, not enough time is provided to make any meaningful conclusions)
Limited opportunities
1</td>
<td>Exploration precedes new content prior to the larger conceptual framework has been presented, but may lack student opportunities to explore without teacher intervention or enough time to make clear connections to the larger framework
Opportunity provided with limited connection
2</td>
<td>Exploration precedes new content that encourages students to work together, to ask probing questions that re-direct their thinking, and teacher acts as a consultant for students, but students may not have a clear reason for why exploration occurred
Opportunities but lacking full follow-through
3</td>
<td>Exploration precedes new content that encourages students to work together, to ask probing questions that re-direct their thinking, and teacher acts as a consultant for students. Students are able to clearly tie their exploration to the larger conceptual framework
Longer quality opportunities
4</td>
</tr>
<tr><td colspan="5">*Comments:* Reformed teaching allows students to build complex abstract knowledge from simpler, more concrete experience. This suggests that any formal presentation of content should be preceded by student exploration. This does not imply the converse...that all exploration should be followed by a formal presentation
Students draw conclusions prior to proceeding, teacher creates a need-to-know setting</td></tr>
</table>

<table>
<tr><td colspan="5">4) This lesson encouraged students to seek and value alternative modes of investigation or of problem solving (questions have more than one right possible answer)</td></tr>
<tr>
<td>No alternative modes explored
0</td>
<td>Lesson designed for instructor to introduce open-ended questions with multiple correct answers or describe multiple modes of investigation
Instructor Tell/Introduce
1</td>
<td>Lesson designed for students to make use of or explore multiple modes of investigation
Students Use
2</td>
<td>Lesson designed for students to generate and explore open-ended questions or to generate multiple modes for investigating a question
Students Generate
3</td>
<td>The central method of learning in the class is student generation of and exploration of an open-ended problem using multiple modes of investigation.
Central focus of class
4</td>
</tr>
<tr><td colspan="5">*Comments:*
Divergent thinking is an important part of mathematical and scientific reasoning. A lesson that meets this criterion would not insist on only one method of experimentation or one approach to solving a problem. A teacher who valued alternative modes of thinking would respect and actively solicit a variety of approaches, and understand that there may be more than one answer to a question.
Modes of investigation refer to different approaches or lines of evidence for address a problem. In a lower scoring class, these are presented to the students by the instructor. In a high scoring class students are actively involved in generating approaches.</td></tr>
</table>

5) The focus and direction of the lesson was often determined by ideas originating with students (is there a clear plan to incorporate student ideas?)				
Lesson is entirely instructor directed 0	Lesson plan accommodates instructor pausing for student questions and ideas 1	Lesson plan call for student generated ideas 2	Lesson plan designed adjustments based on student input. 3	Lesson plan is entirely student directed, with content guided by instructor, but has allowances for different ideas, and questions 4
Comments: If students are members of a true learning community, and if divergence of thinking is valued, then the direction that a lesson takes can not always be predicted in advance. Thus, planning and executing a lesson may include contingencies for building upon the unexpected. A lesson that met this criterion might not end up where it appeared to be heading at the beginning.				

Content: Propositional Knowledge (What the Teacher knows, and how well they are able to organize and present material in a learner-oriented setting)

6) The lesson involved fundamental concepts of the subject (Is *content* concept-oriented?)

No clear focus, just a series of random facts 0	A suggestion of concepts, but not obvious and mostly facts rather than overall concepts 1	Concept taught, but not necessarily within a conceptual framework. Topic is bogged down in term definitions 2	Concepts are presented within a conceptual framework, but still contains miscellaneous details/facts and/or tangents 3	Instructor ties concepts to conceptual framework without any tangential material that potentially confounds 4

Comments:
The emphasis on “fundamental” concepts indicates that there were some significant scientific or mathematical ideas at the heart of the lesson. For example, a lesson on the multiplication algorithm can be anchored in the distributive property. A lesson on energy could focus on the distinction between heat and temperature.

7) The lesson promoted strongly coherent conceptual understanding (Presented in a logical and clear fashion—*how it’s presented*; does the lesson make sense, general flow)

Not presented in any logical manner, lacks clarity and no connections between material and no concepts 0	Lesson is disjointed and not consistently focused on the concepts 1	Lesson is may be clear and/or logical but relation of content to concepts is very inconsistent (or vice versa) 2	Lesson is predominantly presented in a clear and logical fashion, but relation of content to concepts is not always obvious 3	Lesson is presented in a clear & logical manner, relation of content to concepts is clear throughout and it flows from beginning to end. 4

Comments: The word “coherent” is used to emphasize the strong inter-relatedness of mathematical and/or scientific thinking. Concepts do not stand on their own two feet. They are increasingly more meaningful as they become integrally related to and constitutive of other concepts.

<table>
<tr><td colspan="5">8) The teacher had a solid grasp of the subject matter content inherent in the lesson</td></tr>
<tr><td>Teacher had no clear understanding of content
0</td><td>Teacher has some of the fundamentals, but lesson is still wrought with errors
1</td><td>Mistakes are abundant or non-trivial, may promote misconceptions but many fundamentals are sound
2</td><td>May have minor mistakes, overall accurate delivery
3</td><td>No mistakes, all information presented is accurate.
4</td></tr>
<tr><td colspan="5"><i>Comments:</i>
This indicates that a teacher could sense the potential significance of ideas as they occurred in the lesson, even when articulated vaguely by students. A solid grasp would be indicated by an eagerness to pursue student’s thoughts even if seemingly unrelated at the moment. The grade-level at which the lesson was directed should be taken into consideration when evaluating this item.</td></tr>
</table>

<table>
<tr><td colspan="5">9 Elements of abstraction (i.e., symbolic representations, theory building) were encouraged when it was important to do so (is the instructor using abstractions (representations of phenomena that cannot be observed directly) in a way that scaffolds student development of conceptual understanding)</td></tr>
<tr><td>Teacher uses only text/facts with no opportunities for students to develop conceptual understanding
Not present
0</td><td>Teacher uses few elements of abstraction (e.g., diagrams, equations) and not in a logical sequence to develop student conceptual understanding
Few
1</td><td>Teacher uses few elements of abstraction (e.g., diagrams, equations) in a logical sequence to develop student conceptual understanding
Few in Sequence
2</td><td>Teacher uses multiple elements of abstraction (e.g., diagrams, equations) in a logical sequence to develop student conceptual understanding
Many in Sequence
3</td><td>Teacher uses multiple elements of abstraction (e.g., diagrams, equations) in a logical sequence to develop and assess student conceptual understanding
Assess
4</td></tr>
<tr><td colspan="5"><i>Comments:</i>
Conceptual understanding can be facilitated when relationships or patterns are represented in abstract or symbolic ways. Not moving toward abstraction can leave students overwhelmed with trees when a forest might help them locate themselves.</td></tr>
</table>

<table>
<tr><td colspan="5">10) Connections with other content disciplines and/or real world phenomena were explored and valued</td></tr>
<tr>
<td>No connections drawn to real world/other disciplines
0</td>
<td>Some connection to real world/other disciplines made in passing, but not central for content comprehension
Not integral to lesson
1</td>
<td>Teacher makes a deliberate effort to connect to real world/ other disciplines, but teacher does all the talking
Integral but passive
2</td>
<td>Students participate in making connections to other disciplines/real world phenomena
A single set of strong ties is generated
Collaborative development
3</td>
<td>Students participate in making multiple connections to other disciplines and real world phenomena in ways that extend their understanding of central concepts
A robust network of ties is generated
4</td>
</tr>
<tr><td colspan="5"><i>Comments:</i>
Connecting mathematical and scientific content across the disciplines and with real world applications tends to generalize it and make it more coherent. A physics lesson on electricity might connect with the role of electricity in biological systems, or with the wiring systems of a house. A mathematics lesson on proportionality might connect with the nature of light, and refer to the relationship between the height of an object and the length of its shadow.
The goal is to integrate the new knowledge with other learning particularly from other disciplines and to show their application in real world applications/phenomena. The goal is to build ties between students existing knowledge, the new knowledge and real world application. Time invested in assisting students in building a single set of strong ties has more value than developing a large number of weak ties.</td></tr>
</table>

Content: Procedural Knowledge (What students did)

11) Students used a variety of means (models, drawings, graphs, symbols, concrete materials, manipulatives, etc.) to represent phenomena (variety of means, could also include written interpretation)

Students are not asked to do anything 0	Students use only one means of representing or interpreting phenomena Single Use 1	Students use at least 2 means of representing or interpreting phenomena Multiple Means 2	Students use at least 2 means of representing and interpreting phenomena Representing and Interpreting 3	Students use multiple means of representing and interpreting phenomena Multiple Means, Multiple Uses 4

Comments:

Multiple forms of representation allow students to use a variety of mental processes to articulate their ideas, analyze information and to critique their ideas. A “variety” implies that at least two different means were used. Variety also occurs within a given means. For example, several different kinds of graphs could be used, not just one kind.

Students that are *asked* to interpret a graph, or map, or diagram does count as interpreting phenomena.

<table>
<tr><td colspan="5">12) Students made predictions, estimations, and/or hypotheses (PEH) and devised means for testing them-</td></tr>
<tr>
<td>No opportunities for students to make PEHs
0</td>
<td>Teacher may ask class to make PEHs as a whole, only a few students are involved in response, no devised means for testing
Poorly executed
1</td>
<td>Teacher may ask students to make PEHs, mechanism to involve majority of students in generation but no devised means for testing.
Incomplete execution
2</td>
<td>All students are engaged in generating PEHs and in devising testing to enhance understanding of a central concept. Instructor drives generation of PEH and/or testing.
Highly prescribed
3</td>
<td>All students are engaged in generating PEHs and in devising testing to enhance understanding of a central concept.. Students drive generation of PEH and testing
Student driven
4</td>
</tr>
<tr><td colspan="5">*Comments:*
This item does not distinguish among predictions, hypotheses and estimations. Another word that might be used in this context is “conjectures”. The idea is that students explicitly state what they think is going to happen before collecting data.

A highly scoring class would require that students have the experience of drawing together data, making a prediction, hypothesis or estimation (PEH), and testing the quality of their PEH in a way that enhances their understanding of the central concepts of the lesson.</td></tr>
</table>

<table>
<tr><td colspan="5">13) Students were actively engaged in thought-provoking activity that often involved the critical assessment of procedures (quality)</td></tr>
<tr>
<td>Students are completely passive
0</td>
<td>Students engage in a single thought-provoking activity, perhaps with prompting for minimal critical assessment of procedure
Teacher driven, few opportunities incomplete
1</td>
<td>Students engage in a thought provoking activity combined with a follow on prompting for critical assessment of procedure
Complete opportunity
2</td>
<td>Students engage in a single activity that requires critical analysis and synthesis of both content and procedures <i>or</i> in multiple examples of level 2 activities
Multiple opportunities or a single complete deep activity
3</td>
<td>Students engage in activities that requires both critical analysis and consideration of where/how students could proceed with new knowledge
Student driven, deep, multiple complete opportunities
4</td>
</tr>
<tr><td colspan="5"><i>Comments:</i>
This item implies that students were not only actively doing things, but that they were also actively thinking about how what they were doing could clarify the next steps in their investigation.

Critical assessment of procedures:
- question assumptions
- explore next steps
- consider why you are using a procedures
- evaluate if what you just did makes sense (road check)</td></tr>
</table>

<table>
<tr><td colspan="5">14) Students were reflective about their learning (what do you think, and how do you know?)</td></tr>
<tr>
<td>No reflection
0</td>
<td>Teacher sets up at least one opportunity for students to reflect on learning.
1</td>
<td>Teacher sets up some opportunities for students to reflect perhaps with prompts
Absence of scaffolding to leverage learning experiences
2</td>
<td>Teacher sets up multiple opportunities for students to reflect with prompts and assists students in understanding relationship to future learning in some way
Partial implementation
Not well scaffolded
3</td>
<td>Students have pervasive opportunities to reflect with structured prompts that scaffold their ability to leverage learning experiences for future use.
Thorough
Ongoing, students practice increasing metacognition
4</td>
</tr>
<tr><td colspan="5">*Comments:*
Active reflection is a meta-cognitive activity that facilitates learning. It is sometimes referred to as “thinking about thinking.” Teachers can facilitate reflection by providing time and suggesting strategies for students to evaluate their thoughts throughout a lesson. A review conducted by the teacher may not be reflective if it does not induce students to *re-examine* or *re-assess* their thinking.
We want student to reflect on what they have learned, how they have learned, and on the utility of both these things in further learning (either as content or strategy). Ongoing opportunities for reflection will score more highly, as will structured prompts that scaffold students ability to leverage learning experiences for future use.</td></tr>
</table>

15) Intellectual rigor, constructive criticism, and the challenging of ideas were valued (negotiating meaning/ debating ideas)				
Students did not have the opportunity to demonstrate rigor, offer criticisms, or challenge ideas No opportunity 0	At least once the students respond (perhaps by shout out”) to teacher’s queries regarding alternate ideas, alternative reasoning, alternative interpretations. Single query/one response 1	Students participate in a teacher directed discussion of differing points of view and evaluation of ideas Teacher-facilitated discussion 2	Students participate in a teacher-guided but student driven, debate of ideas. Teacher is integral in drawing conclusion regarding evaluation of ideas Teacher-guided group debate/discussion 3	Every student participates in debate of ideas that results in group negotiated conclusion that makes deliberate use of evidence/ arguments to support claims. Negotiated student group debate 4
Comments: At the heart of mathematical and scientific endeavors is rigorous debate. In a lesson, this would be achieved by allowing a variety of ideas to be presented, but insisting that challenge and negotiation also occur. Achieving intellectual rigor by following a narrow, often prescribed path of reasoning, to the exclusion of alternatives, would result in a low score on this item. Accepting a variety of proposals without accompanying evidence and argument would also result in a low score.				

<table>
<tr><th colspan="5">Classroom Culture: Communicative Interactions (Student-Student Interaction)*</th></tr>
<tr><td colspan="5">16) Students were involved in the communication of their ideas to others using a variety of means and media (variety of types and scales of delivery)- A</td></tr>
<tr>
<td>No student interactions – Students asking questions of the instructor or responding individually to questions posed by the instructor does not constitute interaction
0</td>
<td>At least one opportunity for student interaction that makes use of a single mode and scale of interaction
Single mode
1</td>
<td>Either more than one type of student-student communication, but not at a variety of scales (i.e., pairs, small group, group to group, whole class) or vice versa
Not complete
2</td>
<td>Multiple modes and scales are represented in the interactions. They may not be well facilitated or well integrated into the learning experience
Complete but not well executed
3</td>
<td>Students have multiple opportunities to interact at different scales using multiple modes. Communication is well facilitated.
Comprehensive integration of student interaction
4</td>
</tr>
<tr><td colspan="5"><i>Comments:</i>
The intent of this item is to reflect the communicative richness of a lesson that encouraged students to contribute to the discourse and to do so in more than a single mode (making presentations, brainstorming, critiquing, listening, making videos, group work, etc.). Notice the difference between this item and item 11. Item 11 refers to representations. This item refers to active communication.
The goal of the communication is to increase students' understanding of central concepts or their skill level on central skills. A high scoring class requires both a variety of modes for students interaction (e.g. brainstorming, problem solving, discussing, presenting, group work) <i>And</i> interactions at multiple scales (e.g. student-student, student-class, whole class). In high scoring classes, communication is well facilitated. The amount of time students spend in interaction is scored below in Q18.</td></tr>
</table>

*Communicative interactions in a classroom are an important window into the culture of that classroom. Lessons where teachers characteristically speak and students listen are not reformed. It is important that students be heard, and often, and that they communicate with one another, as well as with the teacher. The nature of the communication captures the dynamics of knowledge construction in that community. Recall that communication and community have the same root.

17) The teacher's questions triggered divergent modes of thinking (by students)				
No divergent modes of thinking No opportunity 0	Students listen to teacher present an example of more than one answer or interpretation, but student thinking limited to individual questions about the material. Teacher-sourced divergent modes 1	Students interact with each other in response to teacher-framed question(s) that has/have more than one answer or interpretation, but the directions ask for just one "right" response Student interact/respond to divergent modes 2	Students work with each other on one or more instructor posed problem that has more than one solution, and to generate complete solutions Students actively engaged in divergent mode problems 3	Students work with each other on open ended problems Opportunities provided for students to ask divergent questions of each other and encouraged to pursue alternative solutions- Student-student driven queries of divergent modes 4
Comments: This item suggests that teacher questions should help to open up conceptual space rather than confining it within predetermined boundaries. In its simplest form, teacher questioning triggers divergent modes of thinking by framing problems for which there **may be more than one correct answer** or framing phenomena that can have more than one valid interpretation.				

<table>
<tr><td colspan="5">18) There was a high proportion of student talk and a significant amount of it occurred between and among students (quantity of interactions)</td></tr>
<tr><td>No student-student talk
0</td><td>Students talk to each other at least once (about lesson content)
1</td><td>Student-student talk occurs at least 10% of the time during the course of the class
2</td><td>Student-student talk occurs more than 25% of the time during the course of the class
3</td><td>In any given moment during the lesson, students are more likely to be talking to each other than the teacher (>50% student to student)
4</td></tr>
<tr><td colspan="5">*Comments:* A lesson where a teacher does most of the talking is not reformed. This item reflects the need to increase both the amount of student talk and of talk among students. A “high proportion” means that at any point in time it was as likely that a student would be talking as that the teacher would be. A “significant amount” suggests that critical portions of the lesson were developed through discourse among students.</td></tr>
</table>

<table>
<tr><td colspan="5">19) Student questions and comments often determined the focus and direction of classroom discourse (quality of student interactions)</td></tr>
<tr><td>No student input
0</td><td>Student conversations are short and limited to “the answer,” no negotiation of meaning
1</td><td>Student conversations are brief but do involve some negotiation of meaning
2</td><td>Student conversations are in depth examinations of a problem
3</td><td>Student conversations are detailed, multi-faceted examinations of recent and previously learned content that is student directed
4</td></tr>
<tr><td colspan="5">*Comments:*
This item implies not only that the flow of the lesson was often influenced or shaped by student contributions, but that once a direction was in place, students were crucial in sustaining and enhancing the momentum.</td></tr>
</table>

20) There was a climate of respect for what others had to say				
No ideas beyond instructor are heard Or there is a climate of disrespect 0	Student voices are present and respected Respected 1	Faculty and students volunteer ideas; they respect each others point of view and refer to each others points Used 2	A majority of faculty and students volunteer ideas or their ideas are solicited; they respect each others point of view and refer to each others points Sought 3	Every voice is solicited, heard, respected, and valued. Student talk is critical for success; different points of view are discussed and resolved to enhance learning of central ideas Critical 4
Comments: Respecting what others have to say is more than listening politely. Respect also indicates that what others had to say was actually heard and carefully considered. A reformed lesson would encourage and allow every member of the community to present their ideas and express their opinions without fear of censure or ridicule.				

Classroom Culture: Student/Teacher Relationships

21) Active participation of students was encouraged and valued

Entirely instructor directed, no student questions 0	Some student questions, may be opportunities to “shout out” ideas 1	Some student questions/ input are encouraged, and they appear to shift the direction of the lesson 2	Many students engaged some of the time in valuable conversations that leads to class discussions that appears to shift the direction 3	All students are actively engaged in meaningful conversation that guides the direction of the lesson from beginning to the end. 4

Comments:
This implies more than just a classroom full of active students. It also connotes their having a voice in how that activity is to occur. Simply following directions in an active manner does not meet the intent of this item. Active participation implies agenda-setting as well as “minds-on” and “hands- on”.

22) Students were encouraged to generate conjectures, (or) alternative solutions, and/or different ways of interpreting evidence

Instructor may present interpretations, conjectures, etc., but asks students to do nothing 0	At least one time, students were asked to consider an alternate solution, make a conjecture, or interpret evidence in more than one way. 1	Teacher-student interactions lead students through a very directed format that considers alternate solutions, and/or conjectures and/or evidence 2	Teacher-student interactions facilitate students through a flexible format that considers alternate solutions, and/or conjectures, and/or evidence 3	Whole lesson is dedicated to students discussing, exploring and critiquing/ considering alternate solutions, and/or different ways of interpreting evidence, with minimal teacher guidance 4

Comments: Reformed teaching shifts the balance of responsibility for mathematical of scientific thought from the teacher to the students. A reformed teacher actively encourages this transition. For example, in a mathematics lesson, the teacher might encourage students to find more than one way to solve a problem. This encouragement would be highly rated if the whole lesson was devoted to discussing and critiquing these alternate solution strategies.

<table>
<tr><td colspan="5">23) In general the teacher was patient with the students</td></tr>
<tr><td>No opportunity to assess or teacher was not patient (no wait time, answers own questions). Unwanted behavior is tolerated/ ignored
0</td><td>There is a bit of wait time after asking a question, instructor avoids answering his/her own questions. Or instructor works with student(s) to clarify their vague question
1</td><td>Clear wait time (waiting for multiple student thoughts, waiting for all students have a chance to consider the question; not just taking the first raised hand or “shout out”).
2</td><td>Providing some time for student-student interaction (still on task), but may not be enough time for all to achieve goals.
3</td><td>Instructor provides adequate time for meaningful conversations to occur between students (enough time to achieve goal)
4</td></tr>
<tr><td colspan="5"><i>Comments</i>
Patience is not the same thing as tolerating unexpected or unwanted student behavior. Rather there is an anticipation that, when given a chance to play itself out, unanticipated behavior can lead to rich learning opportunities. A long “wait time” is a necessary but not sufficient condition for rating highly on this item.</td></tr>
</table>

<table>
<tr><td colspan="5">24) The teacher acted as a resource person, working to support and enhance student investigations (activity beyond answering a question)</td></tr>
<tr><td>No investigations (activity that engages students to apply content through problem solving)
No investigation
0</td><td>Very teacher directed, limited student investigation, very rote
Rote response to student queries
1</td><td>Primarily directed by teacher with occasional opportunities for students to guide the direction
Teacher-student co-guidance
2</td><td>Students have freedom, but within confines of teacher directed boundaries
Student-driven direction of queries
3</td><td>Students are actively engaged in their own learning process, students determine what and how, teacher is available to help when needed
4</td></tr>
<tr><td colspan="5"><i>Comments</i>: A reformed teacher is not there to tell students what to do and how to do it. Much of the initiative is to come from students, and because students have different ideas, the teacher’s support is carefully crafted to the idiosyncrasies of student thinking. The metaphor, “guide on the side” is in accord with this item.</td></tr>
</table>

<table>
<tr><td colspan="5">25) The metaphor “teacher as listener” was very characteristic of this classroom- both D</td></tr>
<tr>
<td>Teacher was the only “talker”

No listening opportunity

0</td>
<td>Teacher listened, and acknowledged or validated an idea presented at least once.

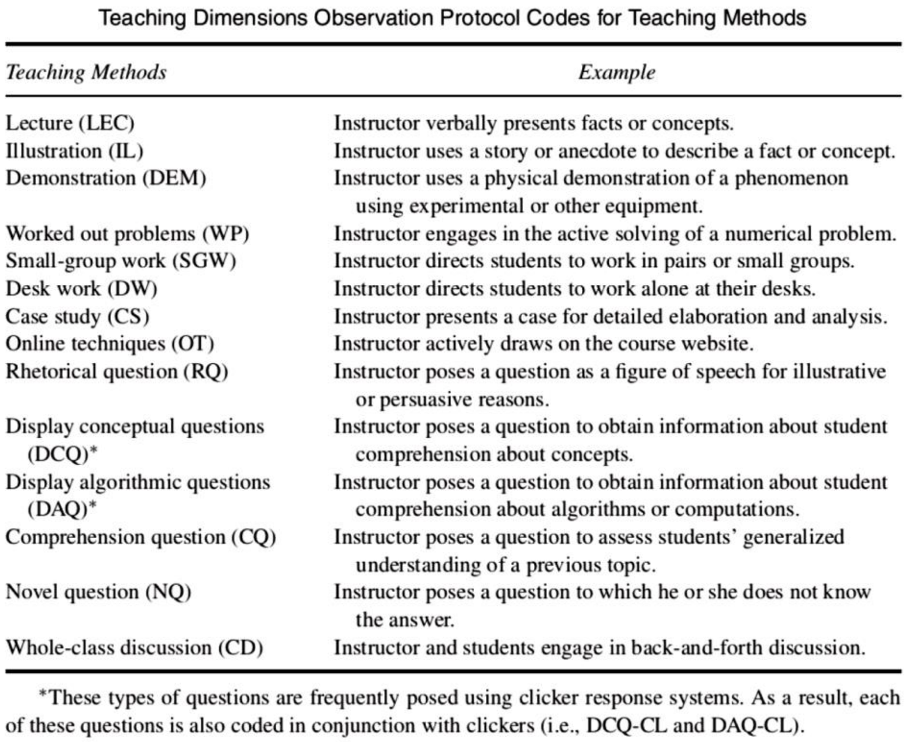
Teacher listening opportunity (at least once)
1</td>
<td>Teacher is listening throughout (from beginning to end), but doesn’t act on any ideas (but does acknowledge)

Teacher listens throughout
2</td>
<td>Teacher listens from beginning to end of lesson, but doesn’t necessarily act on ideas throughout

Teacher listens throughout and acts periodically
3</td>
<td>Teacher listens and acts on what students are saying from the beginning to the end of the lesson (from gaining prior knowledge all the way to assessing student understanding).

Teacher listens throughout and acts continuously
4</td>
</tr>
<tr><td colspan="5"><i>Comments</i>:
This metaphor describes a teacher who is often found helping students use what they know to construct further understanding. The teacher may indeed talk a lot, but such talk is carefully crafted around understandings reached by actively listening to what students are saying. “Teacher as listener” would be fully in place if “student as listener” was reciprocally engendered.</td></tr>
</table>

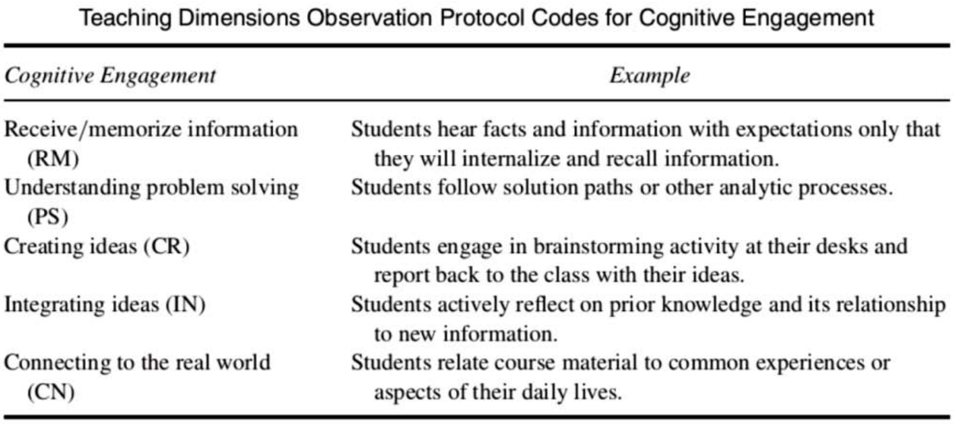
Teaching Dimensions Observation Protocol (Hora and Ferrare, 2013, Journal of Learning Sciences)



Teaching Dimensions Observation Protocol Codes for Teaching Methods

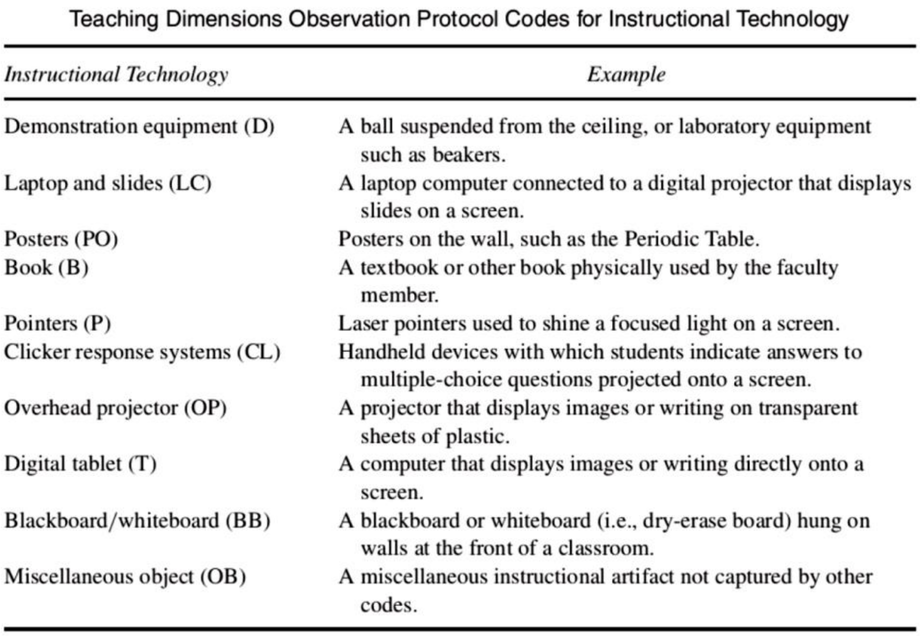
Teaching Methods	*Example*
Lecture (LEC)	Instructor verbally presents facts or concepts.
Illustration (IL)	Instructor uses a story or anecdote to describe a fact or concept.
Demonstration (DEM)	Instructor uses a physical demonstration of a phenomenon using experimental or other equipment.
Worked out problems (WP)	Instructor engages in the active solving of a numerical problem.
Small-group work (SGW)	Instructor directs students to work in pairs or small groups.
Desk work (DW)	Instructor directs students to work alone at their desks.
Case study (CS)	Instructor presents a case for detailed elaboration and analysis.
Online techniques (OT)	Instructor actively draws on the course website.
Rhetorical question (RQ)	Instructor poses a question as a figure of speech for illustrative or persuasive reasons.
Display conceptual questions (DCQ)*	Instructor poses a question to obtain information about student comprehension about concepts.
Display algorithmic questions (DAQ)*	Instructor poses a question to obtain information about student comprehension about algorithms or computations.
Comprehension question (CQ)	Instructor poses a question to assess students' generalized understanding of a previous topic.
Novel question (NQ)	Instructor poses a question to which he or she does not know the answer.
Whole-class discussion (CD)	Instructor and students engage in back-and-forth discussion.

*These types of questions are frequently posed using clicker response systems. As a result, each of these questions is also coded in conjunction with clickers (i.e., DCQ-CL and DAQ-CL).



Teaching Dimensions Observation Protocol Codes for Cognitive Engagement

Cognitive Engagement	*Example*
Receive/memorize information (RM)	Students hear facts and information with expectations only that they will internalize and recall information.
Understanding problem solving (PS)	Students follow solution paths or other analytic processes.
Creating ideas (CR)	Students engage in brainstorming activity at their desks and report back to the class with their ideas.
Integrating ideas (IN)	Students actively reflect on prior knowledge and its relationship to new information.
Connecting to the real world (CN)	Students relate course material to common experiences or aspects of their daily lives.



Teaching Dimensions Observation Protocol Codes for Instructional Technology

Instructional Technology	*Example*
Demonstration equipment (D)	A ball suspended from the ceiling, or laboratory equipment such as beakers.
Laptop and slides (LC)	A laptop computer connected to a digital projector that displays slides on a screen.
Posters (PO)	Posters on the wall, such as the Periodic Table.
Book (B)	A textbook or other book physically used by the faculty member.
Pointers (P)	Laser pointers used to shine a focused light on a screen.
Clicker response systems (CL)	Handheld devices with which students indicate answers to multiple-choice questions projected onto a screen.
Overhead projector (OP)	A projector that displays images or writing on transparent sheets of plastic.
Digital tablet (T)	A computer that displays images or writing directly onto a screen.
Blackboard/whiteboard (BB)	A blackboard or whiteboard (i.e., dry-erase board) hung on walls at the front of a classroom.
Miscellaneous object (OB)	A miscellaneous instructional artifact not captured by other codes.

Teaching Dimensions Observation Protocol (TDOP): Coding Section

*Use **pencil** to code the lesson in the categories.*

Minutes	0–4	5–9	10–14	15–19	20–24	25–29
Teaching Methods	LEC IL DEM SGW MM CS PS OT B RQ DCQ DAQ CQ NQ CL CD DW	LEC IL DEM SGW MM CS PS OT B RQ DCQ DAQ CQ NQ CL CD DW	LEC IL DEM SGW MM CS PS OT B RQ DCQ DAQ CQ NQ CL CD DW	LEC DEM IL SGW MM CS PS OT B RQ DCQ DAQ CQ NQ CL CD DW	LEC DEM IL SGW MM CS PS OT B RQ DCQ DAQ CQ NQ CL CD DW	LEC IL DEM SGW MM CS PS OT B RQ DCQ DAQ CQ NQ CL CD DW
Notes: Include brief description of what the instructor is actually doing here (e.g., content being discussed, sequence of argumentation, etc.)						
Cognitive Engagement	RM PS CR IN CN	RM PS CR IN CN	RM PS CR IN CN	RM PS CR IN CN	RM PS CR IN CN	RM PS CR IN CN
Notes:						
Instructional Technology	PO BB LC CL B OP D OB P T	PO BB LC CL B OP D OB P T	PO BB LC CL B OP D OB P T	PO BB LC CL B OP D OB P T	PO BB LC CL B OP D OB P T	PO BB LC CL B OP D OB P T
Notes:						

STEM Gateway
Course Redesign Teaching Professional
Development Program:

What did my Students Think? Building Surveys for Student Feedback

- Is it important to know what students think about your redesigned course?
- How can you find out what’s working and not working from the learners’ perspective?
- How can you use this feedback as input to continuous improvement of your redesigned course?

STEM GATEWAY
Project for Inclusive
Undergraduate STEM Success

"What Did My Students Think?"
Assessing Student Perceptions of Course Redesign Using Surveys

The purpose of this document is to guide you through the process for developing a survey that allows you to incorporate students' perceptions of your redesign efforts into the ongoing assessment of the project. Several resources are provided for you to reference when working through the development of a survey.

Objectives: The first thing to do when developing a survey is to list your objectives for surveying students in your course. Some of the objectives that were discussed at the workshop include:

1) To measure effectiveness (of activities, instructor, balance between student-to-student interaction and instructor-to-student interaction).
2) To improve teaching practices
3) To meet the expectations of STEM Gateway (the funded proposal commits to including student attitudes toward the redesigned courses as part of the overall program evaluation)

Question Construction: The objectives should drive the item construction for the survey. Some things to consider when developing questions are:

a) To what extent should the questions be open-ended versus objective response?
b) Should objective items be posed as a question or a statement?
c) If questions are objective, what Likert scale should be used? See the *Likert Scale* document for ideas.
d) Should 'neutral' be an option?

Review the examples below. The first example frames the item as a question and gives a neutral option. The second question frames the item as a statement which students can agree with to varying degrees and does not include a neutral option. What are the advantages and disadvantages to the various approaches? What approach is best for your purpose?

Examples:
1a. How effective were pre-class assignments in terms of preparing you for lecture?
A. Very effective
B. Somewhat effective
C. Neutral
D. Somewhat ineffective
E. Very Ineffective

1b. Pre-class assignments were effective for preparing me to learn from the lecture.
A. Strongly agree
B. Agree more than disagree
C. Disagree more than agree
D. Strongly disagree

The questions below were suggested by members of the course reform teams. They provide a basis of ideas that can be used or modified.

Example questions suggested by redesign teams at the workshop

1) What would you define as success in the course?- A,B,C,D,F
2) What is your most recent grade estimate?- A,B,C,D,F
3) At the beginning of the semester, I was…Skeptical, neutral, enthusiastic
4) Now, I am…Skeptical, neutral, enthusiastic
5) How well did you learn?
6) How well did you enjoy the material?
7) Are you aware of the learning outcomes from the course?
8) Did you use the learning outcomes to study?
9) How well did the material provided (in-class activities, worksheets, pre-class assignments) prepare you to achieve the learning outcomes?
10) How well did the pre-classs activities prepare you for the in-class activities?
11) Did the assignments align with the exams?
12) Did the exams align with the learning outcomes?
13) Would you recommend the course to a friend?
14) What could be changed about the class to improve learning?
15) What can the instructor do to improve learning?
16) What can you do to improve learning?
17) What changes did you make to improve your learning? Were the changes effective?

*Several other example surveys are included in the zip file for you to review and use to help generate questions.

Bookending a Survey- After listing objectives and constructing items to assess the objectives, it is good practice to bookend the survey with an introduction and closing.

Introduction- It is important to introduce your survey to the audience. Things to consider adding to the introduction are listed below:

- The purpose
- The intended use
- The intended follow-up (how the information will be used)
- Privacy protection
- Instructions to complete the survey

Closing- It is also good practice to close the survey by expressing gratitude to the participants.

Thank you for your thoughtful responses.

Timing for administration- Deciding when to administer the survey largely depends on the objectives of the survey.

Do you want information to improve teaching practices on the fly during the semester? Do you want to measure the effectiveness of the materials and instructional approaches to make changes for the next semester? Aligning the timing to the objectives will ensure that you obtain the data you need at the time you need it.

Platforms for administration- There are several platforms that can be used to survey students. Listed below are several of the platforms that were discussed and the pros and cons to consider when choosing a platform. For an alternative list of platforms and their advantages and disadvantages, see the attached document *Survey Methodology.*

Blackboard Learn- Blackboard Learn has a survey feature. This will allow you to know which students have taken the survey although the responses themselves are anonymous. You will *not* be able to links responses to respondents. You can incentivize students by issuing extra credit for survey completion.

Opinio- UNM has a license to Opinio, a surveying program. It is free to use after you set up an account by submitting a ticket request to IT at https://help.unm.edu/CherwellPortal/SelfService/WinLogon. You will not be able to tell which students have responded using Opinio.

Google Docs- You can create surveys and collect data using a Google tool.

In-class Handout- The benefit of using a hardcopy survey is a higher response rate. However, unless using a Scantron, you will have to input all the data by hand. Even using a Scantron, you will have to input open-ended responses by hand. Survey administration also needs to be budgeted into your class time.

IDEA Form- You can add customized questions to the IDEA form. The benefit of this is limiting the surveys students need to take. The drawback is restricting the number of questions you can ask.

Wrap up

By thinking through the sections above, you enable yourself to create a survey to meet your listed objectives. If you have any specific questions, contact gsmith@unm.edu or astark@unm.edu. We would love for you to share your surveys with us and other course reform team members. Please feel free to send out a copy of the survey you develop to members of the other course reform teams

Also – After completing your analysis of survey results, please forward (a) the instrument you used, and (b) a results summary to Gary and Audriana for incorporation into the project-evaluation files.

Example survey

1. So far, the pace of the class has been...

    a. Too slow
    b. Just right
    c. Too fast

2. Exam 1 was...

    a. Much harder than I thought it would be
    b. Somewhat harder than I thought it would be
    c. Pretty much what I thought it would be
    d. Somewhat easier than I thought it would be
    e. Much easier than I thought it would be

3. My educational background has so far provided me with the informati have needed to succeed with the new learning in this course:

    a. Always or almost always

    b. Usually

    c. Sometimes

    d. Rarely

    e. Never

4. Choose the answer that comes *closest* to your current attitude toward this class. So far, ...

    a. ...the course has been a lot of work, but I feel like I am learning.
    b. ...the course has been a lot of work, and I don't feel like I am learning much.
    c. ...the course has been pretty easy, but I feel like I am learning.
    d. ...the course has been pretty easy, and I don't feel like I am learning much.

5. What is your overall rating of the course, so far:

    a. One of the best courses I've taken
    b. Better than most courses I've taken
    c. About the same as most other courses that I've taken
    d. Worse than most of my past courses
    e. One of the worst courses that I've taken

6. What is your overall rating of the Professors effectiveness at promoting your learning, compared to other instructors?

    a. Among the most effective instructors that I've had
    b. More effective than most instructors
    c. About the same effectiveness as other instructors
    d. Less effective than most instructors

- e. Among the least effective instructors I have had

8. What is your overall rating of your laboratory teaching assistant's effectiveness at promoting your learning, compared to other graduate-student instructors?

- a. Among the most effective graduate-student instructors that I've had
- b. More effective than most graduate-student instructors
- c. About the same effectiveness as other graduate-student instructors
- d. Less effective than most graduate-student instructors
- e. Among the least effective graduate-student instructors I have had

10. The Peer Learning Facilitator, has been very helpful to me when I meet with him outside of class.

- a. Strongly Agree
- b. Agree
- c. Neither Agree nor Disagree
- d. Disagree
- e. Strongly Disagree
- f. Not Applicable

11. How useful are the In-Class assignments in helping you learn?

- a. Almost always useful
- b. Mostly useful
- c. Sometimes useful
- d. Rarely useful
- e. Almost never useful

12. How useful are the online Learning Checks, and the provided feedback, in helping you to identify your learning progress?

- a. Almost always useful
- b. Mostly useful
- c. Sometimes useful
- d. Rarely useful
- e. Almost never useful

13. How does working with classmates help in your learning of new ideas and concepts during in-class assignments?

- a. Working with classmates helps me to discuss new ideas/concepts which leads to a deeper understanding
- b. Working with classmates does not help me to understand new ideas/concepts
- c. Working with a classmate slows down my work and I learn less

14. How useful are the Think-Pair Share and Write-Pair-Share activities in class for helping you learn?

- a. Almost always useful
- b. Mostly useful

c. Sometimes useful
d. Rarely useful
e. Almost never useful

15. How does working with a lab partner help in your learning of new ideas and concepts during lab sessions?

a. Working with a partner helps me to discuss new ideas/concepts which leads to a deeper understanding
b. Working with a partner does not help me to understand new ideas/concepts
c. Working with a partner slows down my work and I learn less

16. How often do you *effectively* complete the assigned reading *before class*? Effective reading isn't the same as skimming. Effective reading includes thinking about, or maybe writing out answers to, the reading questions before class.

a. Before almost every class session
b. On average, before 2 out of the 3 class sessions each week.
c. On average, before 1 out of the 3 class sessions each week
d. Only 2-3 times so far this semester
e. Almost never

17. During most in-class exercises ...

a. ... my partners and I are *equally prepared* to complete the exercise because we did the reading beforehand.

b. ... my partner(s) and I are *equally unprepared* to complete the exercise because we did not do the reading beforehand.

c. ... I am usually prepared but my partner(s) is not... but that doesn't bother me.

d. ... I am usually prepared but my partner(s) is not... and that does bother me.

e. ... I am usually not as prepared as my partner(s), because they did the reading assignments and I did not.

18. How often do you attend office hours for either the professor or the TA and how has it increased your understanding of new concepts?

a. I regularly attend office hours to help me understand new concepts
b. I sometimes attend office hours only when I am not able to understand new concepts
c. I never attend office hours because I am able to understand new concepts
d. I never attend office hours and do not understand new concepts

19. My interest level in this class *before* I signed up for it can best be described as

a. Very interested

b. Somewhat interested
c. Neutral; neither interested nor disinterested
d. Somewhat disinterested
e. Very disinterested

20. As a result of taking this course, so far my interest level in the study can best be described as:

a. Greatly increased since starting the class
b. Somewhat increased since starting the class
c. About the same as before starting the class
d. Somewhat decreased since starting the class
e. Greatly decreased since starting the class

21. Explain one thing that would increase your learning in this class.

Answer:

22. Explain one thing that your laboratory teaching assistant could do that would increase your learning in this class.

Answer:

23. Explain one thing that you could do to that would increase your learning in this class.

Answer:

24. Use this space to offer any additional comments about your course experience so far, and/or suggestions for improving this experience.

Answer:

1. How effective were the pre-class assignments in terms of preparing you for the lecture?

Very ineffective
Somewhat ineffective
Neutral
Somewhat effective
Very effective

2. How effective were the lectures in terms of preparing you to understand the homework?

Very ineffective
Somewhat ineffective
Neutral
Somewhat effective
Very effective

3. How effective were the in-class group assignments in terms of preparing you to understand the homework?

Very ineffective
Somewhat ineffective
Neutral
Somewhat effective
Very effective

4. How effective was the homework in terms of preparing you for quizzes and exams?

Very ineffective
Somewhat ineffective
Neutral
Somewhat effective
Very effective

5. How effective were the Student Learning Outcomes (SLOs) in terms of guiding your study for exams?

Very ineffective
Somewhat ineffective
Neutral
Somewhat effective
Very effective

STSS Research Project:
Student Survey

Welcome to the University of Minnesota STSS research survey! This survey is part of a study designed to learn more about student perceptions of and experiences in classrooms such as this one. This study is completely voluntary and will not affect your grade in this class or your relationship with your instructor or the University; survey data will be kept strictly confidential. The survey should take about 10-15 minutes to complete.

Questions:

1. Student ID #: ________________________________

2. Course/Section: ________________________________

3. Room: ________________________________

4. What grade do you expect to earn in this course?
   ○ A
   ○ B
   ○ C
   ○ D
   ○ F
   ○ Other (Please specify): ________________________________

5. Prior to this course, have you ever taken a class in a room like this at the University of Minnesota?
   ○ Yes
   ○ No

For the next set of questions, please indicate whether you Strongly Agree, Agree, Disagree, or Strongly Disagree with the following statements. (If you do not know the answer to a question, please leave that question blank and go on to the next one):

The CLASSROOM in which I am taking this course…

		Strongly Agree	Agree	Disagree	Strongly Disagree
6.	Increases my excitement to learn.	○	○	○	○
7.	Facilitates multiple types of learning activities.	○	○	○	○
8.	Helps me develop professional skills that can be transferred to the real world.	○	○	○	○
9.	Enriches my learning experience.	○	○	○	○
10.	Helps me develop confidence in working in small groups.	○	○	○	○
11.	Promotes discussion.	○	○	○	○
12.	Encourages my active participation.	○	○	○	○
13.	Offers a physically comfortable learning environment.	○	○	○	○
14.	Makes me want to attend class regularly.	○	○	○	○
15.	Helps me develop connections with my classmates.	○	○	○	○
16.	Enables me to locate and critically evaluate information.	○	○	○	○
17.	Helps me develop confidence in analyzing.	○	○	○	○
18.	Enables me to communicate effectively.	○	○	○	○
19.	Helps me develop confidence in presenting.	○	○	○	○
20.	Engages me in the learning process.	○	○	○	○
21.	Helps me develop confidence in writing.	○	○	○	○
22.	Nurtures a variety of learning styles.	○	○	○	○
23.	Helps me develop connections with my instructor.	○	○	○	○
24.	Helps me to define issues or challenges and identify possible solutions.	○	○	○	○
25.	Prepares me to implement a solution to an issue or challenge.	○	○	○	○
26.	Helps me to examine how others gather and interpret data and assess the soundness of their conclusions.	○	○	○	○
27.	Deepens my understanding of a specific field of study.	○	○	○	○
28.	Assists me in understanding someone else's views by	○	○	○	○

	imagining how an issue looks from his or her perspective.				
29.	Helps me to grow comfortable working with people from other cultures	○	○	○	○
30.	Improves my confidence that I can speak clearly and effectively.	○	○	○	○
31.	Encourages me to create or generate new ideas, products, or ways of understanding.	○	○	○	○
32.	Prompts me to incorporate ideas or concepts from different courses when completing assignments.	○	○	○	○
33.	Enabled the instructor to make intentional connections between theory and practice in this course.	○	○	○	○

For the next set of questions, please indicate whether you Strongly Agree, Agree, Disagree, or Strongly Disagree with the following statements:

		Strongly Agree	Agree	Disagree	Strongly Disagree
34.	The instructor is effective in using the technology available in the classroom for instructional purposes.	○	○	○	○
35.	This classroom is an appropriate space in which to hold this particular course.	○	○	○	○
36.	The instructor is effective in using the classroom for instructional purposes.	○	○	○	○
37.	The in-class exercises for this course are enhanced by the features of this classroom.	○	○	○	○

How often did the following activities occur in your course?

		More than once per class	About once per class	About once a week	Two or three times a month	About once a month	Two or three times a semester	About once a semester	Never
38.	Students worked in small groups (2-3) on an in-class learning activity.	○	○	○	○	○	○	○	○
39.	Students worked in medium-sized groups (4-9) on an in-class learning activity.	○	○	○	○	○	○	○	○
40.	The work of an individual student was displayed or projected to the whole class.	○	○	○	○	○	○	○	○
41.	The work of a group of students was displayed or projected to the whole class.	○	○	○	○	○	○	○	○
42.	The instructor consulted with individual students during an in-class learning activity.	○	○	○	○	○	○	○	○
43.	The instructor consulted with groups of students during an in-class learning activity.	○	○	○	○	○	○	○	○
44.	An in-class learning activity required students to use the internet to conduct research or locate information.	○	○	○	○	○	○	○	○
45.	An in-class learning activity required students to explain course ideas or concepts to other students.	○	○	○	○	○	○	○	○
46.	An in-class learning activity required students to visit a course management system (e.g. Moodle).	○	○	○	○	○	○	○	○
47.	An in-class learning activity required students to use social media (e.g. Twitter, Facebook).	○	○	○	○	○	○	○	○
48.	Played media with sound (e.g., DVD, CD)	○	○	○	○	○	○	○	○

This semester, how often have you done each of the following in this course? (If you don't remember how often you've done one of these things, just leave that item blank.)

		More than once per class	About once per class	About once a week	Two or three times a month	About once a month	Two or three times a semester	About once a semester	Never
49.	Asked questions during your class	○	○	○	○	○	○	○	○
50.	Made a presentation in your class	○	○	○	○	○	○	○	○
51.	Contributed to class discussions that occurred during your class	○	○	○	○	○	○	○	○
52.	Helped explain course ideas or concepts to other students in your course	○	○	○	○	○	○	○	○
53.	Came to your class having completed readings or assignments	○	○	○	○	○	○	○	○
54.	Discussed ideas from your readings or course with other students during class	○	○	○	○	○	○	○	○
55.	Worked with other students on projects during your class	○	○	○	○	○	○	○	○

In this classroom, how easy is it to:

	Easy	Somewhat Easy	Neither Easy Nor Difficult	Somewhat Difficult	Difficult
56. Focus on a single source of information?	○	○	○	○	○
57. Identify who is speaking during class?	○	○	○	○	○
58. Follow what is going on during class?	○	○	○	○	○

59. Please describe one situation in which this room WORKED WELL for you. Provide as many details as possible.

60. Please describe one situation in which this room DID NOT WORK WELL for you. Provide as many details as possible.

61. What are your overall thoughts about the classroom in which you are taking this course?

THANK YOU FOR YOUR TIME AND THOUGHTFUL RESPONSES!

STEM Gateway
Course Redesign Teaching Professional Development Program:

Debriefing and Looking Ahead- What did We Learn During the Fall?

- What changes do we need to make for next semester?
- What information will be used to trigger adjustments?
- How will the team plan the adjustments?
- What milestones and goals did we meet?
- What milestones and goals do we still have?

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Debriefing and Looking Ahead

Course Redesign 2015-2016 Reflection Form

STEM Gateway would like to document the experiences of the Course Reform Teams Cohort 4. Please take time to formulate thoughtful responses to the questions below. Then, bring a copy of the completed form to the December meeting to share your insights with other course redesign teams.

1. What aspects of your redesign have worked well?

2. What are challenges you have faced with your redesign efforts?

3. How will you address issues that you are facing for the spring semester?

4. How have you made your work known to colleagues in the department?

5. How have you kept your department chair informed of your work?

6. What do your chair and colleagues think about your work?

STEM Gateway
Course Redesign Teaching Professional Development Program:

Why Aren’t My Students Learning?

- Are you blaming your students for low achievement?
- What might be happening?
- How might you assist students’ achievement of outcomes in your course?

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Why Aren't All of My Students Learning?

Gary Smith and Audriana Stark

STEM GATEWAY

Outcomes:

You will be able to:

- Explain the reasons that may account for at least two issues that you have about unsatisfactory student learning.
- Outline interventions to your current instruction that are designed specifically to resolve the issues you face with student learning.

How do you suppose students respond when they are asked why they don't do well in our classes?

"It's not me; it's the teacher/test/material that is causing my poor learning performance."

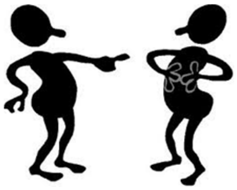
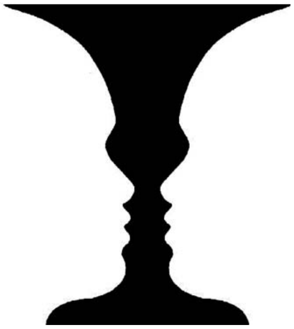


Image at: http://sfhelp.org/art/accuse.gif

What is it?



Vase or Face?

Student or Teacher?

Image at: https://phylliciapoynterict.files.wordpress.com/2013/02/gestalt.gif

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Look at your lists---

What student factors do we attribute a lack of learning to?

Why some students don't do well in our classes

What other student <u>situational factors</u> could be causing poor student performance?

Attribution

Attributions are explanations for events and behaviors.

Fundamental Attribution Error

When explaining ***other's*** behavior, people tend to …

… overestimate internal, personal factors

… underestimate external, situational factors

Heider, F. (1944). Social perception and phenomenal causality. Psychological Review, 51, 358–374

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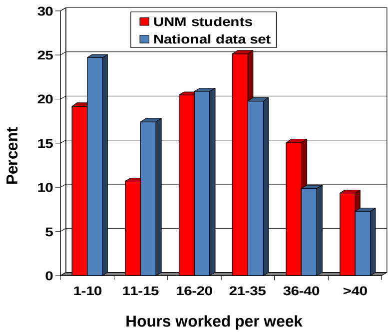
Who are my students?

Photos by: UNM

UNM students work more hours (primarily off campus) than the average US college student

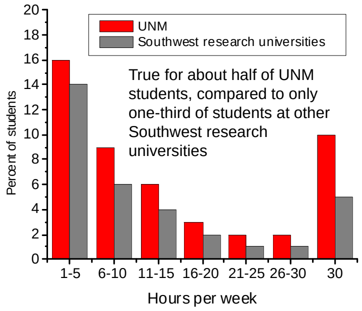


Source: Profile of the American College Student, 2008

UNM students are more likely to be care givers in their families

About 40% of UNM freshmen and 50% of seniors provide care to parents, children, and /or siblings (16% of seniors commit >30 hrs/wk to this obligation).

Providing care for dependents living with you (parents, children, spouse, etc.)

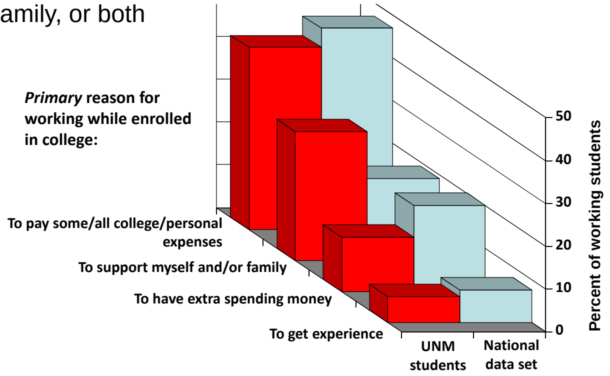


True for about half of UNM students, compared to only one-third of students at other Southwest research universities

Source: 2009 NSSE

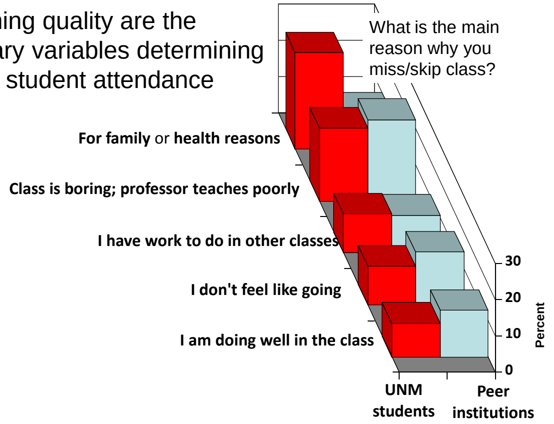
UNM students are more likely than their national peers to be working to support themselves, their family, or both

Primary **reason for working while enrolled in college:**



Source: Profile of the American College Student, 2008

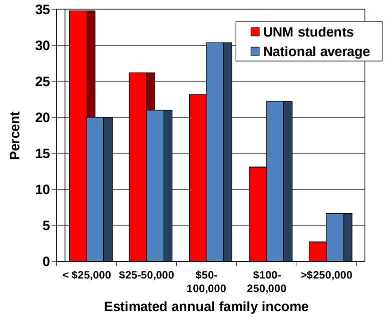
Personal concerns and teaching quality are the primary variables determining UNM student attendance



What is the main reason why you miss/skip class?

Source: Profile of the American College Student, 2008

UNM students are, compared to the national college-student population, more likely to be financially under-resourced



Some 2014 statistics:

- New Mexico ranks 43rd in median family income
- 42% of UNM undergraduates receive Pell Grants (more than any other public flagship university, which average ~20%)
- New Mexico ranks worse in the percentage (31%) of children living in families with incomes defined below the poverty level.

Source: Profile of the American College Student, 2008; UNM-OIA; Southern Education Foundation

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In a single, semester-long class with 49 students, I worked with students who confided these ongoing life issues:

- Two veterans with diagnosed PTSD
- Two spouses of servicemen who were deployed in theater
- One whose wife unexpectedly began a divorce action and left him with their 2 children
- One who was providing hospice to his dying mother in his own home, while caring for both his and his mother's livestock on different properties
- One who discovered that her fiancé was cheating with her best friend
- One persevering through infections caused by a congenital problem that awaited impending surgery
- One dealing with fallout of pulling away from her family related to seeing her stepfather abuse her brother

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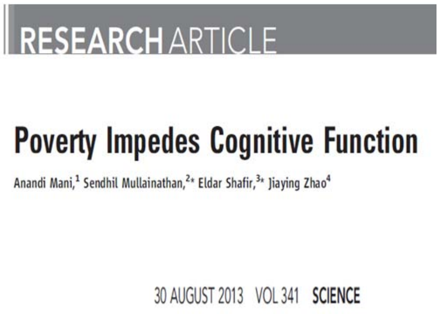


RESEARCH ARTICLE

Poverty Impedes Cognitive Function

Anandi Mani,[1] Sendhil Mullainathan,[2*] Eldar Shafir,[3*] Jiaying Zhao[4]

30 AUGUST 2013 VOL 341 SCIENCE

Fundamental Attribution Error

When explaining *their own* behavior, people tend to …

… underestimate

internal, personal factors

… overestimate

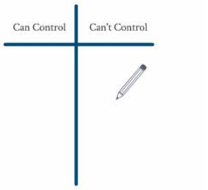
external, situational factors

Look at your lists---

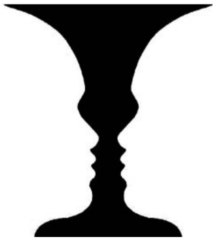
What *instructor* factors do we attribute a lack of learning to?

Brainstorming Activity

For your course:
- what can you control?
- what is out of your control?



How can exercises like this keep teachers and students from blaming one another for a lack of learning in the classroom?



Vase or Face?
Student or Teacher?

Brainstorming Activity

Now imagine giving this same activity to your students

For your course:
- what can you control?
- what is out of your control?

A Story

Two students, Pat and Chris, each receive D's on their first exam in Algebra. Pat dismayed and disappointed, gives up on the course and any chance of a career in STEM. Chris, surprised and shocked, doubles down on studying and working on the course determined to do better.

How do these two students differ?

“I’m just not good at this stuff.”

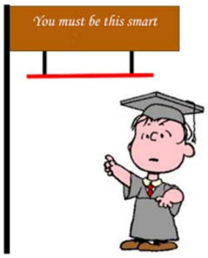


Image at: http://2.bp.blogspot.com/-9NB2KuM45pQ/UpDHV1BL-sI/AAAAAAAAB0k/nx6SCLhRt-g/s1600/You+must+be+this+smart+to+do+astronomy.png

Exploring Self-Theories

A **B C D** **E**

Growth Theory Mindset	Fixed Theory Mindset
Local, changeable judgments about intelligence and ability: *If you work harder you’ll do better.*	Global, fixed judgments about intelligence and ability: *You’re either smart or you’re dumb.*
Effort is the way of accomplishing goals: If you want to succeed, you’ll try harder.	*Effort is a sign of low ability*: If you have to try hard, you must not be smart.
Attuned to feedback; filters out evaluation.	*Attuned to evaluation*; filters out feedback.
Learning goals: Seeks to increase competence.	*Performance goals*: Seeks to win positive evaluations (grades) and avoid negative ones.
Response to failure: *Increased effort; adopt a new learning strategy.*	Response to failure: *Excuses, avoidance, withdrawal from course; failure is a sign of low ability.*

(adapted from Dweck, 1999, and Tagg, 2003)

What student attitude do you desire in your course?

For each statement below, select a letter that represents your desired expectation of students in the continuum from A to E.

A. I like coursework that I’ll learn from even if I make some mistakes along the way	**A**	**B**	**C**	**D**	**E**	**E.** I mostly like coursework that I can do perfectly without any mistakes.
A. It’s much more important to me to learn new things in my classes than it is to get the best grades.	**A**	**B**	**C**	**D**	**E**	**E.** I would rather get a good grade in a class than learn a lot.
A. I like coursework best when it makes me think hard.	**A**	**B**	**C**	**D**	**E**	**E.** The main thing I want when I do my coursework is to show how good I am at it.

How can you help students realize their current mindset and move to a growth mindset?

Increase Awareness

Encourage Students

"This is 'awareness', 'heightened awareness' is on the next hill."

Let’s take a deeper look into some of the other concerns listed.

Reflect in your journal …

- Explain the reasons that may account for at least two issues that you have about unsatisfactory student learning.
- Outline interventions to your current instruction that are designed specifically to resolve these two issues that you face with student learning.

Starting the Semester: Making Sure Learners are On Board with Your Redesign

Motivate students to learn cooperatively in groups/teams

Guiding questions provide students with a roadmap for class preparation

Many students lack adequate comprehension of how to learn from text

Students use ineffective strategies for learning

Making Sure Learners are On Board with Your Redesign

What is the most important goal of your college education and, therefore, of this course?

A. Acquiring information (facts, principles, concepts)

B. Learning how to use information and knowledge in new situations

C. Developing lifelong learning skills

How students actually answer this question

What is the most important goal of your college education and, therefore, of this course?

A. Acquiring information (facts, principles, concepts) **7%**
B. Learning how to use information and knowledge in new situations **38%**
C. Developing skills to continue learning after college **55%**

(quantitative n = 1377)

First-day questions for the learner-centered classroom, G.A. Smith, *National Teaching and Learning Forum*, Sept. 2008

How do learners want to learn?

Attempt learning on their own, outside of class

A. Acquiring information (facts, principles, concepts)

B. Learning how to use information and knowledge in new situations
C. Developing lifelong learning skills

Prefer learning in class, working with peers and instructor

Return

Learning "venues":

Learning on your own

Learning in class with others

Of the three goals, which do you think ***you can make headway on outside of class*** by your own reading and studying, and which do you think would be best achieved in class ***working with your classmates and me***?"

Photo by Aurora Pun

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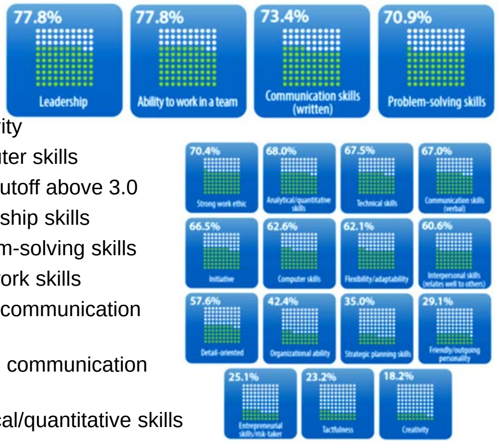
Motivate students to learn cooperatively in groups/teams

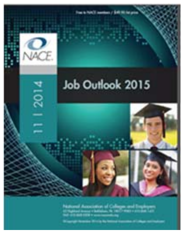
Photos by Gary Smith



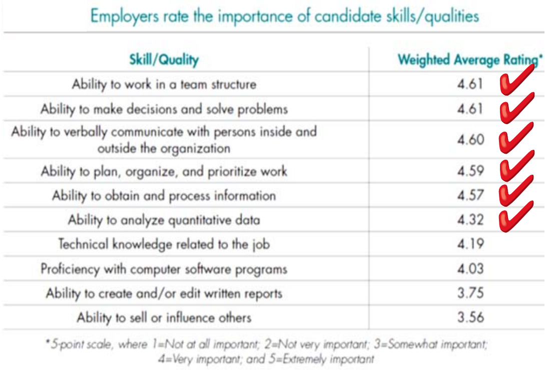
1. Creativity
2. Computer skills
3. GPA, cutoff above 3.0
[✓ 4.] Leadership skills
[✓ 5.] Problem-solving skills
[✓ 6.] Teamwork skills
7. Verbal communication skills
[✓ 8.] Written communication skills
9. Analytical/quantitative skills

How important is it, to you, to develop skills in your coursework that will help you land a job when you graduate?

Can you pick which *four* in the following list are among the *top 5* most desired characteristics among recent college graduates as reported by hiring companies?



1. Creativity
2. Computer skills
3. GPA, cutoff above 3.0
4. Leadership skills
5. Problem-solving skills
6. Teamwork skills
7. Verbal communication skills
8. Written communication skills
9. Analytical/quantitative skills

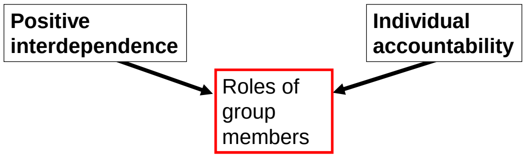


Employers rate the importance of candidate skills/qualities

Skill/Quality	Weighted Average Rating*	
Ability to work in a team structure	4.61	✓
Ability to make decisions and solve problems	4.61	✓
Ability to verbally communicate with persons inside and outside the organization	4.60	✓
Ability to plan, organize, and prioritize work	4.59	✓
Ability to obtain and process information	4.57	✓
Ability to analyze quantitative data	4.32	✓
Technical knowledge related to the job	4.19	
Proficiency with computer software programs	4.03	
Ability to create and/or edit written reports	3.75	
Ability to sell or influence others	3.56	

*5-point scale, where 1=Not at all important; 2=Not very important; 3=Somewhat important; 4=Very important; and 5=Extremely important

✓ = **employer-desired skill that matches a learning outcome for this course**



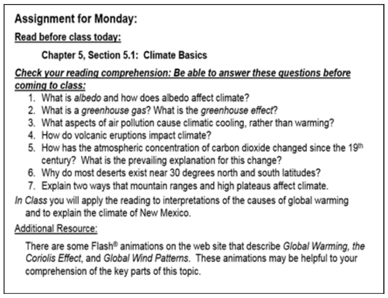
Positive interdependence

Individual accountability

Roles of group members

Return

Guiding questions provide students with a roadmap for class preparation



Assignment for Monday:

Read before class today:

Chapter 5, Section 5.1: Climate Basics

Check your reading comprehension: Be able to answer these questions before coming to class:

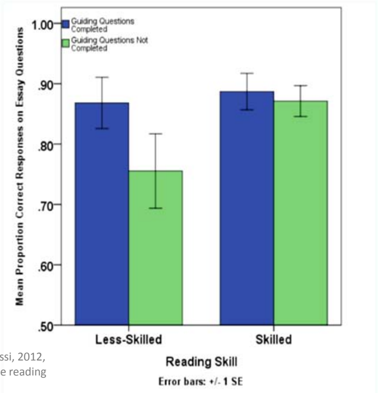
1. What is *albedo* and how does albedo affect climate?
2. What is a *greenhouse gas*? What is the *greenhouse effect*?
3. What aspects of air pollution cause climatic cooling, rather than warming?
4. How do volcanic eruptions impact climate?
5. How has the atmospheric concentration of carbon dioxide changed since the 19th century? What is the prevailing explanation for this change?
6. Why do most deserts exist near 30 degrees north and south latitudes?
7. Explain two ways that mountain ranges and high plateaus affect climate.

In Class you will apply the reading to interpretations of the causes of global warming and to explain the climate of New Mexico.

Additional Resource:

There are some Flash® animations on the web site that describe *Global Warming, the Coriolis Effect*, and *Global Wind Patterns*. These animations may be helpful to your comprehension of the key parts of this topic.

Guiding questions improves reading comprehension, especially for less-skilled readers



Stiegler-Balfour and Benassi, 2012, Guiding questions advance reading comprehension

Return

Provide resources to students to improve learning from reading

SQ3R: SURVEY – QUESTION – READ– RECITE – REVIEW

SQ5R: SURVEY – QUESTION – READ – RECORD – RECITE – REVIEW – REFLECT

SURVEY

- Check organization of material, general content, headings, subheadings, side-bars.
- Look over maps, diagrams, charts.
- Read introduction, conclusion.

QUESTION

- Ask yourself what you want to learn from this reading.
- Ask questions about headings, subheadings as you work through them.
- Form questions about each section.
- Try "who, what, when, where, why, and how" questions. How does this section relate to the others? Some textbooks have study questions at the end of the chapter.

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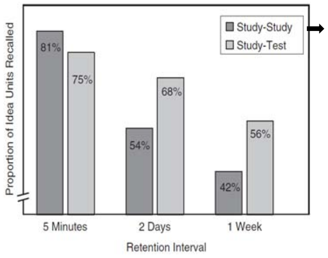
Many students lack adequate comprehension of how to learn from text



College students read a passage and then, after a 2-minute delay, either reread the passage (the <u>study-study</u> condition) or wrote as much of the information as they could recall (<u>study-test</u>).

Respondents were given a final test after a test delay (or "<u>retention interval</u>") of 5 minutes, 2 days, or 1 week.

(Roediger, & Karpicke, 2006, Test-enhanced learning: Taking memory tests improves long-term retention. *Psychological Science*, *17*:249)

READ

- Read material in chunks.
- Look for and respond to the questions you posed previously as you read.

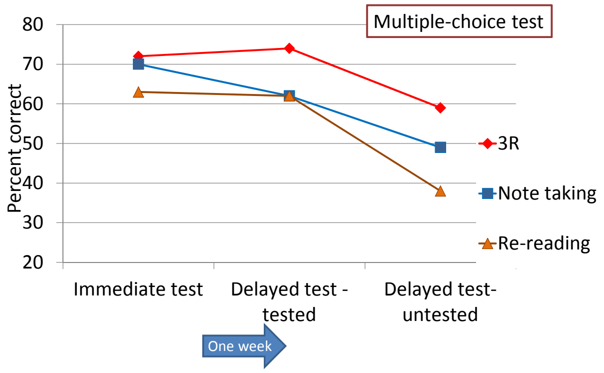
RECITE

- Check your recall of the material.
- Can you answer the question you formulated? Put the material into your own words. Talk about what you have read.

REVIEW

- After you have read the whole assignment, look over your notes.
- Go for the large picture.
- Notice how the ideas are linked.
- Try to recall the main points.
- What are the subordinate points for those main ideas?

3R strategy generates greater learning and retention



(McDaniel et al., 2009, *Psychological Science*, 20(4) 516-522)

Do your students, and you, know what approaches to studying are most effective for learning?

What do you think are the strategies most used by students?

How can our instructional strategies improve student learning?

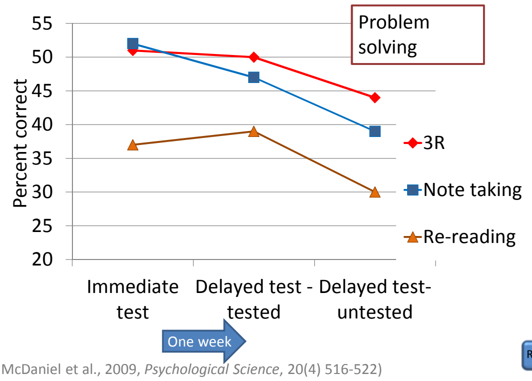
Misconceptions about learning impede student success

Learning approach	Research result on learning effectiveness
Self-explanation	M
Summarization	L
Highlighting/underlining	L
Rereading	L
Practice testing	H
Distributed practice	H

Dunlosky et al., 2013, *Psychological Science in the Public Interest*, *14*(1), 4–58.

Return

3R strategy generates greater learning and retention



Return

(McDaniel et al., 2009, *Psychological Science*, 20(4) 516-522)

Why Aren't My Students Learning?

Gary Smith
Assistant Dean of Faculty Development in Education
Office for Medical Educator Development

Audriana Stark
Organization, Information, & Learning Sciences

Learning outcomes: After this session, you will be able to…

> …Explain the reasons that may account for at least two issues that you have about unsatisfactory student learning.
>
> ..Outline interventions to your current instruction that are designed specifically to resolve the issues you face with student learning.

Agenda

I. What is frustrating you about student learning? What is the problem? What do you think is happening?
II. Attribution Theory … Students point fingers, too.
What characteristics of successful student learning are in/out of my control?
III. Mindsets – self theories about learning
IV. Potential solutions for why students don't do well
V. Write in journal- reflection

Brainstorming Activity: Examining Attribution Theory

1. Think of a typical course you teach. In the table below, write down as many ideas as possible that you control about the course. Then, list as many ideas as possible of elements that you cannot control about the course.

Can Control	Can’t Control

For further reading about attribution theory: Weiner, B. (1985). An Attributional theory of achievement, motivation, and emotion. *Psychological Review, 92(4), 548-573.*

Learner Mindsets

What student attitude do you desire in your course?

For each statement below, circle a letter that represents your desired expectation in the continuum from statement A to B.

A. I like coursework that I'll learn from even if I make some mistakes along the way	A	B	C	D	E	E. I mostly like coursework that I can do perfectly without any mistakes.
A. It's much more important to me to learn new things in my classes than it is to get the best grades.	A	B	C	D	E	E. I would rather get a good grade in a class than learn a lot.
A. I like coursework best when it makes me think hard.	A	B	C	D	E	E. The main thing I want when I do my coursework is to show how good I am at it.

Self-Theories of Intelligence – Individual's Mindsets about Learning

Growth Theory Mindset	Fixed Theory Mindset
Local, changeable judgments about intelligence and ability: *If you work harder you'll do better.*	Global, fixed judgments about intelligence and ability: *You're either smart or you're dumb.*
Effort is the way of accomplishing goals: If you want to succeed, you'll try harder.	*Effort is a sign of low ability*: If you have to try hard, you must not be smart.
Attuned to feedback; filters out evaluation.	*Attuned to evaluation*; filters out feedback.
Learning goals: Seeks to increase competence.	*Performance goals*: Seeks to win positive evaluations (grades) and avoid negative ones.
Response to failure: *Increased effort; adopt a new learning strategy.*	Response to failure: *Excuses, avoidance, withdrawal from course; failure is a sign of low ability.*

(Based on C.S. Dweck, *Self-Theories: Their role in motivation, personality, and development*, and J. Tagg, 2003, *The Learning Paradigm College*. Also see C.S. Dweck, 2008, *Mindset*)

Are students aware of their mindset?

The link to the Mindset survey is:

http://community.mindsetworks.com/my-mindset?force=1

Meaningful Learning from Text through Purposeful Reading: SQ5R

SURVEY – QUESTION – READ – RECORD – RECITE – REVIEW – REFLECT

SURVEY

- Check organization of material, general content, headings, subheadings, side-bars.
- Look over maps, diagrams, charts.
- Read introduction, conclusion.

SURVEY - Before reading in earnest, read the introduction and summary or abstract (if provided). Skim through the reading material and pay attention to topic headings, bold-faced or italicized words, pictures, charts, and graphs. These items can give you an idea of the general structure and content before you begin reading. If provided by your teacher, examine the questions provided with the reading assignment to make yourself aware of what is most important to know before class. The survey step prepares your brain to capture knowledge from the reading because you are aware of what the reading is about; think of it as analogous to doing stretching exercises before undertaking strenuous activities.

QUESTION

- Ask yourself what you want to learn from this reading.
- Ask questions about headings, subheadings as you work through them.
- Form questions about each section.
- Try “who, what, when, where, why, and how” questions. How does this section relate to the others? Some textbooks have study questions at the end of the chapter.

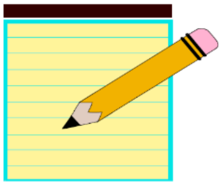
QUESTION - Set a purpose for your reading by developing questions about the material before you start reading. Use the topic and heading information that you gathered in the survey step to create questions to be answered while you read. Begin asking yourself who, what, where, when, why, and how questions. Questions are most beneficial when they are general and cover the main topics and important points identified during the survey step.

READ

- Read material in chunks.
- Look for and respond to the questions you posed previously as you read.

READ – If the text is not already divided by closely spaced section headings, break the material into sections that will take no more than about 20 minutes to read. Read the assignment section by section. Look for answers to your questions (and the questions that accompany the assignment, if provided), key concepts, and supporting details. After reading each section, think about the material you have just read and answer the questions you have asked. Look carefully at the charts, graphs, tables, and pictures; these can serve to present new information as well as tie together concepts from the reading.

RECORD



- Record key points of what you have learned using your preferred method of note-taking.
- Highlight key words or phrases; make an audio record of key ideas; write out the points in short form.

RECORD - Go back and underline or highlight key concepts *and take notes*. Note can be made on a separate sheet of paper, on note cards, in the margins of the reading, or any way that works well for you. But always be sure that you’re writing something in your own words in order to improve your brain processing of what you’re reading (Do this after each section.)

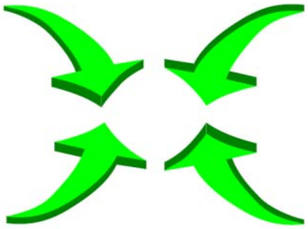
RECITE

- Check your recall of the material.
- Can you answer the question you formulated? Put the material into your own words. Talk about what you have read.

RECITE - Next, look away from the material and try to recite the key information and ideas. Put the material in your own words and go back and re-read until you feel comfortable with it. This may be frustrating at first, but it will lead to better understanding and save you review time in the long run. You don't like talking to yourself? Pets can be good listeners! (Do this after each section.)

Repeat the *Read – Record – Recite* steps for each section of the text

REVIEW



- After you have read the whole assignment, look over your notes.
- Go for the large picture.
- Notice how the ideas are linked.
- Try to recall the main points.
- What are the subordinate points for those main ideas?

REVIEW - After completing the entire reading assignment, scan back over the text and review the information aloud or in your head. Talk about the material with a classmate if possible (perhaps with a teammate before class starts). Try to identify overall themes and relationships between concepts. Make any necessary revisions of your notes or markings so they can be easily understood later.

REFLECT

- How does the material you learned fit in with what you already know?
- Consider class notes, previous learning, class discussion etc.

REFLECT- Deep, memorable learning involves connecting newly learned information and ideas with what you already know. In nearly all courses, reading assignments are not meant to stand alone but are, instead, interconnected with previous topics, upcoming topics, and learning opportunities that take place during class time. Immediately after completing the assignment, contemplate how it fits in with what else you're learning in the course and what you knew about this topic beforehand. Later, come back to your notes and see if subsequent learning opportunities in the course permit you to elaborate on what you initially learned while reading.

Does this seem like it will take a lot of time? It can, so don't wait until the night before a test to assume that you can purposefully read your assignments for meaningful learning. Many students find that when they don't take these steps they frequently find themselves lost or distracted during their reading and frequently start over or end up re-reading. When they follow SQ5R, however, they find themselves spending less time on the reading assignment because they only read it once.

(Parts of this document were adapted from: LGresham/Learning Skills Advisor/Conestoga College Learning Strategies/reading/SQ5R.doc at http://www.scribd.com; Reading Tips at http://www.radford.edu/content/LARC/home.html)

Do your students, and you, know what approaches to studying are most effective for learning?

Learning approach	Effectiveness for learning – *(high, medium, low)*	Research result on learning effectiveness	Your learning strategy knowledge score
Self-explanation: Explaining how new information is related to known information, or explaining steps taken during problem solving			
Summarization: Writing summaries (of various lengths) of to-be-learned texts			
Highlighting/underlining: Marking potentially important portions of to-be-learned materials while reading			
Rereading: Reading text material again after an initial reading			
Practice testing: Self-testing or taking practice tests over to-be-learned material			
Distributed practice: Implementing a schedule of practice that spreads out study and learning activities over time			

Dunlosky, J., Rawson, K. A., Marsh, E. J., Nathan, M. J., & Willingham, D. T. (2013). Improving Students' Learning With Effective Learning Techniques: Promising Directions From Cognitive and Educational Psychology. *Psychological Science in the Public Interest*, *14*(1), 4–58.

STEM Gateway
Course Redesign Teaching Professional Development Program:

Checking Your Alignment

- Are your outcomes, learning activities, and assessments appropriately aligned?
- Do you provide scaffolding opportunities to raise students from low-level thinking to high-level thinking?

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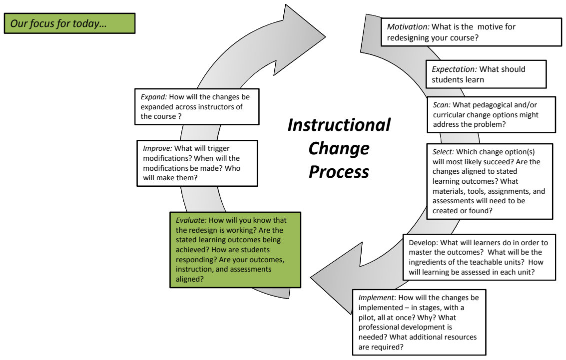
Checking Your Alignment

Gary Smith and Audriana Stark

Outcomes:
Participants will be able to:

- demonstrate alignment of outcomes, learning activities, and assessments using Blooms taxonomy of the cognitive domain
- demonstrate how sequencing of learning activities and assessments scaffold student achievement to desired outcome levels "teachable units"

STEM Gateway Professional Development Program
Designing Instructional Change to Improve Student Success



Our focus for today…

Instructional Change Process

Motivation: What is the motive for redesigning your course?

Expectation: What should students learn

Scan: What pedagogical and/or curricular change options might address the problem?

Select: Which change option(s) will most likely succeed? Are the changes aligned to stated learning outcomes? What materials, tools, assignments, and assessments will need to be created or found?

Develop: What will learners do in order to master the outcomes? What will be the ingredients of the teachable units? How will learning be assessed in each unit?

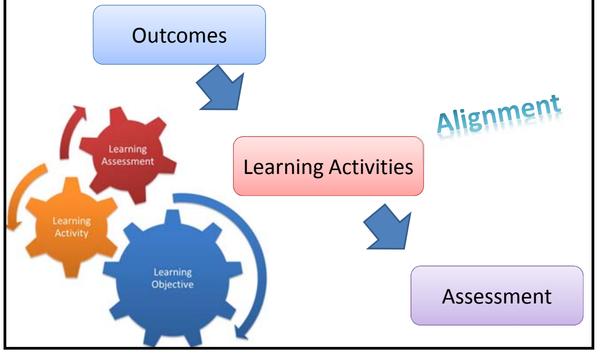
Implement: How will the changes be implemented – in stages, with a pilot, all at once? Why? What professional development is needed? What additional resources are required?

Evaluate: How will you know that the redesign is working? Are the stated learning outcomes being achieved? How are students responding? Are your outcomes, instruction, and assessments aligned?

Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

Outcomes should align with classroom learning and assessment

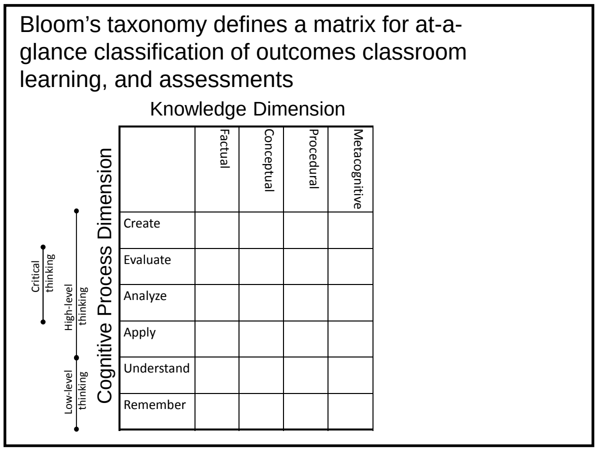


Bloom's taxonomy is a model for designing courses by aligning …

What students are assessed as knowing and doing …

… with what students are asked to do in order to master learning

… with the outcomes of the course – *what students should know and be able to do upon completion*

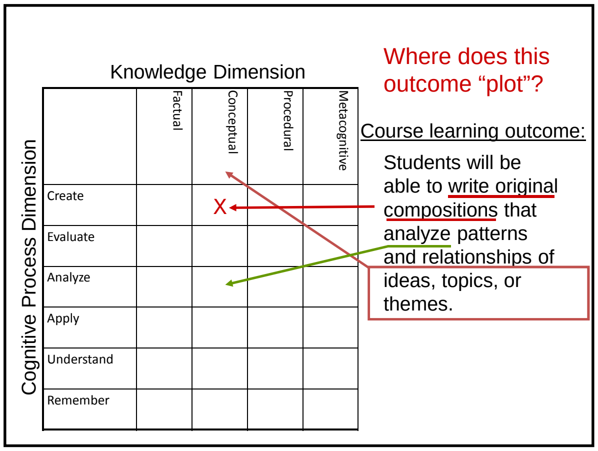


Bloom's taxonomy defines a matrix for at-a-glance classification of outcomes classroom learning, and assessments

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				



Where does this outcome "plot"?

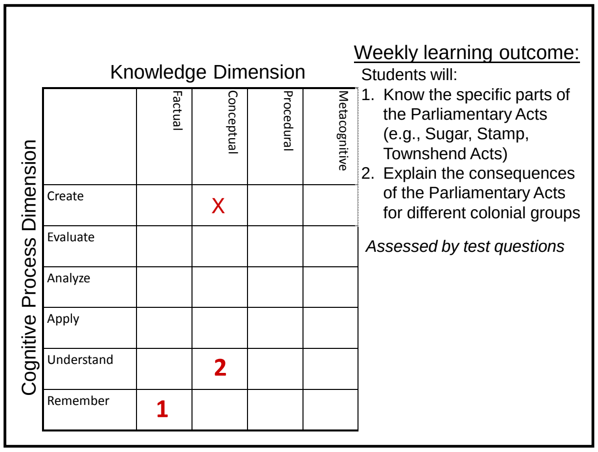
Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create		X		
Evaluate				
Analyze				
Apply				
Understand				
Remember				

Course learning outcome:

Students will be able to write original compositions that analyze patterns and relationships of ideas, topics, or themes.



Weekly learning outcome:

Students will:

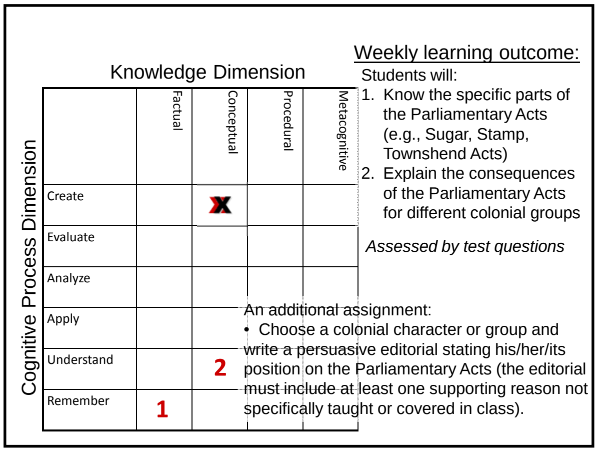
1. Know the specific parts of the Parliamentary Acts (e.g., Sugar, Stamp, Townshend Acts)
2. Explain the consequences of the Parliamentary Acts for different colonial groups

Assessed by test questions

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create		X		
Evaluate				
Analyze				
Apply				
Understand		2		
Remember	1			



Weekly learning outcome:

Students will:

1. Know the specific parts of the Parliamentary Acts (e.g., Sugar, Stamp, Townshend Acts)
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Assessed by test questions

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create		X		
Evaluate				
Analyze				
Apply				
Understand		2		
Remember	1			

An additional assignment:

- Choose a colonial character or group and write a persuasive editorial stating his/her/its position on the Parliamentary Acts (the editorial must include at least one supporting reason not specifically taught or covered in class).

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create		X		
Evaluate		X		X
Analyze				
Apply				
Understand		2		
Remember	1			

Add a component:
- **Provide a peer review of one colleague's editorial.**
- **Self review and edit your editorial**
- **Turn in your revised editorial**

Undertaking an *alignment analysis* *using "Bloom's Matrix"*

Plot course outcomes, instructional component, and assessment questions for your course on the Bloom chart

Photo by: Gary Smith

Activity

Undertaking an *alignment analysis*

Match each *course outcome* to Bloom dimensions

Place problematic outcomes on the side

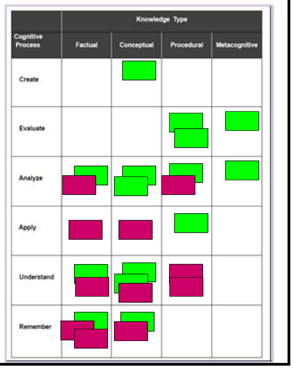
Cognitive Process	Knowledge Type			
	Factual	Conceptual	Procedural	Metacognitive
Create		🟩		
Evaluate			🟩🟩	🟩
Analyze	🟩	🟩🟩	🟩	🟩
Apply			🟩	
Understand	🟩	🟩🟩		
Remember	🟩	🟩		

Activity

Undertaking an *alignment analysis*

Match each instructional component to Bloom dimensions

Place problematic cards on the side

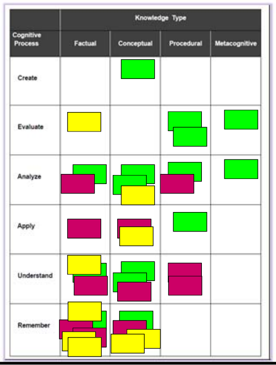


Cognitive Process	Knowledge Type			
	Factual	Conceptual	Procedural	Metacognitive
Create		🟩		
Evaluate			🟩🟩	🟩
Analyze	🟩🟥	🟩🟩	🟩🟥	🟩
Apply	🟥	🟥	🟩	
Understand	🟩🟥	🟩🟩🟥	🟥🟥	
Remember	🟩🟥🟥	🟩🟥		

Activity

Undertaking an *alignment analysis*

Match each 🟨 *assessment question* to Bloom dimensions →



Cognitive Process	Knowledge Type			
	Factual	Conceptual	Procedural	Metacognitive
Create		🟩		
Evaluate	🟨		🟩🟩	🟩
Analyze	🟩🟥	🟩🟩🟨	🟩🟥	🟩
Apply	🟥	🟥🟨	🟩	
Understand	🟨🟩🟥	🟩🟩🟥	🟥🟥	
Remember	🟨🟩🟥🟥🟨🟨	🟩🟥🟨🟨		

Questions

?

	Knowledge Type			
Cognitive Process	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				

Bloom’s Taxonomy of the Cognitive Domain

Anderson & Krathwohl, 2001, *A Taxonomy for Learning, Teaching, and Assessing:* Longman Publishing Group.

Cognitive process:	What the learner does:
6. Create	Brings together parts to form a new whole or solve a problem that requires new creative thinking.
5. Evaluate	Judges the value of something by application of criteria, processes, or standards.
4. Analyze	Identifies how parts relate to one another or to a larger structure or purpose; considers available evidence to reach a conclusion, inference or generalization
3. Apply	Use methods, concepts, principles, theories in new situations; solve realistic problems that require the identification of issues and use of appropriate generalizations and skills.
2. Understand	Constructs meaning by explaining, classifying, comparing,, summarizing
1. Remember	Recalls or recognizes information: facts, definitions, generalizations

Knowledge type:	Knowledge gained:
1. Factual	*Basic elements* (e.g., terms, people, formulas) that learners must know to be acquainted with a discipline or solve problems in the discipline.
2. Conceptual	The *interrelationships among the basic elements* within a larger structure that enables the elements to function together (e.g., classifications, principles, theories, models, structures).
3. Procedural	*How to do something* — methods of inquiry, algorithms, techniques — along with criteria for when to use appropriate procedures
4. Metacognitive	Knowledge of learning and awareness of one’s own cognition – *“knowing what you do and do not know”*

Knowledge Dimension

Cognitive Process Dimension

	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				

An Exercise to Show How Bloom's Taxonomy can be Used to Categorize and Align Program Outcomes, Course Outcomes, Assignments, and Assessments

Knowledge Type

Cognitive Process

	Factual	Conceptual	Procedural	Metacognitive
Create				
Evaluate				
Analyze				
Apply				
Understand				
Remember				

1. Plot this History program outcome with an "*X*" within one (or more?) squares on the above Bloom's taxonomy matrix:

   Students will be able to write original compositions that analyze patterns and relationships of ideas, topics, or themes.

Please stop here for discussion!

2. Plot these course objectives that a teacher intends to assess with test questions:

   Students will:
   1. *Know the specific parts of the Parliamentary Acts (e.g., Sugar, Stamp, Townshend Acts)*
   2. *Explain the consequences of the Parliamentary Acts for different colonial groups*

Please stop here for discussion!

3. Plot this additional assignment:

   Choose a colonial character or group and write a persuasive editorial stating his/her/its position on the Parliamentary Acts (the editorial must include at least one supporting reason not specifically taught or covered in class.

Please stop here for discussion!

4. What benefits would come from adding this step to the assignment?
   - *Provide a peer review a draft of one colleague's editorial.*
   - *Self review and edit your editorial*
   - *Turn in your revised editorial*

(afterL Krathwohl, 2002, A revision of Bloom's taxonomy: Overview: *Theory into Practice*, 41(4), p. 212-218)

STEM Gateway
Course Redesign Teaching Professional Development Program:

Closing the Loop: How to Evaluate your Accomplishments

- Did the redesign project achieve its goals?
- What information will you need to evaluate project success?
- How will you obtain that information?

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Course Redesign Teaching Professional Development Program:

Strategies for Expanding and Sustaining your Redesign Project

- How are you planning to sustain and expand your redesign after this semester?
- What is a community of practice (CoP)?
- How can a CoP provide a foundation for your continued success?
- How do you initiate a CoP among the teachers of the course?

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Sustaining STEM Redesign Projects

STEM GATEWAY

Gary Smith
Director, Office of Medical Educator Development
and
Audriana Stark
Organization, Information, and Learning Science

Table of Contents

Sustaining STEM Course Redesign

What does it mean to sustain the redesign?

Sustaining redesign means assuring that your hard work and goals for further innovations to improve student learning persist beyond the STEM Gateway program. Sustaining your redesign means to maintain the momentum that you have and your motivation for continuous improvement of your curriculum.

Sustaining also means to expand your redesign to other instructors. This aspect is important in order to attain greater consistency in learning experiences across all sections of the course and to assure the implementation of your changes with a continued spirit of improvement, as teaching assignments change and different instructors assume teaching roles in the redesigned course.

Sustaining your pedagogical changes also requires a supportive environment of colleagues. Your motivation to continue your work as innovative teachers will be enhanced within a culture that values teaching. This may even lead to additional redesign projects among your colleagues that will improve student learning experiences across a larger curriculum rather than only within individual courses.

Essential factors for continuing your innovations and encouraging innovative teaching among your colleagues

We wrote this guide as a menu of ideas that you can choose from that are based in decades of scholarly research about change processes. Here are the essential overarching ideas to keep in mind.

Focus on the Advantages for Change

Dissatisfaction is a common catalyst for change. Even though you may have achieved the primary goals for your redesign project, keep asking: "What isn't working well? How could this be better?" Initiate conversations with colleagues about their concerns for student learning, the goals of teaching, and the roles of courses within your curriculum. Be willing to share your progress to illustrate how others can benefit from adopting your changes or undertaking changes of their own. Sharing of resources, knowledge, and stories related to course design can create a synergistic effect that can make your efforts together greater than the sum of separate efforts.

Be Strategic in Your Efforts to Persuade Others

Although scientists commonly call upon data to support an argument, people seldom adopt changes because of data. Showing results from your redesign could be beneficial to demonstrating an advantage to change but persuading people to teach differently will likely require additional support from you or others. We rarely discard what we know in order to take up something that is unfamiliar, especially if the change seems particularly complex or complicated. Seeing an innovation at work enhances adoption, so invite colleagues to visit your classes and show them your instructional materials. Share your materials, offer advice, and point colleagues to useful resources that they can use in order to keep their change work manageable, such as the use of Graduate and Teaching Assistants. Encourage colleagues to try out new approaches by combining them with or adapting them to existing practice and experience. Initial success with these modest changes can pave the pathway to greater innovation and higher fidelity implementation of your redesign elements. Open, collaborative communication channels are essential for sustaining and enlarging the number of colleagues who are willing to be progressive with their teaching.

Connect with the Values of Higher Education

Universities are creators and disseminators of knowledge not only through research and other creative works but also through teaching and mentoring. Where possible, develop synergy between research and teaching by including research and publication about teaching. Involve graduate students in your education projects and mentor them to be better prepared, and more competitive, for future faculty positions.

Be Resilient

Celebrate immediate positive results but don't expect them. Be prepared to support your colleagues who may be discouraged from investing additional effort. "Performance dips" are typical when implementing significant changes and improvement commonly requires building confidence, accumulating tacit knowledge with new methods, and learning from mistakes. Sharing stories of challenges and setbacks can help reluctant instructors adopt the mindset that views challenges or mistakes as learning opportunities that can improve practice. Vulnerability is essential to taking risks and being creative. Encourage people to persist through challenges, as you have done, and remain resilient throughout the process.

Build a Culture of Teaching Excellence

Sustainable innovations are built around supportive social systems. Social networks and communities of practice become sources of inspiration, learning, and a feeling of belonging to groups who share the value of being excellent teachers as measured by what students learn and are motivated to accomplish. These groups may exist within your department, or cross disciplinary boundaries, or both. Groups may be composed of people at various levels of the organization from graduate student to tenured faculty to department chairs. You can help to seed them and you can encourage department leadership to be opinion leaders for valuing teaching. Aligning values and inspiring a shared vision of improving teaching and learning in your department can mobilize your colleagues to build and maintain a culture of excellence in teaching.

Look for these elements as you use this guide as a handbook for sustaining your redesign project.

Gary Smith and Audriana Stark April 2016

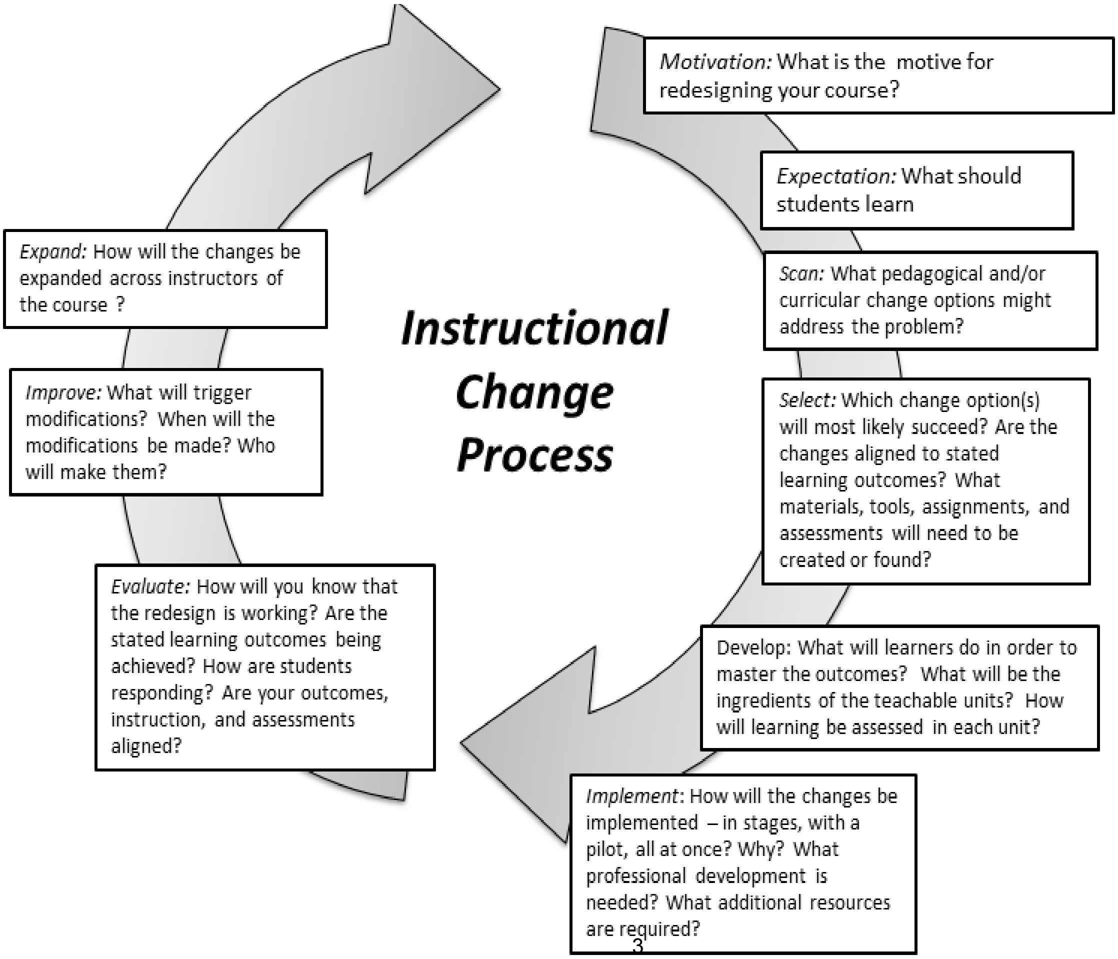
Continuously Improving Teaching and Learning

Effective course design is a continuous process. The steps for continuous instructional change are shown in the figure below, Instructional Change Process. Determining outcomes, designing instructional components, and evaluating results and making adjustments allows for growth as a teacher and improved learning experiences for students.

> *Without continual growth and progress, such words as improvement, achievement, and success have no meaning*.
>
> \- Benjamin Franklin

Essential Questions

- **How will you know that the course design is effective?**
- **How will you use what you learn when implementing new material to improve the way you teach?**



Instructional Change Process

Motivation: What is the motive for redesigning your course?

Expectation: What should students learn

Scan: What pedagogical and/or curricular change options might address the problem?

Select: Which change option(s) will most likely succeed? Are the changes aligned to stated learning outcomes? What materials, tools, assignments, and assessments will need to be created or found?

Develop: What will learners do in order to master the outcomes? What will be the ingredients of the teachable units? How will learning be assessed in each unit?

Implement: How will the changes be implemented – in stages, with a pilot, all at once? Why? What professional development is needed? What additional resources are required?

Evaluate: How will you know that the redesign is working? Are the stated learning outcomes being achieved? How are students responding? Are your outcomes, instruction, and assessments aligned?

Improve: What will trigger modifications? When will the modifications be made? Who will make them?

Expand: How will the changes be expanded across instructors of the course ?

Use data to inform decisions

- Collect data that can inform your teaching (student attitudinal surveys, pre-post concept inventories, exam questions, etc.)
- Analyze data to determine what is working and what is not working. Make adjustments as necessary.

This process can be enhanced through synergistic efforts with others who teach the course (See *Undertaking Lesson Study)*.

Organizing Material for Dissemination

Organizing and making resources available to all instructors that teach the course can enhance the adoption, implementation, and growth of curricular components.

Alone we can do so little.
Together we can do so much.
–Hellen Keller

Essential Questions

- **How can you share the redesign materials with other instructors?**
- **How will others know that the resources exist or are updated?**

Organize Material

Organize activities, worksheets, assessments, clicker questions, etc., with a structure that permits easy sharing.

Share Resources on the Cloud

Choose an online storage site to host work that can be shared amongst instructors (ie. Google Drive, PB Works, BlackBoard Learn, DropBox). Pick one that works for you and your colleagues.

Send Notification

Encourage instructors to send notifications when new or revised material is added.

Engaging New Instructors in Your Course-Redesign Project

Expanding your redesigned curriculum and pedagogy to other instructors and those who teach the course in the future is an essential aspect of sustaining your effort and innovation for the benefit of future students.

> *"Share your knowledge. It is a way to achieve immortality."*
> - Dalai Lama XIV

Essential Questions

- **How will you inform instructors who were not part of your redesign project about what you did and are doing?**
- **How will you encourage and support them to adopt your practices and materials and contribute to continuous course improvement?**

Explain what you are doing *and* why

Share your proposal and reports that you generated for STEM Gateway

Share assessment data and involve new instructors in outcomes assessment and student surveys

Make a handbook that outlines the instructional strategies and illustrates their use

(Example handbook prepared by General Chemistry teams available from STEM Gateway)

Make your redesign components accessible for easy adoption and adaptation

Use the cloud (e.g., OneDrive, Dropbox, Google Drive) to share activities, worksheets, assessments, clicker questions, etc., with a structure that permits easy sharing.

(Also see: *Organizing Material for Dissemination)*

Form a community of practice among instructors to share knowledge in a trusting environment

Meet informally or formally to discuss challenges to student learning, successful and unsuccessful activities, and to share experiences

(Also see: *Fostering Communities of Practice)*

Undertake *lesson study* – collectively investigate challenging learning outcomes in terms of different ways to teach the concepts

(Also see: *Undertaking Lesson Study)*

Encourage observation in classes that have implemented the redesign

Much of the knowledge of teaching practice is tacit and is not readily conveyed by text or conversation

Invite new instructors to watch you implement the redesign pedagogy and curriculum and to discuss the methods you use.

Make videos of various practices that anyone can watch at anytime.

Encourage incremental and iterative implementation of unfamiliar approaches

Avoid unreasonable expectations

Encourage progressive changes that are comfortable and feasible

Help new instructors to set goals for changing and assessing their teaching

Involving Graduate Students

Utilize graduate students as soundboards, instructional designers, pilot students, and instruments of feedback when rolling out new or modified curriculum.

Essential Questions

- **How do you currently utilize graduate students assistants to aid with course redesign?**
- **What other ways can you utilize the experiences and expertise of graduate student assistants?**

> *Good teachers know how to bring out the best in students.*
> Charles Kuralt

Benefit from existing Teaching Assistants

Many graduate students are responsible for teaching labs. Include them in the process of course design and evaluation. Graduate students can help design new curriculum, review and revise course modules, and provide feedback about course content and pedagogy.

Prepare Future Faculty

Involving graduate students in the course design process develops mastery of content and of instructional design, both are needed for effective teaching

Communicating with Colleagues

Sustaining your redesigned course, improving it, and potentially extending redesign efforts to other courses in your department requires the support of your colleagues.

Essential Questions

- **How will you gain the support of other faculty for your redesign effort?**
- **How will you generate enthusiasm for other redesign projects in your department?**

> *"And time for reflection with colleagues is for me a lifesaver; it is not just a nice thing to do if you have the time. It is the only way you can survive."*
> \- *Margaret J. Wheatley*

Tell colleagues what you've accomplished

Request time at a departmental meeting to present your project

Share your accomplishments (e.g., new curricula, positive learning outcomes, positive student surveys or teaching evaluations) in email or personal announcements to faculty colleagues

Include your work in alumni newsletters – your colleagues read them, too!

Invite colleagues to experience what you're doing

Invite colleagues to visit your class and talk about it afterward, soliciting their feedback in addition to elaborating your intentions

Invite colleagues to be guest presenters in your course and assist them to tailor their approach to the format of your course

Talk with your chair to encourage a culture of teaching and learning

Some possible conversation starters from *Faculty Focus*:

"We need to be having more substantive conversations about teaching and learning in our department meetings. What do you think about circulating a short article before some of our meetings and then spending a little time discussing it? Could you recommend some readings?"

"I'm concerned about how we introduce new faculty to teaching in our department. Should our mentoring efforts be more formal? What if we didn't put student ratings from their first year in their dossier? I would love to hear your thoughts on the 'ideal' first-year teaching experience for our new faculty."

"I'd like us to devise some sort of departmental award or recognition for all kinds of work that supports teaching and learning, and I need your help. Is a monetary award the only option?"

For more teaching-focused conversation ideas from *Faculty Focus* for chairs and faculty, check out: http://tinyurl.com/deptchairquestions

Identifying a problem is the first step toward making a change

Fellow redesigners provide a community or network to support and inform your redesign effort

Recruit redesign projects by asking your colleagues what they are dissatisfied about regarding their teaching, student learning, the degree program, etc.

Ask the department chair to survey faculty to identify consensus concerns about degree curriculum or courses that can motivate making changes.

Use your experience to assist colleagues with their own potentially risky and challenging change process with a focus on resolving their concern or a concern that is shared across the department

(Also see: *Continuously Improving Teaching and Learning)*

Fostering Communities of Practices

CoPs provide a social platform to solve everyday problems in teaching and student success, develop and disseminate a set of best practices, tools, insights, and approaches needed to excel as teachers and guide students to excel as learner.

Essential Questions

- **What is a community of practice?**
- **How can you foster a CoP?**

Taking time to build community, to get to know your people will have long-lasting benefits.- Clifton Taulbert

CoP Key Ingredients

Community- respectful, trusting interactions among the members with the consequence of learning from one another to address the shared interest.

Domain- topic area and sense of identity to affirm the purpose of the community (e.g., instructors of the same course, instructors using a particular technology or pedagogy).

Practice- resources and knowledge that the community develops, finds, shares, and maintains (e.g., pedagogical content knowledge, tools, ideas, assessments, lesson plans)

Starting a CoP

Identify Purpose, Members , Vision, and Goals

Coordinators…

- Identify important issues in the domain
- Plan facilitates community events and manage knowledge
- Manages connections between the CoP and other groups and units
- Assesses the health of the community

CoP Activities

☐ Meetings to discuss observed challenges to student learning
☐ Sharing assignments and rubrics
☐ “Brown Bags” to present ideas or solicit help with a challenge
☐ Planning presentations and manuscripts
☐ Discussing item analysis to improve assessments and to examine challenges to student mastery of course outcomes that should be addressed
☐ Collectively addressing weaknesses in student learning through lesson-study projects
☐ Classroom observations, focusing on learning by the observer rather than feedback delivered to the observed instructor

Undertaking Lesson Study

Experimental science assumes scale-up occurs by faithfully implementing a proven program in new settings. Improvement science through lesson study assumes scale-up occurs by integrating content knowledge with knowledge about how to build shared ownership of improvement, to detect and learn from variations in practice, to build and share knowledge among practitioners, and to motivate innovation.

Essential Questions

- Are we achieving the learning outcomes?
- How can we collaboratively improve the outcomes?

> *"The biggest and most long-lasting reforms of undergraduate education will come when individual faculty or small groups of instructors adopt the view of themselves as reformers, within their immediate sphere of influence, the classes they teach every day."*
>
> *- K. Patricia Cross*

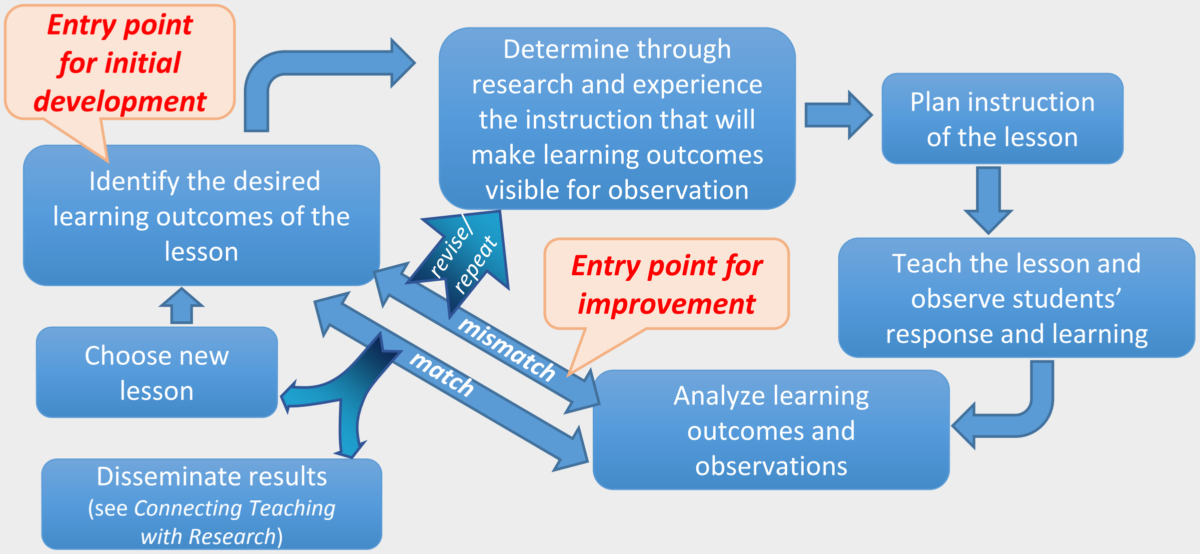
Understand the meaning of lesson study

Jugyoukenkuu (Lesson Study) is the Japanese art of teacher professional development. A group of teachers identify an area of teaching – e.g., topic, concept, instructional method – that needs to be improved or developed. The group then plans the lesson together to address the need. One or more teachers then deliver the new lesson while observed by the others. Learning assessment data is collected and reviewed and areas for further development and improvement are identified.

Lesson study is a collaborative, community-building approach to design and continuous improvement of teaching and learning that can be part of scholarly classroom action research. Having a team effort can help maintain a positive spirit in times of difficulty such as performance gaps.

(For more information about lesson study in higher education, go to the Lesson Study Project at the University of Wisconsin-La Crosse, http://www.uwlax.edu/sotl/lsp/

The process of lesson study



Networking with other team leaders

STEM students take courses from other instructors who have also been actively redesigning their courses. Talk to team leaders about their experiences, how their redesigns are working, and what alignments may exist in your courses and the ways in which you teach.

Essential Questions

- **Who should I talk to about my course redesign project?**
- **What discussions should I have with other team leaders?**

If your actions inspire others to dream more, learn more, do more, and become more, you are a leader.
-John Quincy Adams

Reach out to team leaders

Biology-
Dave Hanson
Jenn Rudgers
Kelly Howe

Chemistry-
Joseph Ho
Julia Fulghum
Hua Guo

Earth and Planetary Sciences-
Aurora Pun

Mathematics-
Derek Martinez

Physics--
Doug Fields
Mark Morgan-Tracy

We also encourage you to reach out to other faculty and continue to build your network. By doing so, you can help to build an institutional culture around excellence in teaching.

Ideas for Discussion

What components of the redesign worked well for you?
What lessons from the redesign did you learn?
How are you assessing your redesign efforts?
We have been having this problem. Have you?
How did you address it?
How are you engaging your colleagues?
How are your students responding?
What roles do your TAs/GAs play?

Connecting with CNM and Branch Campuses

Student enrollment swirls between the UNM campuses and CNM and the full benefit of preparing students for continued success as STEM majors at UNM will be enhanced if your innovations can be adopted at the 2-year campuses.

Essential Questions

- **How can we disseminate what we are doing for the benefit of faculty and students at the 2-year campuses?**
- **How can we learn what our colleagues at 2 year campuses are doing that would benefit our students?**

Competition has been shown to be useful up to a certain point and no further, but cooperation, which is the thing we must strive for today, begins where competition leaves off.

- Franklin D. Roosevelt

Know your counterparts

Contact the branches and CNM to identify the permanent faculty (or frequently employed temporary faculty) who teach your course and introduce yourself and your teaching role at UNM

Find where values align and highlight your shared vision and mission. Discuss the intersection of institutional missions and your roles in it.

Communicate and share your redesign

Write a summary of your redesign project (purpose, general course design, syllabus, types of instructional materials and assessments) and send it to your counterparts. Ask them to share the same. This synergy will create major benefits and advantages for teachers and students, alike.

Explain how the redesign is intended to better prepare students for subsequent STEM courses at UNM.

Provide samples or full access to your redesign materials in order to stimulate partial or complete adoption at the 2-year campuses.

Organize conversations

Convene regular meetings (especially with nearby CNM and UNM-Valencia County) faculty counterparts to discuss common objectives and challenges and seek common goals and solutions.

Invite reciprocal classroom observations to share tacit knowledge of instructional strategies and techniques.

Example: UNM Chemistry & Chemical Biology Department faculty teaching freshmen and sophomore courses meet twice each year with their CNM counterparts with agendas to address common concerns ranging from textbooks, to pedagogy, to assessment.

Connecting Teaching with Research

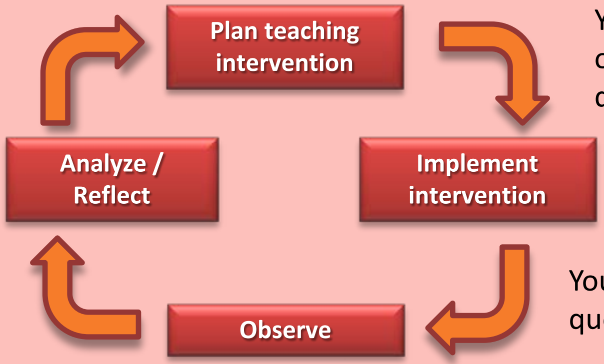
All teaching should be scholarly … and when researchers teach, they commonly contribute to the scholarship of teaching and learning, which is a potential source of engagement to sustain your redesign.

Essential Questions

- How can we simultaneously maintain high commitments to both teaching and research?
- How can we disseminate what we are doing for the benefit of others?

> *"The work of the professor becomes consequential only as it is understood by others. When defined as scholarship … teaching both educates and entices further scholars"*
>
> – *Ernest Boyer,* Scholarship Reconsidered

Engage in classroom action research



Your classroom/lab/website is a laboratory for observational research – both quantitative and qualitative

Your students and/or artifacts of their learning are the objects of your research

Your course redesign provides your research question and design

Learn more about classroom action research at the *Journal of the Scholarship of Teaching and Learning*

Consider outcomes assessment as research questions

A stated outcome can be viewed as a hypothesis about student learning that is tested with assessment data

Use a scientific approach to measure learning and connect it to the design of your teaching

Publish and present your research

The scholarship of teaching and learning diversifies your research portfolio

Present at your disciplinary meetings, special conferences, and publish in journals within your discipline or focused on education

Consider presenting at NMHEAR, a local but nationally respected, low-cost, conference where you can disseminate your research and make enlarge your colleague network

Resources for Inspiration:

- The Science Education Resource Center at Carleton College http://serc.carleton.edu/index.html
- Carl Wieman Science Education Initiative at the University of British Columbia http://www.cwsei.ubc.ca/
- Science Education Initiative at the University of Colorado Boulder- http://www.colorado.edu/sei/
- Multimedia Educational Resource for Learning and Online Teaching https://www.merlot.org/merlot/index.htm
- Vanderbilt University Center for Teaching Guides https://cft.vanderbilt.edu/teaching-guides/
- Center for the Integration of Research, Teaching and Learning http://www.cirtl.net/

Sustaining and Expanding Course Redesign Projects

Notes from the Panel Discussion

Development of an Active Learning Handbook- (The example handbook used in Chemistry can be found in the OneDrive -11 Sustaining and Expanding Redesign Projects)

The Chemistry 121/122 team developed a handbook for engaging new instructors. The handbook provides a shared language and orientation for new instructors. This reduces the amount of time and repetition needed to engage new instructors. It also can be accessed at any time. It does not cover everything but provides a good starting point. Instructors generally start out with Clickers and move to adopt other approaches in the handbook. New instructors are encouraged to pick a few ideas that they are comfortable using in their teaching. Incremental adoption is encouraged. Pieces of the handbook have been shared with teaching assistants.

(Other ideas for Engaging New Instructors can be found in the Sustainability Handbook p. 6-7 that is located in the OneDrive *folder-11 Sustaining and Expanding Redesign Projects)*

Working with Teaching Assistants (TAs)-

Weekly meetings are held with TAs. TAs record how they are teaching (discussion, lecture, clickers, etc.) TAs develop questions in the lesson study format and use it to research deeper into their teaching. They are given 1 week to make a change in approach. Sometimes TAs are not familiar with how to guide learning even after trainings but can make discoveries through the lesson study process in order to improve teaching. Lacking expertise of concepts generally results in providing answers rather than guide students to create their own answer, so training, modeling and, sharing tacit knowledge are needed. Chemistry has created a point system to keep track of the TAs to document occurrences. Keep TAs involved and informed from the beginning. Use an example lab in the lab that can be edited on the go in order to gather TA idea and feedback.

(More ideas for engaging teaching assistants and graduate assistants can be found in the STEM Gateway Sustainability Handbook p.8; for more on Lesson Study see p. 12.)

Classroom Observations

Class observations for the purpose of learning from another, is a critical way to learn tacit knowledge. Instructors can model good teaching practices. Observers should reflect on what the teacher did and why they may be doing it.

(For more information about peer observations see folder 5- Learning from One Another Folder in the One Drive)

Creating a Culture of Teaching in Departments

Success of teaching as departmental activity is dependent upon culture of teaching in the department. It can be frustrating to faculty when the department does not value teaching. The culture of valuing teaching isn't attached to a discipline but rather varies among institutions. Focus on getting department chairs engaged and supporting your work.   It takes a strong voice, time, and personal relationships to help change culture. (See conversations starters p. 10 of the Sustainability Handbook)

Staying in touch

Chemistry holds a weekly meeting to discuss teaching and get people on board. A community of practice framework can provide the platform to engage people. (See Fostering Communities of Practice p. 11 and Engaging New Instructors in the Sustainability Handbook p. 6-7)

ACTIVE LEARNING HANDBOOK

FOR GENERAL CHEMISTRY 121 & 122

Prepared by K. Joseph Ho
Department of Chemistry and Chemical Biology
University of New Mexico

Contents

What is Active Learning?

In the literature, “active learning” is referred to the learning that requires students to cognitively engage and involve in course materials. Research of learning has shown although students can learn by passively receiving information, they learn much better by active engagement. We chose active learning for our general chemistry students to improve their learning of this difficult subject. For our purpose, we use the term “active learning” to describe the collective approach we adopted in our teaching of general chemistry 121 and 122. The philosophy behind this approach is that everything we plan for our students requires them to take an active role in building up their knowledge. For example, students should read the textbook and prepare themselves before each class; during the class, we expect students to engage in problem-solving and learn cooperatively with one another; after the class, we ask our students to continue their engagement of course materials with more ALEKS exercises. All learning strategies we describe in this handbook will not be effective if students are not actively participating. As a teacher, our job is to help and make sure students are actively engaged in these processes.

Faculty needs to be clear about the following Do’s and Don’ts:

Do’s

- The learning outcomes for students should be explained to them in the first class;
- How you expect students to do should be explained in the first class;
- You should actively assess and monitor students’ learning progress throughout the semester;
- You should reflect on teaching based on student’s learning progress on the regular basis, and make necessary changes for the better results;
- You should strive for effective communication with our students to increase their motivation and interests in learning the course materials;

Don’ts

- Faculty should not view active learning as merely a role switch and a reduction of their preparation for the classes and their role in the classroom teaching.
- Faculty should not implement the active learning strategies blindly without frequently assessing and reflecting on the effectiveness of the strategies.
- Most of the active learning strategies require prompt feedback from faculty; do not delay your responses to students’ questions, muddy points, or misunderstanding.

Misconceptions about learning

1. ***There isn't any evidence that active learning is more effective than lecture-based learning.***

   Not true. Mounting evidence can be found in the literature. The most recent research article is "Active learning increases student performance in science, engineering, and mathematics" by Freeman et al. From this meta-analysis, 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).

2. ***Learning is more effective and efficient if teacher explains before students try to solve the problem.***

   Research has shown this is not true. Students actually learned better when similar problem was presented to them before teacher explained the underlying principles. We learn better when we wrestle with new problems before being shown the solution, rather than the other way around.

3. ***A mass learning is more effective than spaced learning.***

   From many research, it is indicated that spaced or distributed learning can have long-term learning effect than a short-term and intense learning. Therefore, it is recommended to divide student study time for different subjects and avoid procrastination. It is also important to re-visit previous concepts periodically in our teaching.

4. ***It is always a good advice to students that reading and re-reading textbook or lecture note is important in an effective, long-term learning. Repetitive exposure builds memory.***

   Research in neuroscience about learning has provided evidence that re-reading is not an effective learning method. Repeated reading provides the illusion of mastery of the underlying ideas. The fact that you can repeat the phrases in a text or your lecture notes is no indication that you understand the significance of the precepts they describe, their application, or how they relate to what you already know about the subject.

   Among other methods we commonly used, highlighting, marking and summarization are also not effective for learning. Practice testing and self-explanation are more effective than the above methods.

5. ***Student's motivation to learn in our classes is low. It is important to make our class fun and interesting. It is also important to avoid asking students to do difficult tasks and causing them frustration.***

   Some kinds of difficulties during learning help to make the learning stronger and better remembered. When learning is easy, it is often superficial and soon forgotten. Not all of our intellectual abilities are hardwired. In fact, when learning is effortful, it changes the brain, making new connections and increasing intellectual ability.

To achieve excellence in any sphere, you must strive to surpass your current level of ability. Striving, by its nature, often results in setbacks, and setbacks are often what provide the essential information needed to adjust strategies to achieve mastery.

6. ***Fluking an exam is bad.***

   Flunking exams is actually a good thing, from cognitive psychology. “Across a variety of experiments, psychologists have found that, in some circumstances, wrong answers on a pretest aren’t merely useless guesses. Rather, the attempts themselves change how we think about and store the information contained in the questions. On some kinds of tests, particularly multiple-choice, we benefit from answering incorrectly by, in effect, priming our brain for what’s coming later. That is: The (bombed) pretest drives home the information in a way that studying as usual does not. We fail, but we fail forward.” This is the message from Benedict Carey in his NY Time article.

Planning for your course

The most common approach faculty takes to design a general chemistry course is a content-based approach. In this approach professors first determine the order of topics – this is usually based on textbook chapters with some modifications according to teacher's experience. Once the order is determined, a class schedule will be planned to fit topics into the weekly lecture meetings. At this point, the course design is almost done and the professor just needs to insert a couple of midterm exams and a final exam to finalize the class schedule. The whole process can be finished within a day, or even a couple of hours for an experienced faculty.

Although this approach is quick and easy, and it allows faculty to makes sure all the required topics will be covered in the course, there are many important aspects about student learning that have not been considered in this approach. For example, is there evidence that shows the planned learning method is effective for student learning? What are the students learning outcomes from this course? What is the mechanism that allows the instructor to improve student learning during the semester? These questions are especially important in a class with diverse student background like in our general chemistry classes that we do not know and should be considered in our course design process.

The approach we recommend and describe in this handbook is called the **backward design**. We call it backward design because we start with the final outcomes we expect our students to reach as the result of the course learning, and go "backward" to work out the best strategies for students to accomplish the final outcomes. This approach focuses on how "students" reach the "learning outcomes", instead of how "professor" teaches the "covered topics".

Before we begin to introduce the steps of backward design, we explain the terminology we use.

1. Each UNM core course has a set of **course level Student Learning Outcomes** (**SLOs**). You can find the SLOs for CHEM 121 and 122 in Appendix A. You need to adopt these SLOs for your course. Each semester, you should collect assessment data against selected SLOs (two to three) and use it for the writing of annual General Education Assessment reports.
2. Based on course SLOs, you can write a set of **Instructional Objectives** (**IOs**) as the course content. For example, for SLO#3 of CHEM 121: "*Explain the structure of the atoms, isotopes and ions in terms of its subatomic particles*"**,** you might have the following three IOs: (1) students practice to identify the numbers of subatomic particles for different elements in the periodic table. (2) students practice to identify isotopes and the numbers of subatomic particles. (3) students practice to identify ions and the numbers of subatomic particles.
3. When we prepare the course level IOs, we need to consider different cognitive and affective levels of student learning activities as described in **Bloom's and Fink's Taxonomies**. Both taxonomies are explained in Appendix B.
4. To monitor students' learning progress throughout the semester, we use both informative and summative assessments. **The informative assessments** are low-stakes assessment focusing on providing a quick and diagnostic measure of student understanding and the effectiveness of

teaching. The **summative assessments** are high-stakes assessments serving for the purpose of grading and reporting.

We recommend the following steps for your planning of this course:

1. What are the IOs to be covered are determined which are aligned with course SLOs
2. Learning strategies are chosen & designed for students to learn topics planned in IOs
3. How will IOs and SLOs be assessed during and by the end of semester?
4. What are the course activities to be developed and implemented?

We divide our course activities into three categories based on when it happens:

Category	**activities**	**goals**
Pre-class	Reading assignments	Students learn facts from reading; we expect them to understand simple concepts, too.
	Reading quizzes	Quick assessment of students' reading
	Muddy points	Students reflect on their reading and inform teachers about what is not understood.
In-class	Introduction & responses	Teacher summarizes covered topics and responds to students questions
	I-clicker questions	Assessments of student's learning
	Small group discussions	Students learn covered topics by cooperatively solving problems
Post-class	ALEKS exercises	Requiring students to transfer knowledge from short-term memory to long-term memory by retrieving and applying.

Under the framework presented above, you can start to plan for your implementation. The following questions help you form your policy and what to be prepared.

Pre-class

1. How do I let students know the reading assignments? Should I use handouts, e-mails, or announcement in the BlackBoard Learn?
2. Do I want to ask students to read just the textbook in the reading assignments, or do I want to add other materials such as simulation, videos, or handouts?
3. How will I do the reading quizzes? Will I use ALEKS questions, or my own questions delivered on BlackBoard LEARN? Or will I give them a quiz in the beginning of each class as the reading quiz?
4. How will I assign and collect answers from muddy points? Keep in mind the purpose of muddy points is to inform you about students' pre-class reading, and should be collected

before the class. You should have sufficient time to review students' responses before each class. In our current practice, we use LEARN to collect and review responses.

5. What percentage of grade you will give to the pre-class quizzes and muddy points?
6. What are the source or resources of reading assignments? Is there existing resource from course redesign?

In-class

1. How will I organize and present the topics I planned to discuss in each class? Should I use PowerPoint slides as the outline for the classes? Should I give mini-lectures to summarize and further explain the concepts or misconceptions indicated by students' responses?
2. How will I conduct the small group discussions? How will I form groups? How will I make sure each student has a role in the group discussion? How will I credit each student for discussions? How will help group discussion if they have questions? How will I oversee more than one group? How will I organize PLF and TAs to facilitate the discussions?
3. How will I use clicker in the class? What proportion of grade will I give to students for the use of clickers? What is my policy regarding loaning clickers? How will I register students for clicker? (the section of Classroom Technology has more recommendations)

Post-class

1. How will I grade ALEKS? How will I set up ALEKS, objective or open-pie? Do I want periodic assessments? How frequently do I want assessments?
2. Do I want to give students post-class projects or assignments in addition to ALEKS? How will I grade these assignments?

Other Course Policies

1. Will I take attendance? Will attendance be required and counted toward the final grade?
2. This course has the lab (CHEM 123L or 124L) as the co-requisite. If a student has previously passed the lab, they can register this course without the lab. You need to be aware of this curricular rule when students ask you to give them an override for co-requisite. Similar problems also arise when students drop one of these co-requisite courses because they will also be dropped from the other course. The general rule is the faculty for the course student will remain in made the decision for whether an override will be granted. For example, if a student wants to drop the lab and remain in the lecture, they should appeal to the lecture faculty for override. However, when making the decision, you should consider for the integrity of the curriculum and whether it is possible for student to pass the course. For example, if student wants to drop the lab in week 1 and remains in the lecture, you need to make sure the student's intention is not to take the lecture without the lab. You also need to make sure that student understands by taking the lecture alone, he/she cannot take the next course until he/she pass the lab, which will delay their progress. The lab policy is students can stay in the lab when they drop from the lecture only if they have completed

50% of the lab materials and with a passing grade. You can consider a similar rule for your class.

3. You should have a classroom policy in place. For example, will you allow students to use cell phone or surf the internet in class?
4. You should have the date and time and room number for your office hours posted.
5. You should have an e-mail policy in place. For example, will you answer weekend e-mails? In what timeframe will students expect to receive your responses?
6. You should have the grading policy in place.

Learning Strategies Inventory

Source: Faust, J. L., & Paulson, D. R. (1998). Active learning in the college classroom. *Journal on Excellence in College Teaching, 9* (2), 3-24

Muddiest (or Clearest) Point. This variation on the one-minute paper is specifically designed for determining gaps in student comprehension (Angelo & Cross, 1993). The instructor requests a one-minute written response to the question "What was the 'muddiest point' in today's lecture?" or "What concept do you find most difficult to comprehend?" The question may be more specific. Because the instructor collects the responses immediately and can read them before the next lecture period, he or she has the opportunity to make teaching adjustments in response to the students' needs much sooner than would be possible otherwise.

One-Minute Paper. Originally reported by Angelo and Cross (1993), this technique has been adapted for use in virtually every discipline (see, for example, Dorroh, 1993; Fishman, 1997; Kloss, 1993; Ludwig, 1995; Morrissey, 1982). It is a highly effective method for checking student progress and for providing a consistent means of communicating with students. To implement this method, the instructor simply stops class a few minutes early (or pauses at some point during a lecture), poses a specific question (for example, "What was the main point presented in today's class material?"), and gives students one (or perhaps two—but not many more) minute to respond. Students' responses tell the instructor whether or not they view the material in the way he or she envisioned.

Depending on an instructor's objectives, students may submit their responses anonymously or with their names on them. Anonymity may encourage otherwise reticent students to voice concerns or raise questions, but it will not foster direct communication between students and the instructor. Further, it has been argued that allowing anonymous submissions actually detracts from active engagement in the exercise because students may perceive that they have little to gain by applying themselves to the task (Harwood, 1996).

Reading Quiz. Active learning depends on students coming to class prepared. In addition to being an effective means of encouraging students to read assigned material, the reading quiz can be used to measure student comprehension of readings, thus providing the instructor with evidence of students' level of sophistication as readers (Mazur, 1996, 1997). By asking the same sorts of questions on several reading quizzes, instructors can guide students regarding what to look for when reading assigned texts. For instance, if reading quizzes in an English literature class consistently include questions such as "What color were Esmerelda's eyes?" students will learn that it is the details that count. On the other hand, questions such as "What reason did Esmerelda give for murdering Sebastian?" highlight issues of justification. If the goal is to instruct and not merely to coerce, quiz questions must be carefully constructed so that they identify both which students have read the material (for the instructor's benefit) and what is important in the reading (for the students' benefit). Using straightforward questions based directly on the class reading assignments for each day, Paulson (1999) has found a correlation (r = ~ 0.8) between the total points on the reading quizzes and the total course points.

Pair-share. Putting students in pairs provides many of the advantages of group work. A recent meta-analysis of 383 published reports on small-group learning in college science, math, engineering, and technology classes showed that small-group learning promotes greater student achievement, increases retention in courses, and promotes favorable attitudes toward the course material (Springer, Stanne & Donovan, 1998). Students have the opportunity to state their own views, to hear from others, to hone their argumentative skills, and so forth, without the administrative requirements of group work (time spent assigning people to groups, class time used for getting into groups, and so on) (Shakarian, 1995). Further, working in pairs makes it virtually impossible for students to avoid participating, thus making each person accountable.

Pair Discussion. In discussion, students pair off and respond to a question either in turn or as a pair. This method easily can be combined with other techniques, such as those discussed under "Questions and Answers" or the "Critical-Thinking Motivators" discussed above. For example, after students have responded to a list of true-false statements, they can be asked to compare their answers with their partner's and to discuss the statements on which they differed. In science classes, students can be asked to explain how some experimental data support a theory that the instructor has just discussed. Generally, this approach works best when students are given explicit directions, such as "Tell each other why you chose the answer you did."

Note Comparison/Sharing. One reason that some students perform poorly in classes is that they do not have good note-taking skills. That is, although students may listen attentively, they do not always know what to write down, or they may have gaps in their notes that leave the bewildered when they go back to the notes to study or write a paper. One way to avoid some of these pitfalls and to have students model good note taking for each other is to have them compare notes occasion- ally. After covering a crucial concept, the instructor might stop lecturing and have students read each other's notes, filling in the gaps in their own note taking. This activity is especially useful in introductory courses or in courses designed for non-majors or special admissions students. When students see the value of supplementing their own note taking with others' notes, they are more likely to continue the practice outside of class time.

Peer Review. This method works well when students have completed an individual homework assignment or short paper. On the day the assignment is due, students submit one copy to the instructor and one copy to a partner. Partner pairs may be formed just for the day or assigned for the entire term. Each student offers critical feedback on his or her partner's work, standardizes or assesses the partner's arguments, or corrects mistakes in problem solving or gram- mar. Peer evaluation can be a particularly effective way to improve student writing. However, students need to be given specific instructions on what to look for in the work they are assessing. In a course that Paulson teaches entitled Writing for Chemists, for example, students receive a Group Editing Guide, which helps them to focus on the important features in each section of a paper. Without these detailed instructions, students tend to make rather general and not very useful comments. Students also can benefit from assessing an anonymous paper or a paper from a previous class selected by the instructor.

Jigsaw Group. In jigsaw projects, each member of a cooperative-learning group becomes "specialized," mastering a discrete part of the subject matter required to complete the project. He or she thereby possesses knowledge critical to the rest of the group. There are generally four stages in the jigsaw process (Clarke, 1994; Marcus, 1998). First, the instructor organizes students into heterogeneous home groups (if the instructor has assigned students to base groups during the term, the base group may constitute the home group for a given project). Each member of the home group is assigned or chooses a part of the subject matter to be explored. For example, if the project requires applying several moral theories to a case study, each student in the home group is assigned to become an expert on a particular moral theory. In the second stage, students reform into focus groups centered on their selected topics. In our hypothetical example, several students from different home groups who were designated as experts on Kant's moral theory would group together to explore, clarify, and write down the main ideas of that theory. In the third stage, these focus groups disband, and the original groups re-form. The home groups now include an "expert" on each moral theory sub-topic. The experts report their findings to the rest of their home group, and the group discusses the issues in depth. The fourth and final stage of the project requires the group to apply this information. In the example above, each group could determine the moral status of an action portrayed in a case study according to the various moral theories they have mastered.

Active-Review Sessions. In the traditional class review session, the students ask questions and the instructor answers them. Students spend their time copying down answers rather than thinking about the material. In an active-review session, the instructor poses questions, and the students work on them in cooperative-learning groups (either informal or base groups can serve this purpose). Then the instructor asks students to share their solutions with the class, and all students discuss any differences among their proposed answers. The ensuing discussion can be guided according to the questions and answers techniques outlined above.

Work at the Blackboard. In many problem-solving courses (such as mathematics, logic, or critical thinking), instructors tend to review home- work or teach problem-solving techniques by solving the problems themselves. Because students learn more by doing than watching

(Spring- er et al., 1998), this is clearly not the optimal scenario. Rather than illustrating problem solving, instructors can have students work out the problems themselves by asking them to go to the blackboard in small groups. Cooperative groups encourage discussion of problem-solving techniques ("Should we try this?") without embarrassing students who have not yet mastered the required skills. If there is insufficient black- board space, students can still work out problems as a group by using paper and pencil, small dry-erase boards, or even computers if the ap- propriate software is available.

Concept Mapping. A concept map is a way of illustrating the connec- tions that exist between terms or concepts covered in class (Novak, 1990; Novak & Gowin, 1984). Students brainstorm to generate a list of facts, ideas, or concepts for a particular topic and then draw lines connecting related items. Above each line students write the nature of the relation- ship between the items. Because most of the terms in a concept map have multiple connections, students must identify and organize information to establish meaningful relationships between the pieces of information. A concept map is an effective means to show students how the many concepts covered in a typical course are connected. Although individuals as well as groups of students can do concept mapping, the maps produced in groups are usually much more detailed than those produced by individual students

Visual Lists. In this technique, students make a list of opposing points or arguments on paper or on the blackboard. Students typically can generate more comprehensive lists working in groups than they can alone. This method is particularly effective when asking students to compare views or to list the pros and cons of a position. One technique that works well with such comparisons is to have students draw a 'T" and label the left- and right-hand sides of the crossbar with the opposing positions (or "Pro" and "Con"). Students then list everything they can think of to sup- port these positions on the relevant side of the vertical line. Once students have generated as thorough a list as they can, the instructor asks them to analyze the lists by asking questions that are appropriate to the exercise.

Peer-led Team Learning

The Peer-Led Team Learning (PLTL) Workshops generally supplement the lecture. PLTL http://www.sci.ccny.cuny.edu/~chemwksp/ can be used in a course with any size enrollment. Under the PLTL model, undergraduate students who have done well in the class previously are recruited and trained as workshop leaders or peer leaders who guide the efforts of a group of six to eight students. These peer-led groups meet weekly (separate from the lecture and the instructor) to work together on problems that are carefully structured to help the students build conceptual understanding and problem-solving skills. There are no answer keys for either the students or the peer-leaders; the emphasis is on learning to find, evaluate, and build confidence in answers. Simultaneously, the workshops and the peer leaders provide a supportive environment that helps each student participate actively in the process of learning science. Thus, PLTL offers a mix of active-learning opportunities for students and a new role for undergraduate peer leaders that is appropriate for their stage of development; PLTL has been used successfully in courses in chemistry, biology, physics, math, computer science, and engineering. In practice, the weekly workshop replaces traditional recitation sections led by graduate teaching assistants or faculty. Although most peer leaders are undergraduates, many graduate students with appropriate training have also worked effectively and enthusiastically in that role.

Classroom Technology

Blackboard LEARN class management

The BlackBoard LEARN server is maintained by Extended University and UNM IT department. To acquire an account of your course, you need to

1. Go to http://my.unm.edu and login with your UNM Netid and password. Then you go to Loboweb under Faculty Life tab.
2. Look for Web Enhanced Courses in the menu. Click on the link.
3. Select your course by checking the box next to the course name.
4. Press the Submit button (Before you do, make sure you are certain this is what you want. Once a course becomes web-enhanced, you cannot un-do it)
5. Now you can go to http://learn.unm.edu and login with your netid and password. You should be able to see your course listed.
6. You need to set up your LEARN course in order to use it. You can also copy another course's content to this one. Please be referred to the tutorial for BlackBoard under UNM LEARN website.

i-click classroom response system

You will need to (1) contact UNM Bookstore to request enough number of i-clicker to be stocked for students to purchase. (2) contact UNM Media Services to obtain an i-clicker receiver.

You can find a tutorial from i-clicker website. Basically, the following should be completed before your first class:

1. Obtain a copy of i-clicker software from http://iclicker.com
2. Download a class list from loboweb and convert it to the correct format for i-clicker use.
3. Determine the method of student registration as one of the three options: (1) online registration (2) on-call registration (3) manual registration by instructor.
4. Set up the configuration of i-clicker for your course.
5. Set up i-grader to manage the usage of iclicker by students
6. Write i-clicker questions

ALEKS adaptive learning program

1. You can contact Joe Ho (khoj@unm.edu) to get an account under UNM group account.
2. You will receive an e-mail and follow the instruction from the e-mail to complete the setup of ALEKS account.
3. You are now ready to set up your ALEKS course. Refer to Appendix for tutorial.

Assessments of student learning

There are two types of assessments: informative and summative assessments.

Informative assessments

An informative assessment is not for grading purposes. Instead, we use informative assessments to monitor the progress of student's learning. An informative assessment can be used by teachers as a diagnostic tool for the effectiveness of their teaching. When designed properly, an informative assessment can reveal student's misconception and provide direction for both students and teacher how to correct the misconception. It is therefore an important instrument for students' metacognition.

Although informative assessment is not for grading, a small credit is usually given to students to encourage them to take the assessments. It is low-stake so that students are not afraid of participating. It should be presented as an opportunity for them to quickly check on their understanding of the subject. For example, a clicker question is usually given right after a concept is discussed, and they will receive a credit not based on the correctness of their answers. Under such setting, students will not be afraid of losing the credit due to a wrong answer, and focus completely on learning the topic. Students should give an honest answer according to their understanding.

In this course, we have four basic informative assessments: pre- and post-concept inventory tests, reading quizzes, clicker questions, and common core questions in the mid-term exams. We will explain these assessments.

Summative assessments

The summative assessments are exams and quizzes we normally use. They are for the purpose of evaluating student's comprehensive understanding of the materials and their ability to apply the materials. They are important part of the course final grade.

We have two summative assessments in this course: midterm exams and common final exam.

Pre- and post-concept inventory tests

The concept inventory tests we use are originated from the Concept Inventory test published by Purdue University (citing reference) and modified by UNM faculty to provide more complete coverage of topics our general chemistry covers. The same tests have been administered in the co-requisite lab (CHEM 123L and 124L) since 2012, as the pre- and post-tests. The performance gains from the pre- to the post-test are one of the independent measures for student learning from the course.

Reading quizzes

The reading quizzes serves for three purposes (1) for students to evaluate their understanding of the reading assignments (2) for teacher to obtain a general perspective of student's understanding of the reading assignments, and (3) to motivate students to complete the reading assignments. It is therefore, crucial for the effectiveness of pre-class learning. Each quiz should not be long, but specific enough to provide an insight of students' reading. It is common to have three questions in each quiz so that students only need to spend 5 minutes to answer. The questions we should avoid are those answers can be found from the reading text directly. It is the best to ask conceptual questions that require understanding of the text read. One should also avoid asking very long calculations in the reading quizzes. However, sometimes it is desirable to know whether students have paid attention to the steps of calculation explained in the text.

The reading quizzes are conveniently delivered online. The possible platforms for delivery these quizzes are LEARN website, or ALEKS assignments. You can write your own questions using LAERN test and have the quizzes graded automatically. You can view the results and basic statistics from LEARN. If you want to use paper quiz as in the beginning of each class, you need to make sure you have the enough manpower (TA and PLF) for grading them.

The statistics from each reading quiz can provide important information about your students' preparedness of the class. You should review the result of each reading quiz and use it in your preparation of next class. For example, you should add the topics that most of your students does not understanding as indicated by the quiz result to your lesson plan.

Clicker questions

Clicker questions can be used for many different purposes. You can use clicker questions as the reading quizzes, taking attendance, checking on students' learning progress, for peer learning, and surveys.

Reading quizzes: it is usually administered in the very beginning of a class and obtain a quick assessment of student's preparation.

Taking Attendance: you can use the answers of selected questions throughout the class to check for attendance.

Learning progress: questions can be given after the completing of an activity, such as a lecture of a specific topic, and the statistics of students' answer can provide a quick assessment of student learning.

Peer learning: It is usually done with a clicker question first and if many students did not answer it correctly, have students explain to other group members or their neighbors the reason for their answers. We expect students will learn from other student's explanation about the concept during this discussion. Then a similar question will be administered after the discussion to evaluate student learning again. This process can repeat until a satisfactory portion of students have learned the concept indicating by the repeated clicker questions.

Common core questions for midterm exams

We agree to implement common core questions for each midterm exam decided by all faculty members teaching general chemistry. These questions will help us check on the progress of learning about key concepts across sections. These common questions will also provide data for general course assessment required by the University and State of New Mexico.

Midterm exams

There will be four midterm exams administered each semester for grading. Faculty members should coordinate for the date of each exam so that all sections will have the exam date during the same week.

Common final exam

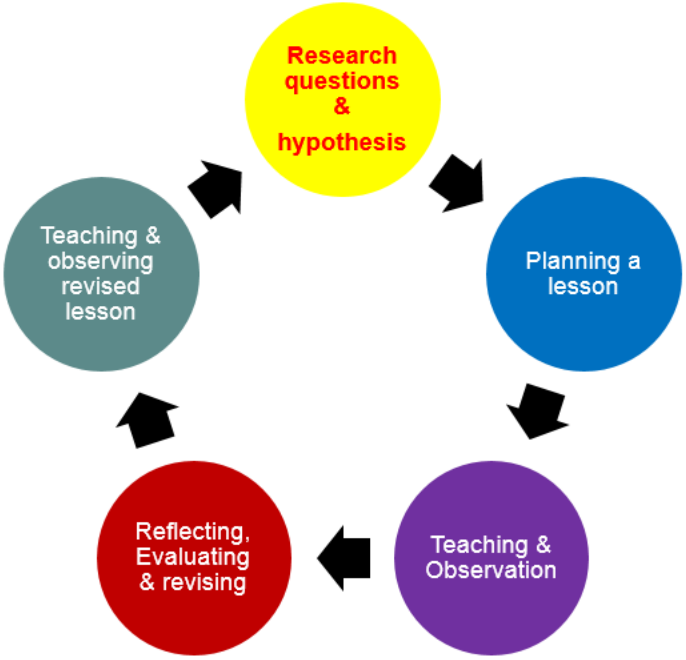
The common final exam will be written by faculty who is not teaching the general chemistry course. All sections will take the same exam, which can have multiple versions, to provide standard assessments of student comprehensive learning from the course. The exam will be written for the SLOs of the course and all midterm exams can be used as references of the questions to be included. Questions on the final exams are expected to have the similar style as the questions of the midterm exams from all sections. Topics which is not taught by any section should not be included. Faculty from each section is responsible to communicate with the exam writer about the topics which are not covered during the semester.

Lesson Study

What is Lesson Study and Why is it recommended?

Lesson study is a practice of teachers to improve student learning through a research of student learning problem they observe. This practice directly targets learning problems in the course, finds solutions in the timely manner and optimizes the implementation. Therefore, Lesson Study can be very effective in providing immediate improvement of student learning and optimize active learning strategies each faculty member employs in their teaching. Through LS group discussions, supports from other members' suggestions are valuable resources of professional developments of the teachers.

How to practice Lesson Study?



In Lesson Study, teachers can start with any steps presented in the above cycle. The most common first step of a lesson study is defining a research question. Teaching observation is a logical source of finding learning problem to be defined as a research question. Therefore, starting your lesson study with teaching observation is recommended.

Management of Peer Learning Facilitators (PLF)

Pre-semester Training

The pre-semester training is given during the week before the semester starts, which should include the following topics

- Principles of Active Learning & cooperative learning
- Practice of Classroom Discussion
- Reflection on the classroom practice
- Your expectation

In-semester Training

You are expected to meet with your PLF at least once a week to go over the following topics:

- Weekly Learning Issues
- Weekly discussion of course topics to be covered
- Discussion of weekly worksheets & answers
- Weekly evaluation of PLF performance

Evaluation

The performance of PLF should come from the following evaluations conducted throughout and by the end of a semester and be used as the basis for the future hiring:

- Student evaluation
- Peer evaluation
- Faculty evaluation

Appendix A Course Level Student Learning Outcomes (SLOs)

Students finishing CHEM 121 should be able to

1. Relate the development of essential chemical theories to the application of the scientific method. (Related to HED Core Competencies Area III no. 1)
2. Use dimensional analysis, the SI system of units and appropriate significant figures to express quantities, convert units and perform quantitative calculations in science. (Related to HED Core Competencies Area III no. 2 and 5)
3. Explain the structure of the atoms, isotopes and ions in terms of its subatomic particles. (Related to HED Core Competencies Area III no. 1 and 2)
4. Use the IUPAC system of nomenclature and knowledge of reaction types to describe chemical changes, predict products and represent the process as a balanced equation. (Related to HED Core Competencies Area III no. 4)
5. Describe physical states and changes, and distinguish these from chemical changes. (Related to HED Core Competencies Area III no. 4)
6. Apply the mole concept to amounts on a macroscopic and a microscopic level and use this to perform stoichiometric calculations including for reactions in solution, gases and thermochemistry. (Related to HED Core Competencies Area III no. 2 and 4)
7. Apply the gas laws and kinetic molecular theory to relate atomic level behavior to macroscopic properties. (Related to HED Core Competencies Area III no. 2 and 4)
8. Describe the energy conversions that occur in chemical reactions, relating heat of reaction to thermodynamic properties such as enthalpy and internal energy; calculate and describe how to measure energy changes in reaction. (Related to HED Core Competencies Area III no. 4 and 5)
9. Use different bonding models to describe formation of compounds (ionic and covalent). Apply knowledge of electronic structure to determine molecular spatial arrangement and polarity. (Related to HED Core Competencies Area III no. 4)
10. Analyze how periodic properties (e.g. electronegativity, atomic and ionic radii, ionization energy, electron affinity, metallic character) and reactivity of elements results from electron configurations of atoms. (Related to HED Core Competencies Area III no. 4)
11. Apply principles of general chemistry to specific real world problems in environment, engineering and health-related fields. (Related to HED Core Competencies Area III no. 4 and Area II no. 2)

Students finishing CHEM 122 should be able to

1. Explain the intermolecular attractive forces that determine physical properties and phase transitions; apply this knowledge to qualitatively evaluate these forces from structure and to predict the physical properties that result. (Related to HED Core Competencies Area III no. 2)
2. Calculate solution concentrations in various units (molarity, molality, mole fraction, % by mass, and % m/v) and explain the effects of temperature, pressure and structure on solubility. (Related to HED Core Competencies Area III no. 2)

3. Describe the colligative properties of solutions and explain them using intermolecular forces. Determine solution concentrations using colligative property values and *vice versa*. (Related to HED Core Competencies Area III no. 2 and 4)

4. Explain reaction rates, rate laws, and half-life; determine the rate, rate law and rate constant of a reaction and calculate concentration as a function of time and *vice versa*. (Related to HED Core Competencies Area III nos. 2 and 4 and Area II nos. 1 and 2)

5. Explain the collision model of reaction dynamics, including activation energy, catalysts and temperature; derive a rate law from a reaction mechanism and evaluate the consistency of a mechanism with a given rate law. (Related to HED Core Competencies Area III no. 2 and 4)

6. Describe the dynamic nature of chemical equilibrium and its relation to reaction rates; apply Le Chatelier's Principle to predict the effect of concentration, pressure and temperature changes on equilibrium mixtures. (Related to HED Core Competencies Area III no. 2)

7. Describe the equilibrium constant and use it to determine whether equilibrium has been established; calculate equilibrium constants from equilibrium concentrations and *vice versa*. (Related to HED Core Competencies Area III no. 2 and 4 and Area II no. 2)

8. Describe the different models of acids and base behavior, and the molecular basis for acid strength. (Related to HED Core Competencies Area III no. 2)

9. Apply equilibrium principles to aqueous solutions, including acid-base and solubility reactions; calculate pH and species concentrations in buffered and unbuffered solutions. (Related to HED Core Competencies Area III no. 2 and 4 and Area II no. 2)

10. Explain titration curves and speciation diagrams; calculate concentrations of reactants from the former and determine dominant species as a function of pH from the latter. (Related to HED Core Competencies Area III no. 2 and 4 and Area II nos. 1 and 2)

11. Explain and calculate the thermodynamic functions enthalpy, entropy and Gibbs free energy for a chemical system; relate these to equilibrium constants and reaction spontaneity. (Related to HED Core Competencies Area III no. 2 and 4)

12. Balance redox equations, express them as two half reactions and evaluate the potential, free energy and equilibrium K for the reaction, as well as predict the spontaneous direction. (Related to HED Core Competencies Area III no. 2 and 4)

13. Construct a galvanic or electrolytic cell; determine the standard (and non-standard) cell-potential of the former and relate current to electron transfer rates in the latter. (Related to HED Core Competencies Area III no. 2 and 4).

Appendix B Sample Course Level Instructional Objectives (IOs)

CHEM 122

1. Explain the intermolecular attractive forces that determine physical properties and phase transitions; apply this knowledge to qualitatively evaluate these forces from structure and to predict the physical properties that result. (Related to HED Core Competencies Area III no. 2)

    1. Intermolecular forces- *origin* and relative strength
    2. Intermolecular forces- relationship with molecular size, shape and strength
    3. Intermolecular forces- relative strength of surface tension, viscosity, phase cohesion
    4. Changes of state- States of matter and molecular processes
    5. Changes of state- Heating curves and the enthalpy of transition
    6. Changes of state- Clausius-Clapeyron equation and graph
    7. Changes of state- Supercritical fluids and the critical point
    8. Changes of state- Phase diagrams, key features and phase changes
    9. Changes of state- Unique properties of water
    10. Solids- Types of solid states and their relative properties
    11. Solids- Unit cells and basic structures: calculation
    12. Solids- Determination of geometry using X-ray diffraction
    13. Solids- Band-gap theory and application in semi-conductors

2. Calculate solution concentrations in various units (molarity, molality, mole fraction, % by mass, and % m/v) and explain the effects of temperature, pressure and structure on solubility. (Related to HED Core Competencies Area III no. 2)

    14. Solutions- solutes, solvents and their interactions
    15. Solutions- the entropy and enthalpy of dissolution
    16. Solutions- effects of structure on solubility (intermolecular forces)
    17. Solutions- effects of temperature and pressure on solubility
    18. Solutions- units of concentration, including molarity, molality, mass percent and mole fraction

3. Describe the colligative properties of solutions and explain them using intermolecular forces. Determine solution concentrations using colligative property values and *vice versa*. (Related to HED Core Competencies Area III no. 2 and 4)

    19. Colligative properties- their physical basis for molecules and ions
    20. Colligative properties- vapor pressure reduction and Raoult's law (and deviations)
    21. Colligative properties- BP elevation and FP depression are not contradictory
    22. Colligative properties- Osmotic pressure and its calculation and measurement
    23. Colligative properties- Isotonic solutions and reverse osmosis
    24. Colligative properties- the Van't Hoff factor for ionic solutes

4. Explain reaction rates, rate laws, and half-life; determine the rate, rate law and rate constant of a reaction and calculate concentration as a function of time and *vice versa*. (Related to HED Core Competencies Area III nos. 2 and 4 and Area II nos. 1 and 2)

    25. Differential rate laws - reaction order determination
    26. Integrated rate laws - half time determination
    27. Integrated rate Laws - graphing concentration vs time

5. Explain the collision model of reaction dynamics, including activation energy, catalysts and temperature; derive a rate law from a reaction mechanism and evaluate the consistency of a mechanism with a given rate law. (Related to HED Core Competencies Area III no. 2 and 4)
    28. Arrhenius equation - effect of temperature and catalyst
    29. Collision model - orientation factor and collision frequency
    30. Reaction mechanism - elementary steps and their rate expressions
    31. Reaction mechanism - overall reaction rate law from a proposed mechanism

6. Describe the dynamic nature of chemical equilibrium and its relation to reaction rates; apply Le Chatelier's Principle to predict the effect of concentration, pressure and temperature changes on equilibrium mixtures. (Related to HED Core Competencies Area III no. 2)
    32. Chemical equilibrium arises in cases of reversible reaction kinetics, both forward and reverse reactions occur.
    33. A system is said to have reached (attained) equilibrium when the rate of the forward reaction ($R_{forward}$) is equal to the rate of the reverse reaction ($R_{reverse}$) so no net change in reactant concentrations occurs.
    34. Chemical equilibrium on a microscopic level is dynamic, not static; reactants are constantly being converted into products and *vice versa*.
    35. Chemical equilibrium on a macroscopic level is stable: regardless of initial state, concentrations change to produce a specific ratio of reactants to products.
    36. Chemical equilibrium represents an incomplete reaction- both reactants and products are present, although some concentrations may be very low.
    37. LeChatelier's principle- an equilibrium system which experience a perturbation in concentration, pressure or temperature responds in such a way as to minimize the size of the perturbation
    38. You should be able to
        a. Predict the effects of changing concentrations, pressure or temperature on the composition of an equilibrium system
        b. Explain these changes using LeChatelier's principle

7. Describe the equilibrium constant and use it to determine whether equilibrium has been established; calculate equilibrium constants from equilibrium concentrations and *vice versa*. (Related to HED Core Competencies Area III no. 2 and 4 and Area II no. 2)
    39. The equilibrium constant K is the quantitative expression of equilibrium.
    40. At equilibrium, K_c equals the ratio of product concentrations to reactant concentrations (to the powers of their respective coefficients)
        a. The concentrations of pure solid phases and liquid solvents are considered to equal 1.
        b. K_p for gas-phase reactions is the ratio of product pressures to reactant pressures (to the powers of their respective coefficients)
    41. If a reaction is combined or changed, the K value changes:
        a. Reversing a reaction gives $K_{rev} = 1/K_{for}$
        b. If a reaction is multiplied by a constant, the K for that reaction should be raised to the power of that constant.
        c. If two reactions are added, the combined reaction K is the quotient of the two reaction Ks
        d. If a reaction B is subtracted from reaction A, $K_{comb} = K_A/K_B$
    42. Large K values imply a product-favored reaction, and small K values a reactant-favored one (assuming 1:1 overall mole ratios between reactant and product)
    43. The equilibrium constant for an elementary (a step within an overall) reaction is the ratio of the forward rate constant to the backward rate constant

    44. The reaction quotient Q equals the ratio of product concentrations to reactant concentrations (to the powers of their respective coefficients) under actual conditions (not just at equilibrium)
    45. Utilize the ICE methodology for solving equilibrium problems
    46. Apply the typical assumptions and approximations for solving equilibrium problems and explain why they work
    47. Write equilibrium constant expressions from overall chemical equations for both solution species and gases, and mixtures of the two.
    48. Calculate K for a reaction from equilibrium concentrations (or pressures)
    49. Calculate K if a reaction is reversed, multiplied by a factor, or combined with other reactions.
    50. Calculate equilibrium concentrations and K from known initial concentrations and one known equilibrium concentration.
    51. Predict the direction of reaction from the equilibrium constant and known concentrations (Q).
    52. Calculate the equilibrium concentration of species at equilibrium given their initial values and the equilibrium constant.

8. Describe the different models of acids and base behavior, and the molecular basis for acid strength. (Related to HED Core Competencies Area III no. 2)
    53. Define acids and bases by Bronsted-Lowry, and Lewis
    54. Determine relative acidity by structural analysis for different acids
    55. Write conjugate acid-base pair and compare relative strength
    56. Acidity in aqueous solution - leveling effect and pH scale.
    57. Acidity in aqueous solution - autoionization, pH and pOH relation.

9. Apply equilibrium principles to aqueous solutions, including acid-base and solubility reactions; calculate pH and species concentrations in buffered and unbuffered solutions. (Related to HED Core Competencies Area III no. 2 and 4 and Area II no. 2)
    58. pH calculation - strong acids and strong bases
    59. pH calculation - weak acids and weak bases
    60. pH calculation - conjugate acid of weak base and conjugate base of weak acid
    61. pH calculation - percent dissociation and approximation
    62. pH calculation - polyprotic acids
    63. pH calculation - buffer solution pH, buffer preparation
    64. Qualitative prediction of salt acidity/basicity
    65. Solubility - expression of solubility product, K_{sp}, common ion effect and pH effect
    66. Solubility - calculate molar salt solubility and initial ion concentrations for precipitation

10. Explain titration curves and speciation diagrams; calculate concentrations of reactants from the former and determine dominant species as a function of pH from the latter. (Related to HED Core Competencies Area III no. 2 and 4 and Area II nos. 1 and 2)
    67. Interpret key features of different types of pH titration (e.g. strong acid into weak bases)
    68. Calculate pKa's for analytes such as weak acid and weak base
    69. Solution stoichiometry
    70. pH calculation along any point of titration curve (exact pH calculation), including endpoint pH
    71. Select suitable indicators for acid-base titration
    72. Deterine dominant species along any point of tritration curve
    73. Deterine dominant species for polyprotic acids via speciation diagrams (e.g. phosphoric acid, proteins)

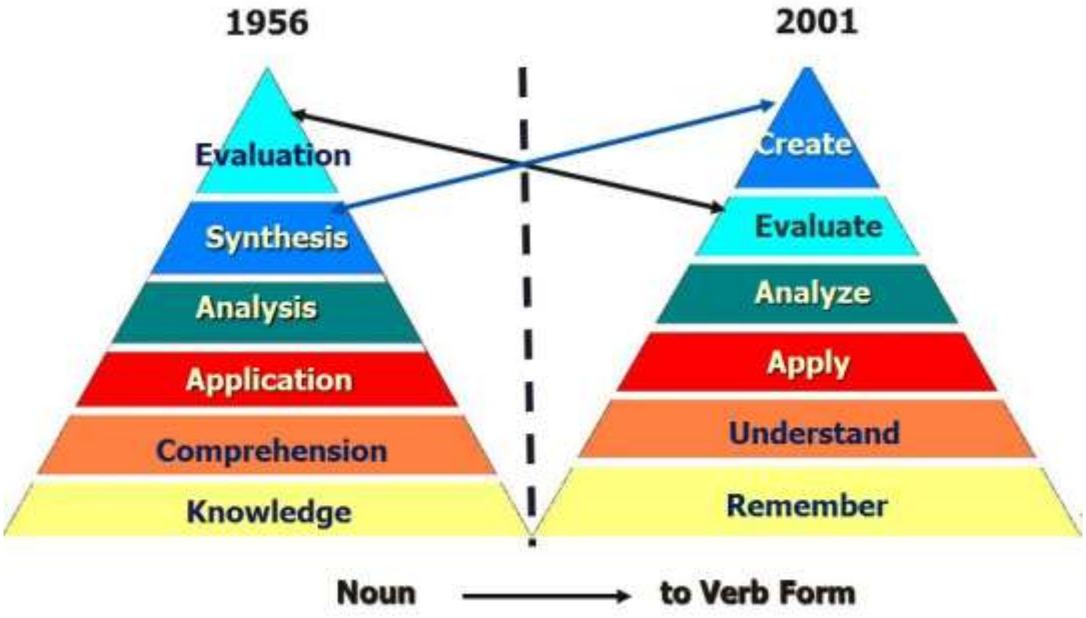
11. Explain and calculate the thermodynamic functions enthalpy, entropy and Gibbs free energy for a chemical system; relate these to equilibrium constants and reaction spontaneity. (Related to HED Core Competencies Area III no. 2 and 4)
    74. Explain how entropy relates to physical state, molecular sizes and structure
    75. Qualitatively predict signs of entropy change for phase transitions and chemical reactions
    76. Explain Hess's law and apply it to quantities (H, G, S) in chemical reactions
    77. Predict spontaneity according to sign of ΔG or ΔS

12. Balance redox equations, express them as two half reactions and evaluate the potential, free energy and equilibrium K for the reaction, as well as predict the spontaneous direction. (Related to HED Core Competencies Area III no. 2 and 4)
    78. Determination of oxidation numbers - redox reactions, half reactions
    79. Balance redox reactions using half reactions
    80. Calculate Gibbs free energy and equilibrium constant for redox reactions

13. Construct a galvanic or electrolytic cell; determine the standard (and non-standard) cell-potential of the former and relate current to electron transfer rates in the latter. (Related to HED Core Competencies Area III no. 2 and 4).
    81. Construction of a Galvanic cell - cell components, functions, flow of electrons and ions
    82. Apply the Nernst equation to find nonstandard cell potentials
    83. Calculate the quantities in electrolytic cells

Appendix C Bloom’s & Fink’s Taxonomies

Bloom’s original & Revised Cognitive Taxonomies



Fink’s Taxonomy

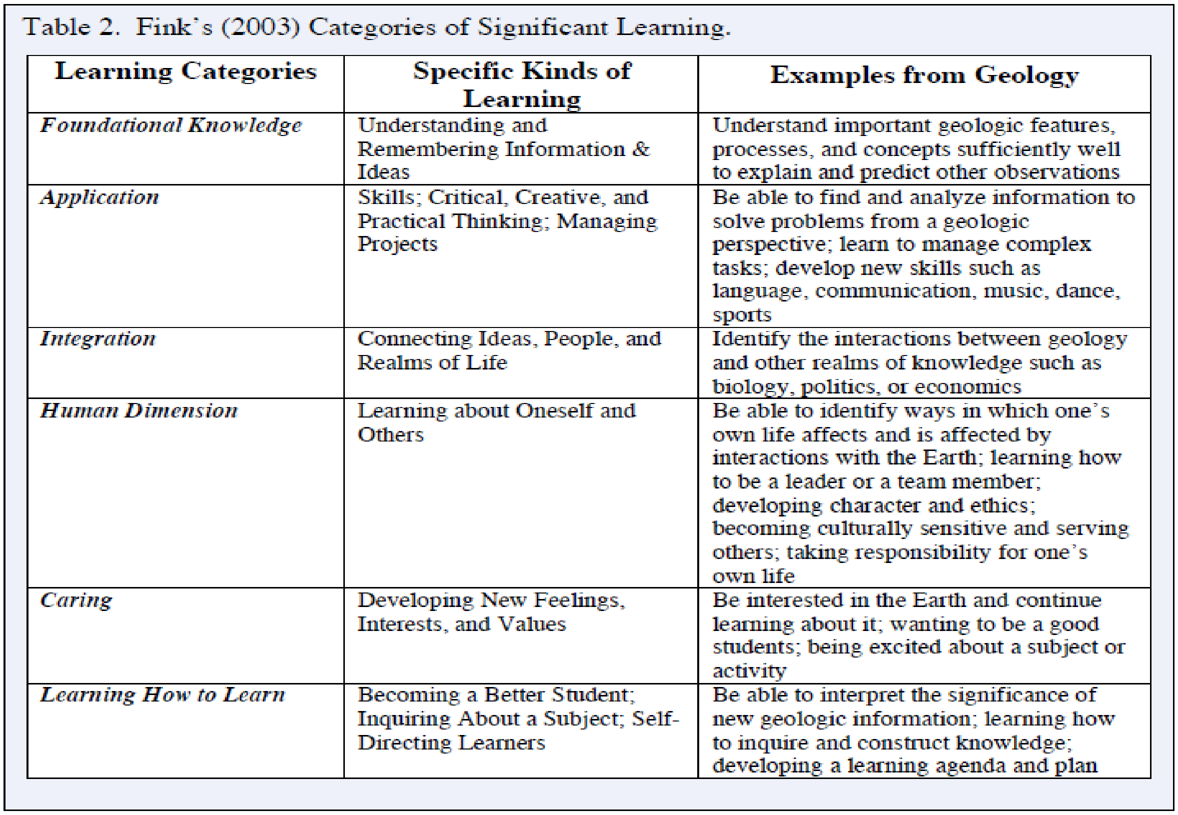


Table 2. Fink’s (2003) Categories of Significant Learning.

Learning Categories	Specific Kinds of Learning	Examples from Geology
Foundational Knowledge	Understanding and Remembering Information & Ideas	Understand important geologic features, processes, and concepts sufficiently well to explain and predict other observations
Application	Skills; Critical, Creative, and Practical Thinking; Managing Projects	Be able to find and analyze information to solve problems from a geologic perspective; learn to manage complex tasks; develop new skills such as language, communication, music, dance, sports
Integration	Connecting Ideas, People, and Realms of Life	Identify the interactions between geology and other realms of knowledge such as biology, politics, or economics
Human Dimension	Learning about Oneself and Others	Be able to identify ways in which one’s own life affects and is affected by interactions with the Earth; learning how to be a leader or a team member; developing character and ethics; becoming culturally sensitive and serving others; taking responsibility for one’s own life
Caring	Developing New Feelings, Interests, and Values	Be interested in the Earth and continue learning about it; wanting to be a good students; being excited about a subject or activity
Learning How to Learn	Becoming a Better Student; Inquiring About a Subject; Self-Directing Learners	Be able to interpret the significance of new geologic information; learning how to inquire and construct knowledge; developing a learning agenda and plan

Appendix X Sample Syllabus

SYLLABUS for CHEM 121

Instructor: Prof. ABC
Office Location: SMLC 1st Floor
Office Hours: MWF 10-11 AM
Class Meeting Day(s): MWF
Class Location / Room: DSH 125

Email: abc@unm.edu
Office Phone: 505-277-1111
Course Credits: 3 CH
Class Time: 9:00 – 9:50 AM
Term / Semester: Fall 2015

Course Description

Introduction to the chemical and physical behavior of matter. Meets New Mexico Lower Division General Education Common Core Curriculum Area III: Science (NMCCN 1214).

Course Objectives and Student Learning Outcomes

CHEM 121 should be able to

1. Relate the development of essential chemical theories to the application of the scientific method. (Related to HED Core Competencies Area III no. 1)
2. Use dimensional analysis, the SI system of units and appropriate significant figures to express quantities, convert units and perform quantitative calculations in science. (Related to HED Core Competencies Area III no. 2 and 5)
3. Explain the structure of the atoms, isotopes and ions in terms of its subatomic particles. (Related to HED Core Competencies Area III no. 1 and 2)
4. Use the IUPAC system of nomenclature and knowledge of reaction types to describe chemical changes, predict products and represent the process as a balanced equation. (Related to HED Core Competencies Area III no. 4)
5. Describe physical states and changes, and distinguish these from chemical changes. (Related to HED Core Competencies Area III no. 4)
6. Apply the mole concept to amounts on a macroscopic and a microscopic level and use this to perform stoichiometric calculations including for reactions in solution, gases and thermochemistry. (Related to HED Core Competencies Area III no. 2 and 4)
7. Apply the gas laws and kinetic molecular theory to relate atomic level behavior to macroscopic properties. (Related to HED Core Competencies Area III no. 2 and 4)
8. Describe the energy conversions that occur in chemical reactions, relating heat of reaction to thermodynamic properties such as enthalpy and internal energy; calculate and describe how to measure energy changes in reaction. (Related to HED Core Competencies Area III no. 4 and 5)
9. Use different bonding models to describe formation of compounds (ionic and covalent). Apply knowledge of electronic structure to determine molecular spatial arrangement and polarity. (Related to HED Core Competencies Area III no. 4)
10. Analyze how periodic properties (e.g. electronegativity, atomic and ionic radii, ionization energy, electron affinity, metallic character) and reactivity of elements results from electron configurations of atoms. (Related to HED Core Competencies Area III no. 4)

11. Apply principles of general chemistry to specific real world problems in environment, engineering and health-related fields. (Related to HED Core Competencies Area III no. 4 and Area II no. 2)

Course Requirements

Textbook: Chemistry by Tro, 2nd or 3rd edition

ALEKS access: You must purchase access for 1 ($60) or 2 semesters ($70). You can purchase directly from ALEKS (www.aleks.com) or through UNM bookstore.

Calculator: Must be a simple scientific calculator for classroom, homework, and exam use. The calculator should not have a graphing or programming functions.

i-clicker: available to be purchased in UNM Bookstore. You must register during the first week of the semester through on-call registration set up in the first 5 minutes of each class, and make it available for use in every class. The i-clicker will not be available for loan by the instructor.

Midterm exams: There will be four midterm exams administered in scheduled classes. The tentative schedule of these exams are listed below. Date and time are subject to change through announcement in the class. You are responsible for following any schedule changes.

Midterm 1 (9/11), Midterm 2 (10/15), midterm 3 (11/12), and midterm 4 (12/1).

Final exam: A comprehensive final exam will be administered during the UNM final's week. The date, time, and room are listed under UNM registrar's website. The final exam is two hours. Fail to take the final exam will result in a "W" grade.

Attendance: Attendance to the classes will not be required, but skipping a class can result in losing points from iclicker questions and other credits given for in-class activities.

Grading

Attendance Policy (*Suggested minimum language*) Regular and punctual attendance is required. UNM *Pathfinder* policies apply, which in part means instructor drops based on non-attendance are possible. This policy applies regardless of the grading option you have chosen.

Accommodation Statement (*required language*) Accessibility Services (Mesa Vista Hall 2021, 277-3506) provides academic support to students who have disabilities. If you think you need alternative accessible formats for undertaking and completing coursework, you should contact this service right away to assure your needs are met in a timely manner. If you need local assistance in contacting Accessibility Services, see the Bachelor and Graduate Programs office.

Academic Integrity *(Suggested language)* The University of New Mexico believes that academic honesty is a foundation principle for personal and academic development. All University policies regarding academic honesty apply to this course. Academic dishonesty includes, but is not limited to, cheating or copying, plagiarism (claiming credit for the words or works of another from any type of source such as print,

Internet or electronic database, or failing to cite the source), fabricating information or citations, facilitating acts of academic dishonesty by others, having unauthorized possession of examinations, submitting work of another person or work previously used without informing the instructor, or tampering with the academic work of other students. The University's full statement on academic honesty and the consequences for failure to comply is available in the college catalog and in the *Pathfinder*.

Cell Phones and Technology *(Suggested)* As a matter of courtesy, please turn off cell phones, pagers, and other communication and entertainment devices prior to the beginning of class. Notify me in advance if you are monitoring an emergency, for which cell phone ringers should be switched to vibrate.

Library and Tutorial Services *(Suggested)* UNM-Main campus provides many library services and some tutorial services for distance students. For library services, go to http://www.unm.edu/libraries/ to link to a specific library or to contact a librarian. For tutorial services, go to http://caps.unm.edu/online to explore UNM's online services.

Other (*optional--include information about helpful resources, study requirements, or anything that may help students in the class or help you manage the class.)*

SCHEDULE OF ACTIVITIES

(Use any format, but be sure to list all assessable activities and their dates, holidays, due dates, field trips, etc. Always include a disclaimer about change—see below.)

WEEK ONE—

WEEK TWO—

The Schedule of Activities is subject to change. Minor changes will be announced in class, major ones provided in writing.

Appendix xx i-Clicker setup

Download i-clicker software

You can download the software from i-clicker website:
https://www1.iclicker.com/downloads-release-notes/
or from our community website
http://genchem.pbworks.com

Tutorial for setup i-clicker

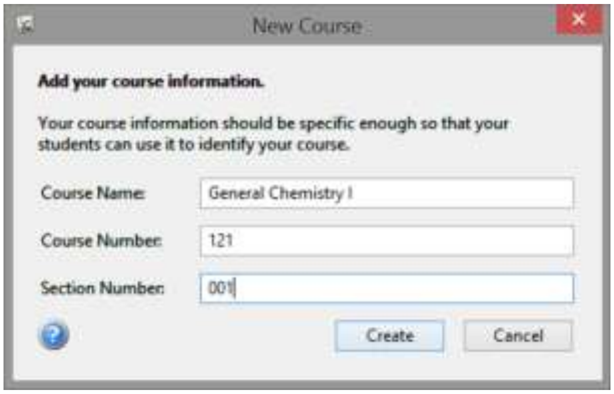
Start iclicker.exe from the software folder.

Choose your course:

[Click the New button to create a new course.]

(*) = i>clicker GO enabled course

Click on New to create a new course.



Add your course information.

Your course information should be specific enough so that your students can use it to identify your course.

Course Name: General Chemistry I

Course Number: 121

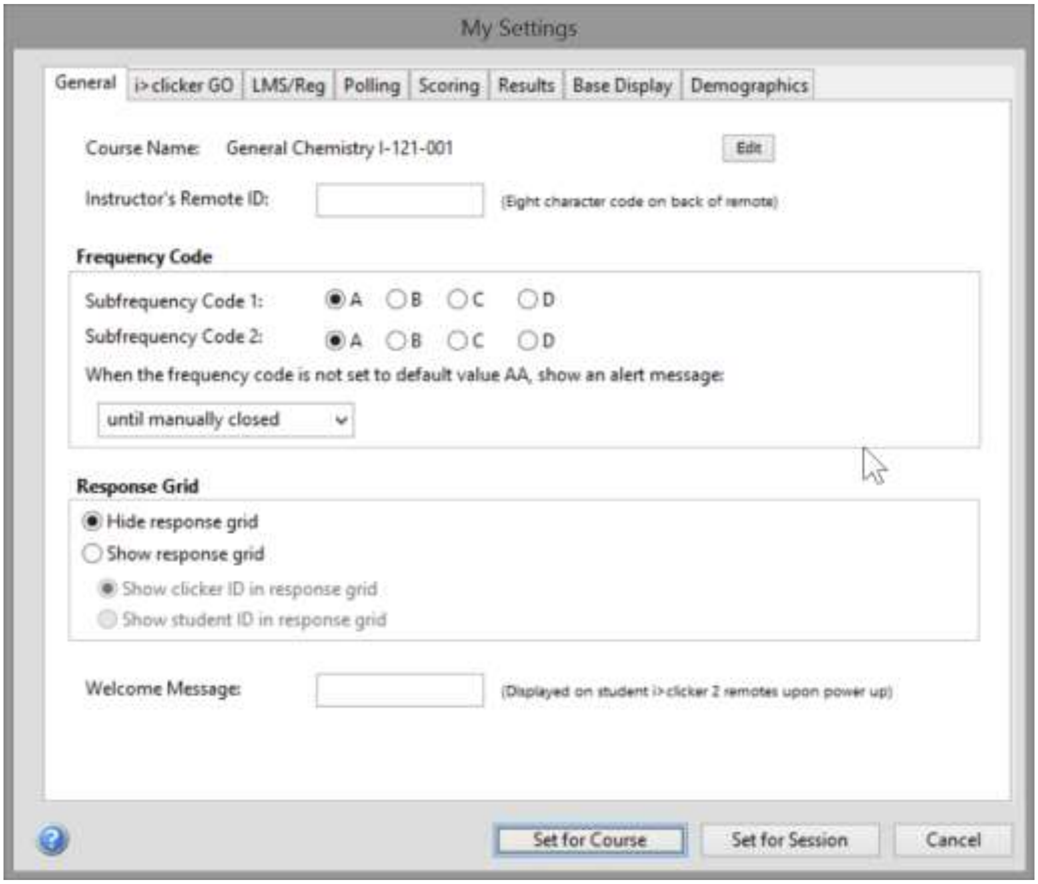
Section Number: 001

Select the new course you just created and "Choose" button:

In the next window, you press the “My Setting” button to set up your options.

You will enter the My Setting window which consists of many tabs that you can go to for different parameter settings:

Once you finish setting each tab, you have three choices of action: Set for Course, Set for Session, or Cancel. The set for course button makes your setting effective until you change any parameter of this window again. The set for session button is only effective for this session; if you close the program, all changes will return to the last setting.



Course Name: General Chemistry I-121-001

Instructor's Remote ID: (Eight character code on back of remote)

Frequency Code

Subfrequency Code 1: ● A ○ B ○ C ○ D

Subfrequency Code 2: ● A ○ B ○ C ○ D

When the frequency code is not set to default value AA, show an alert message:

until manually closed

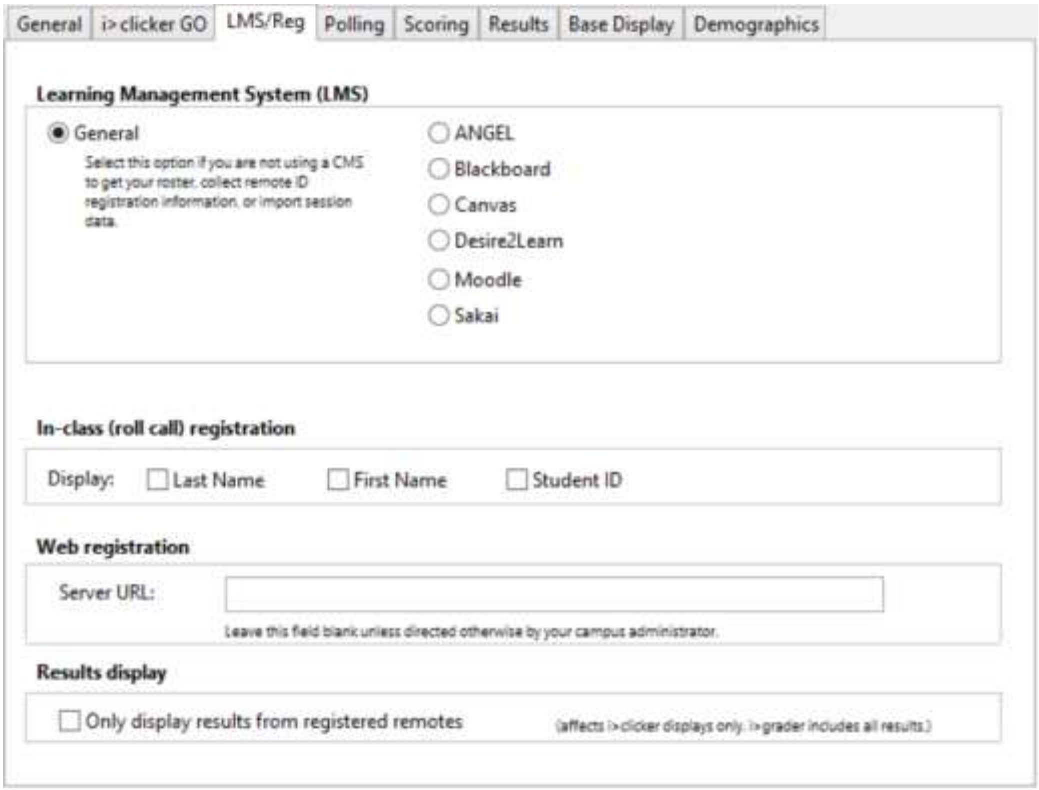
Response Grid

● Hide response grid

○ Show response grid

- ● Show clicker ID in response grid
- ○ Show student ID in response grid

Welcome Message: (Displayed on student i>clicker 2 remotes upon power up)



Learning Management System (LMS)

● General

Select this option if you are not using a CMS to get your roster, collect remote ID registration information, or import session data.

○ ANGEL

○ Blackboard

○ Canvas

○ Desire2Learn

○ Moodle

○ Sakai

In-class (roll call) registration

Display: ☐ Last Name ☐ First Name ☐ Student ID

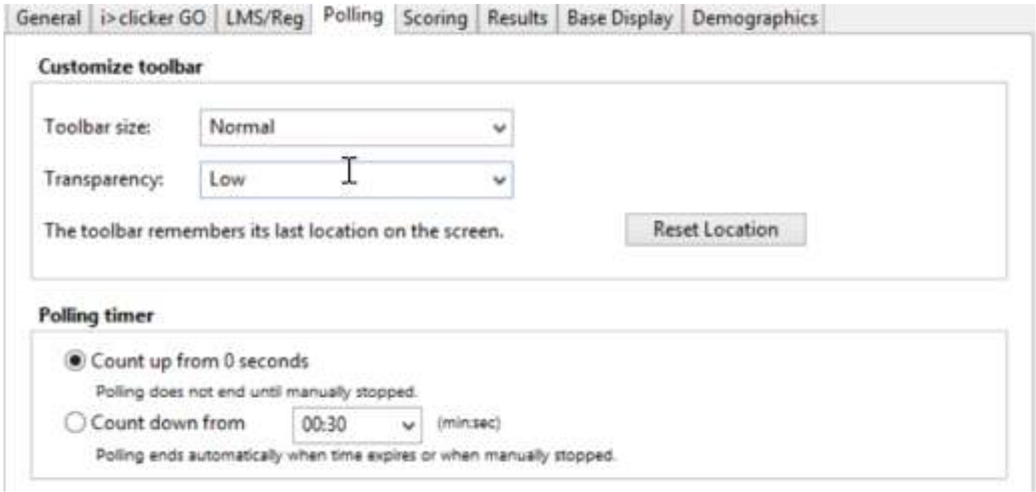
Web registration

Server URL:

Leave this field blank unless directed otherwise by your campus administrator.

Results display

☐ Only display results from registered remotes (affects i>clicker displays only. i>grader includes all results.)



Customize toolbar

Toolbar size: Normal

Transparency: Low

The toolbar remembers its last location on the screen.

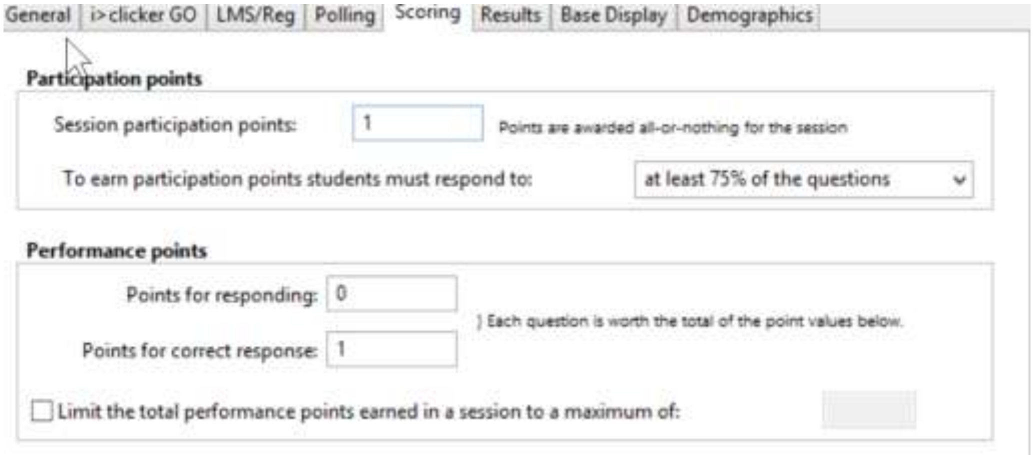
Polling timer

● Count up from 0 seconds

Polling does not end until manually stopped.

○ Count down from 00:30 (min:sec)

Polling ends automatically when time expires or when manually stopped.



Participation points

Session participation points: 1 Points are awarded all-or-nothing for the session

To earn participation points students must respond to: at least 75% of the questions

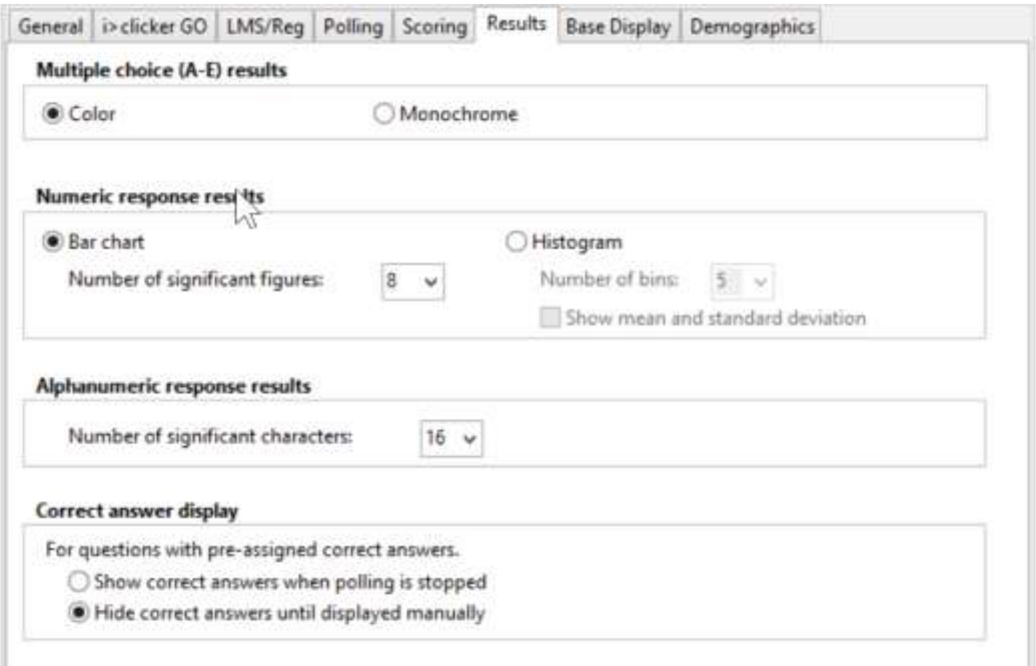
Performance points

Points for responding: 0

Points for correct response: 1

} Each question is worth the total of the point values below.

☐ Limit the total performance points earned in a session to a maximum of:



Multiple choice (A-E) results

● Color ○ Monochrome

Numeric response results

● Bar chart

Number of significant figures: 8

○ Histogram

Number of bins: 5

☐ Show mean and standard deviation

Alphanumeric response results

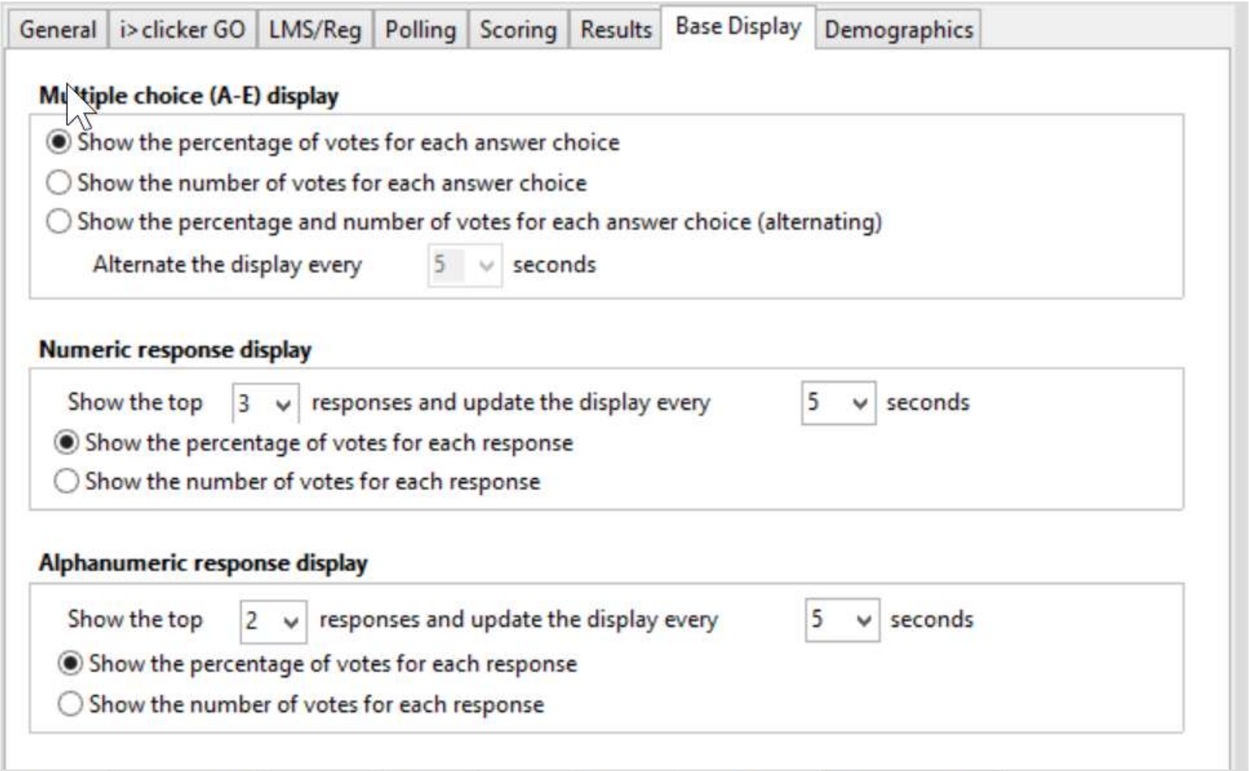
Number of significant characters: 16

Correct answer display

For questions with pre-assigned correct answers.

○ Show correct answers when polling is stopped

● Hide correct answers until displayed manually



Multiple choice (A-E) display

● Show the percentage of votes for each answer choice

○ Show the number of votes for each answer choice

○ Show the percentage and number of votes for each answer choice (alternating)

Alternate the display every 5 seconds

Numeric response display

Show the top 3 responses and update the display every 5 seconds

● Show the percentage of votes for each response

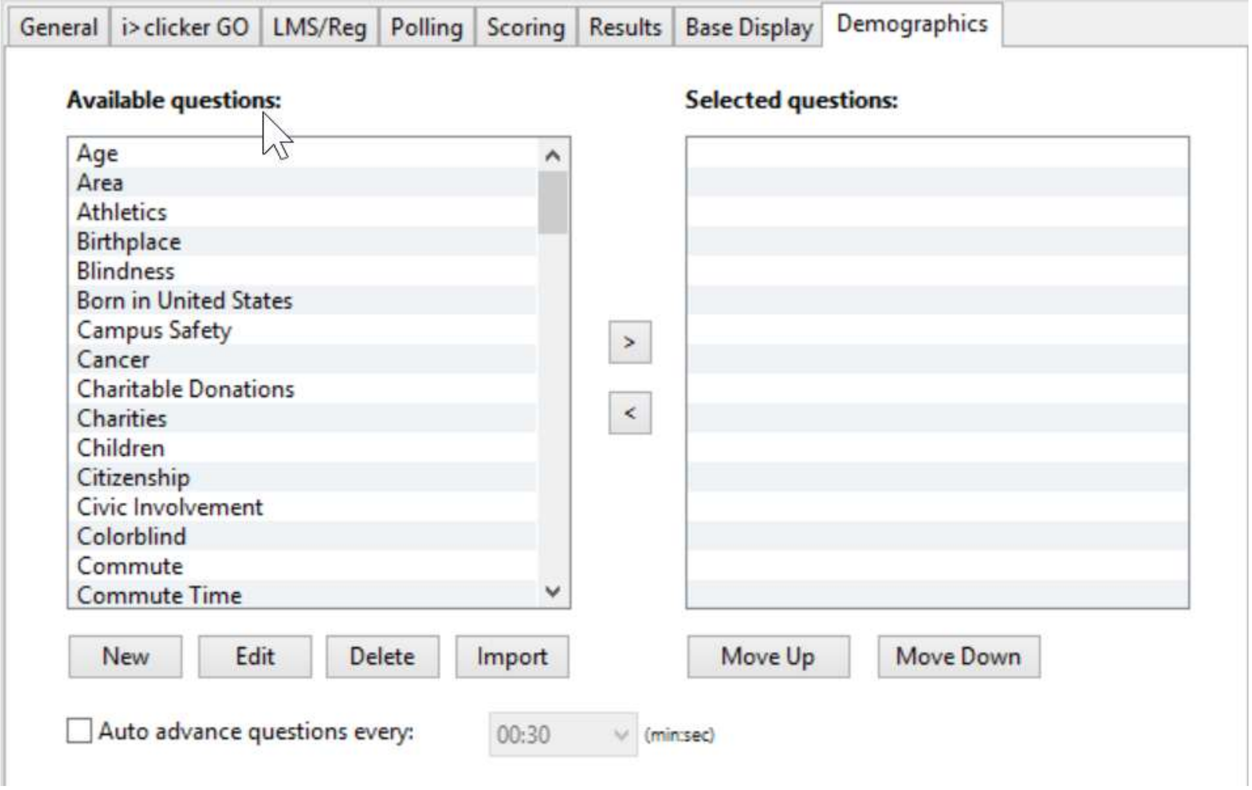
○ Show the number of votes for each response

Alphanumeric response display

Show the top 2 responses and update the display every 5 seconds

● Show the percentage of votes for each response

○ Show the number of votes for each response



Available questions:

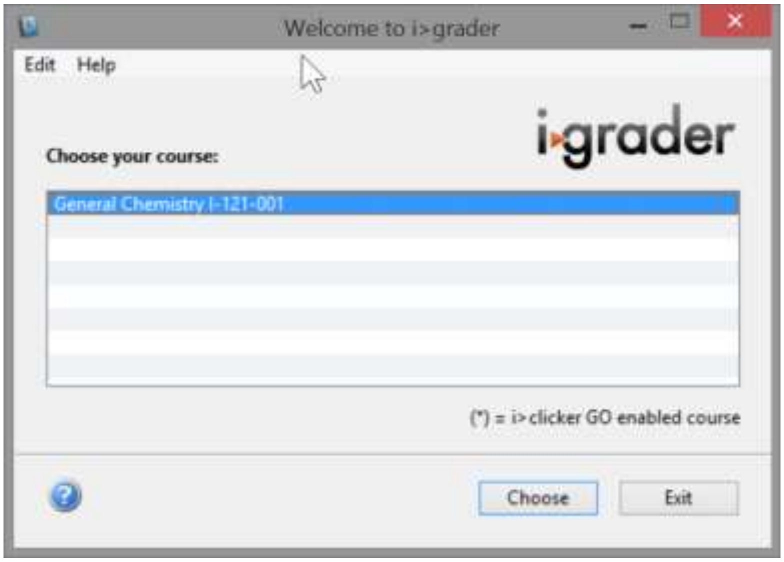
- Age
- Area
- Athletics
- Birthplace
- Blindness
- Born in United States
- Campus Safety
- Cancer
- Charitable Donations
- Charities
- Children
- Citizenship
- Civic Involvement
- Colorblind
- Commute
- Commute Time

Selected questions:

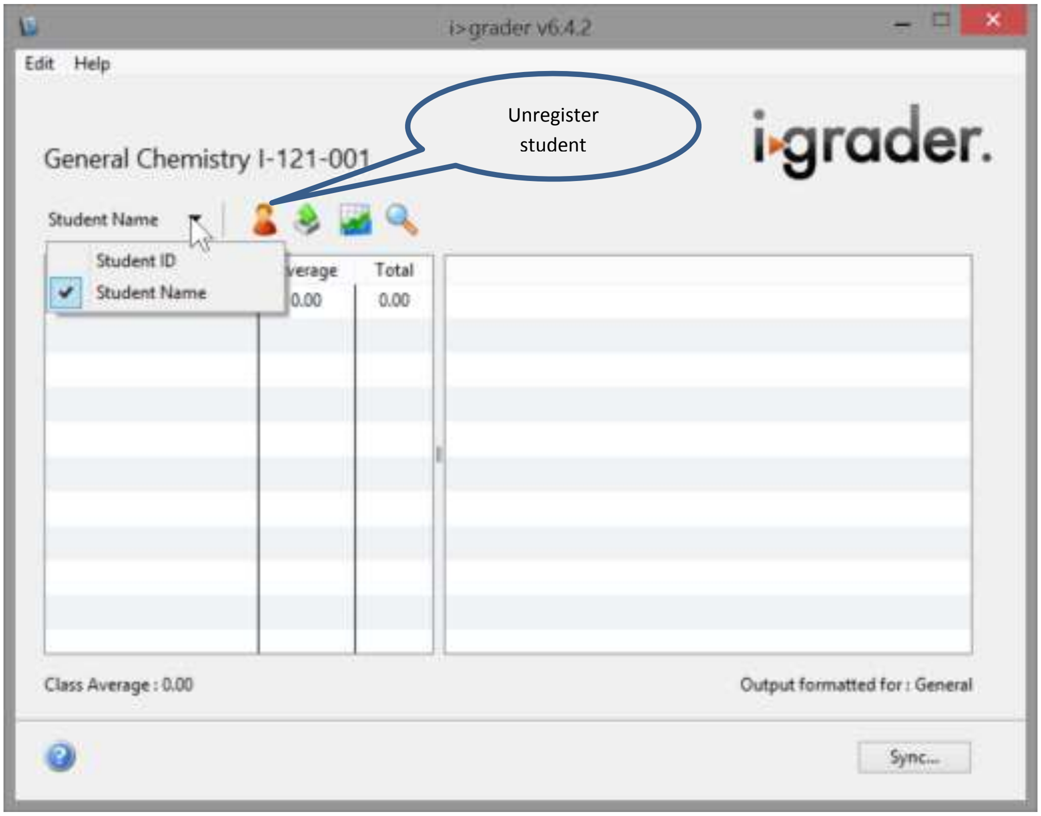
☐ Auto advance questions every: 00:30 (min:sec)

Tutorial for set up i-grader

Start the i-grader program: i-grader.exe



Choose a course and press the “Choose” button.

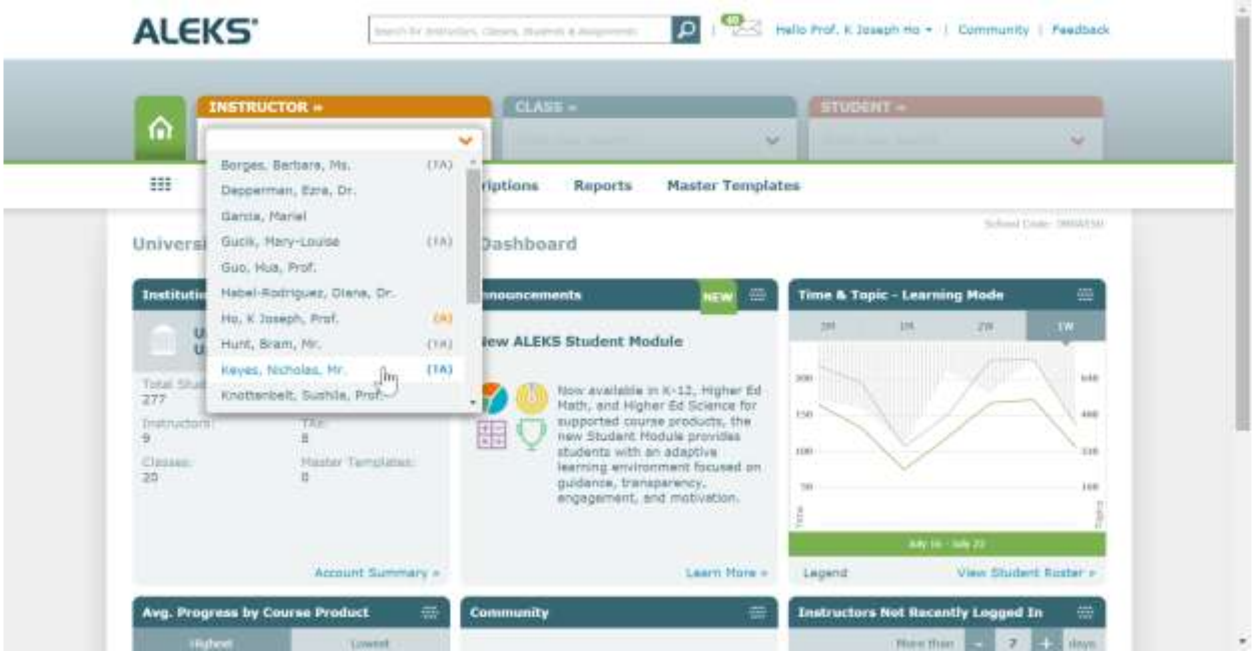


Unregister student

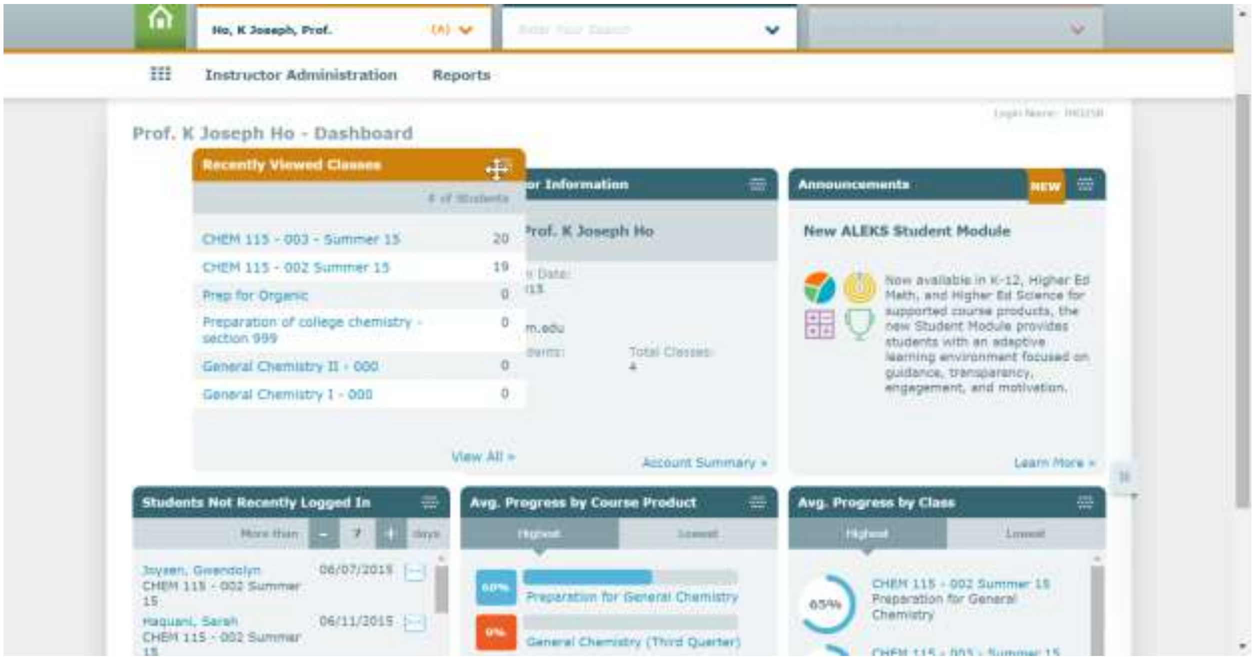
Appendix xxx Manage ALEKS account

Login to ALEKS

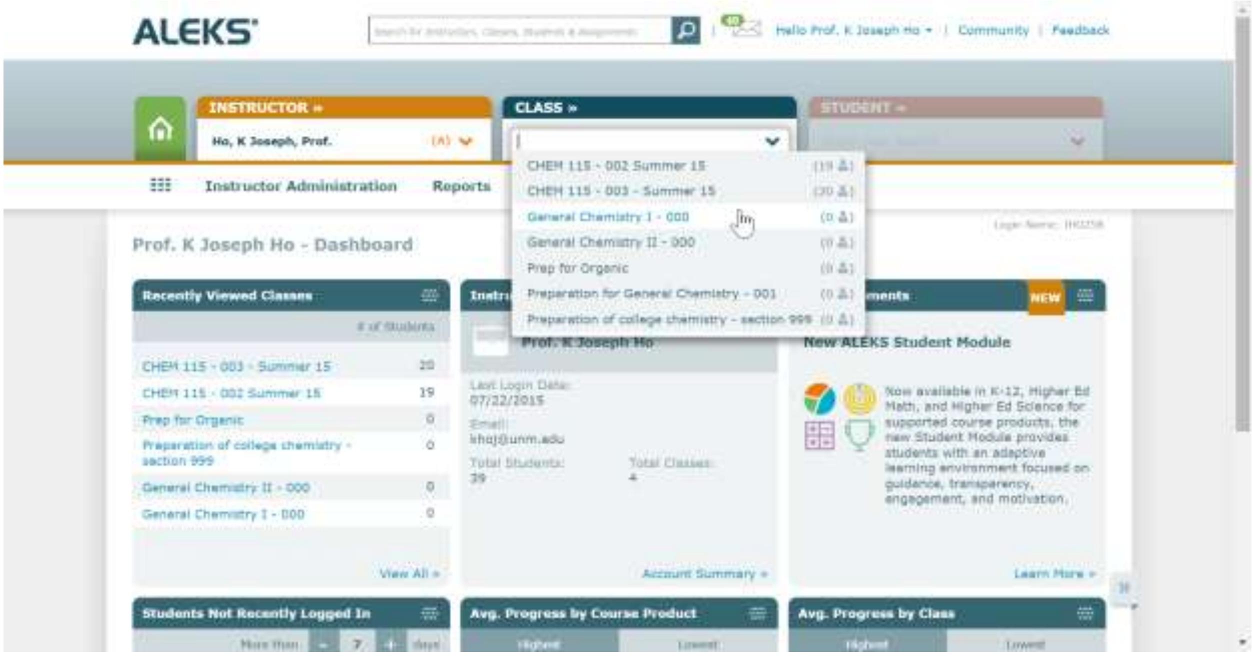
[***http://aleks.com***](http://aleks.com)



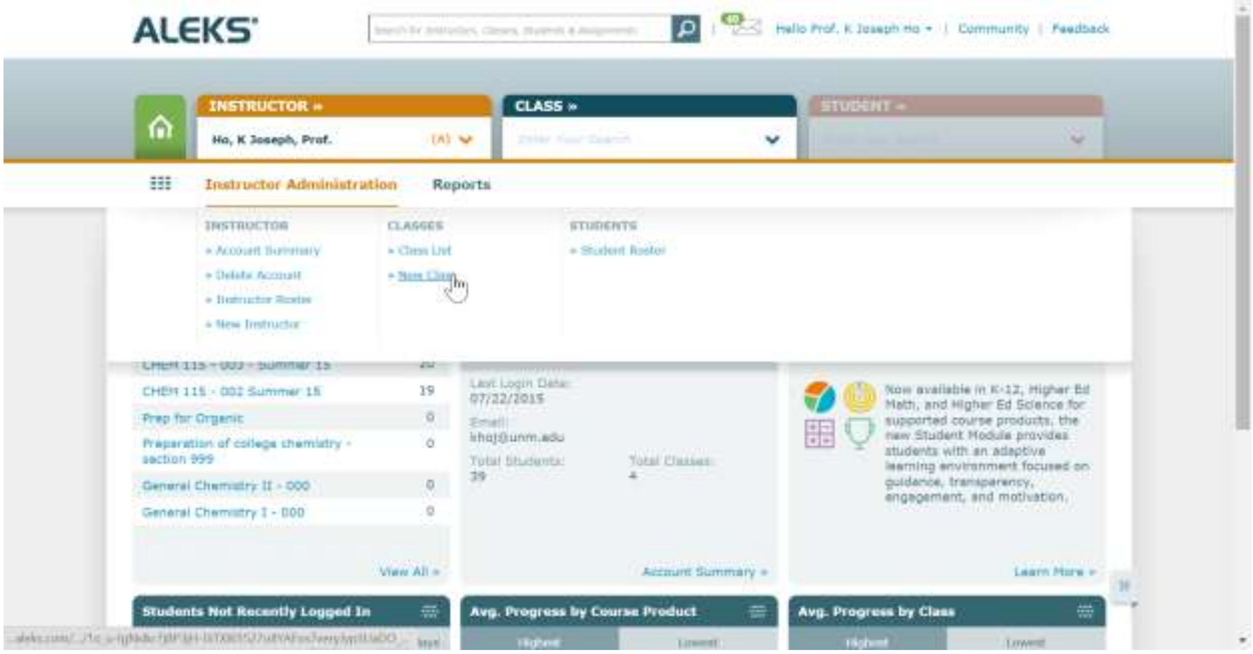
Under “Instructor”, choose your name. You can move the items in the dashboard to different location as you prefer.



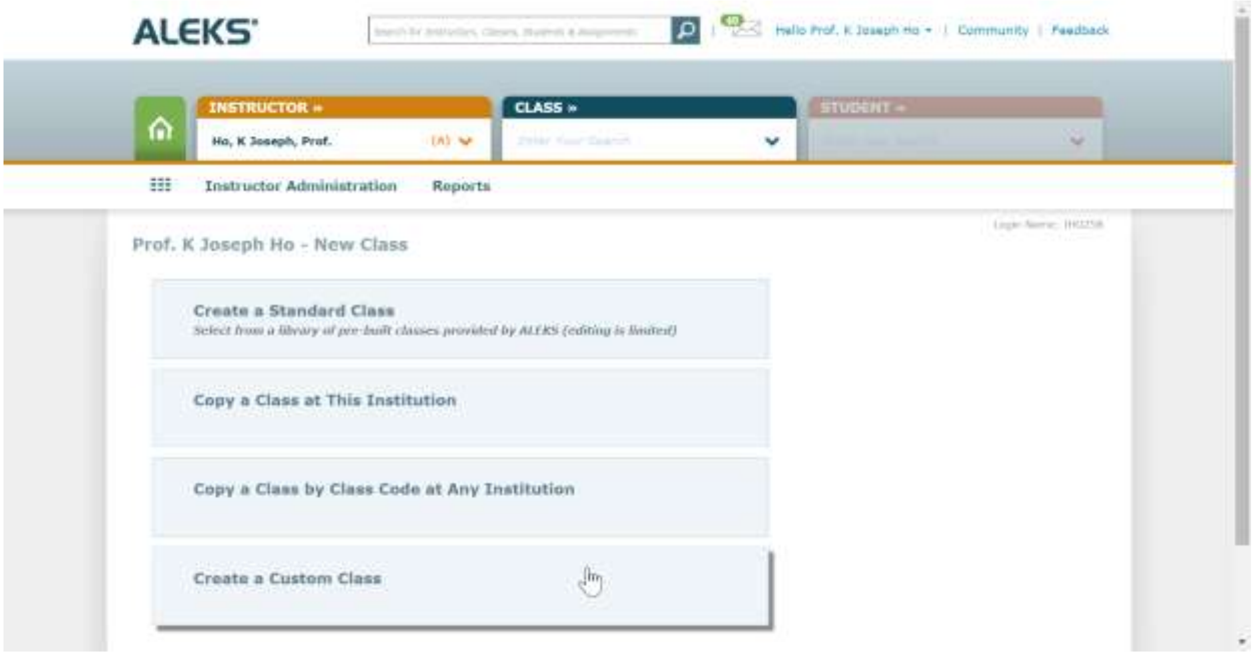
You can choose a course to work on.



Or you can create a new course by going under “Instructor Administration” menu, and select “New Class” under the “CLASSES” sub-menu.



Most commonly, you will choose “Create a custom class” under the New Class menu. You can also copy a class from this UNM site, in case you know a course template or other faculty’s class.



Prof. K Joseph Ho - New Class

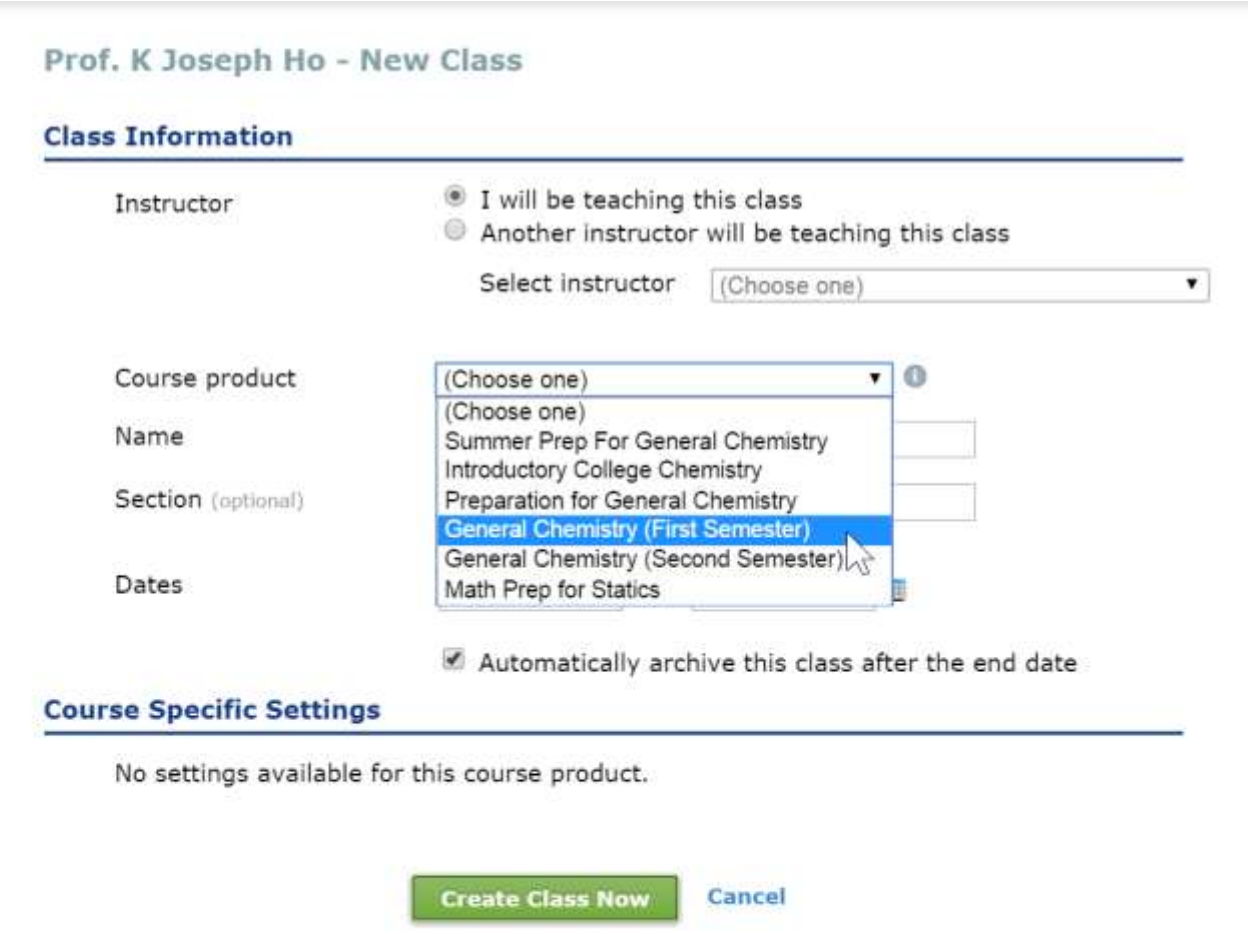
Create a Standard Class
Select from a library of pre-built classes provided by ALEKS (editing is limited)

Copy a Class at This Institution

Copy a Class by Class Code at Any Institution

Create a Custom Class

Under a new class window, you choose the appropriate class type:



Prof. K Joseph Ho - New Class

Class Information

Instructor
● I will be teaching this class
○ Another instructor will be teaching this class
Select instructor (Choose one)

Course product (Choose one)

Name

Section (optional)

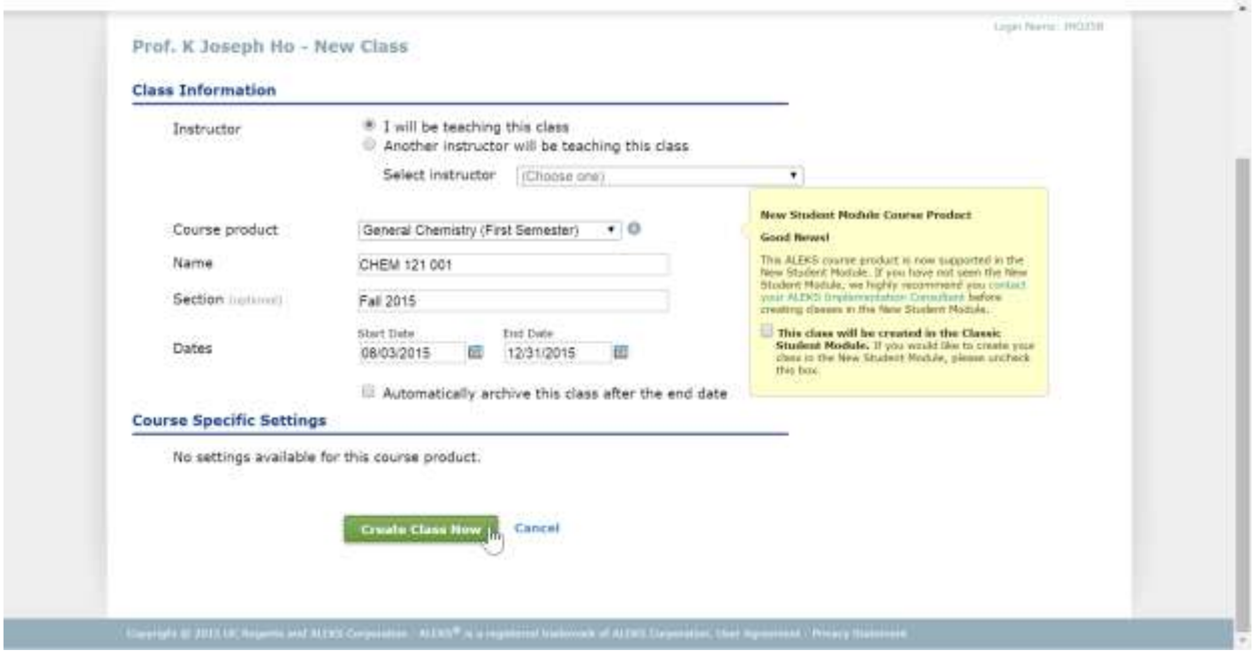
Dates

☑ Automatically archive this class after the end date

Course Specific Settings

No settings available for this course product.

And fill out the rest of the fields and press the “Create Class Now” button.



Prof. K Joseph Ho - New Class

Class Information

Instructor
● I will be teaching this class
○ Another instructor will be teaching this class
Select instructor: (Choose one)

Course product: General Chemistry (First Semester)

Name: CHEM 121 001

Section (optional): Fall 2015

Dates: Start Date 08/03/2015 End Date 12/31/2015

☐ Automatically archive this class after the end date

New Student Module Course Product

Good News!

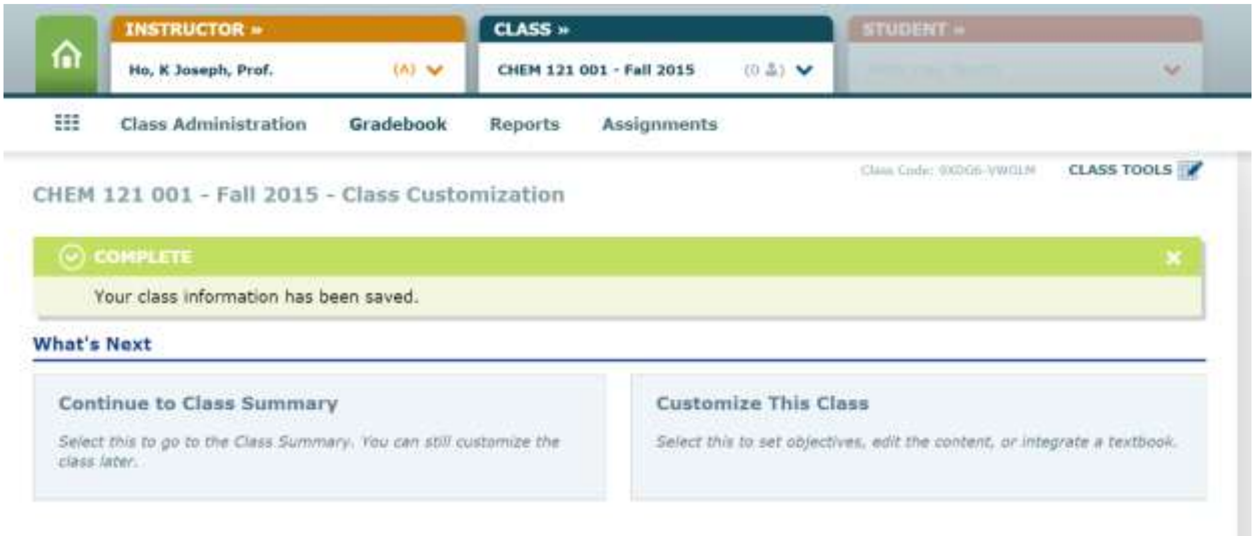
This ALEKS course product is now supported in the New Student Module. If you have not seen the New Student Module, we highly recommend you contact your ALEKS Implementation Consultant before creating classes in the New Student Module.

☐ **This class will be created in the Classic Student Module.** If you would like to create your class in the New Student Module, please uncheck this box.

Course Specific Settings

No settings available for this course product.

Now you will see the following window:



CHEM 121 001 - Fall 2015 - Class Customization

COMPLETE

Your class information has been saved.

What's Next

Continue to Class Summary

Select this to go to the Class Summary. You can still customize the class later.

Customize This Class

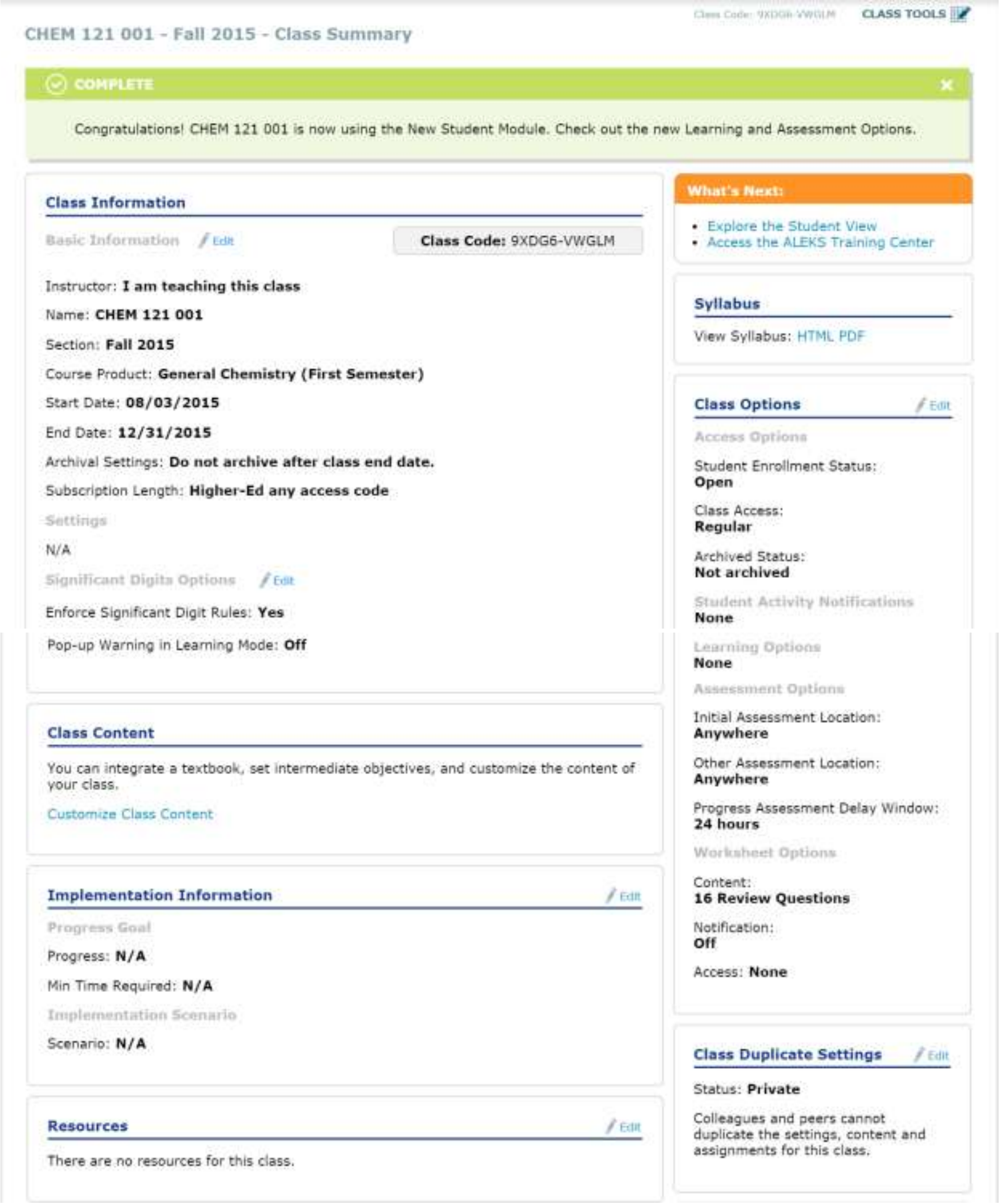
Select this to set objectives, edit the content, or integrate a textbook.

You can choose this option to see the summary

Or

You can choose this option to continue

On more options.



CHEM 121 001 - Fall 2015 - Class Summary

Congratulations! CHEM 121 001 is now using the New Student Module. Check out the new Learning and Assessment Options.

Class Information

Basic Information

Class Code: 9XDG6-VWGLM

Instructor: **I am teaching this class**

Name: **CHEM 121 001**

Section: **Fall 2015**

Course Product: **General Chemistry (First Semester)**

Start Date: **08/03/2015**

End Date: **12/31/2015**

Archival Settings: **Do not archive after class end date.**

Subscription Length: **Higher-Ed any access code**

Settings

N/A

Significant Digits Options

Enforce Significant Digit Rules: **Yes**

Pop-up Warning in Learning Mode: **Off**

Class Content

You can integrate a textbook, set intermediate objectives, and customize the content of your class.

Customize Class Content

Implementation Information

Progress Goal

Progress: **N/A**

Min Time Required: **N/A**

Implementation Scenario

Scenario: **N/A**

Resources

There are no resources for this class.

What's Next:

- Explore the Student View
- Access the ALEKS Training Center

Syllabus

View Syllabus: HTML PDF

Class Options

Access Options

Student Enrollment Status:
Open

Class Access:
Regular

Archived Status:
Not archived

Student Activity Notifications
None

Learning Options
None

Assessment Options

Initial Assessment Location:
Anywhere

Other Assessment Location:
Anywhere

Progress Assessment Delay Window:
24 hours

Worksheet Options

Content:
16 Review Questions

Notification:
Off

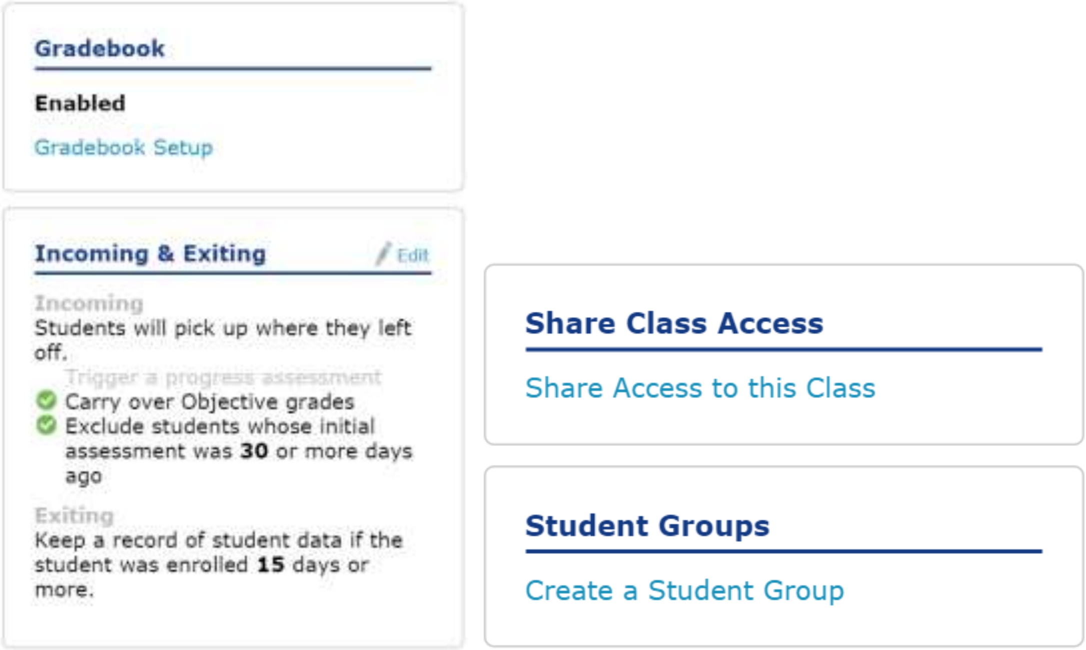
Access: **None**

Class Duplicate Settings

Status: **Private**

Colleagues and peers cannot duplicate the settings, content and assignments for this class.

More options continue next page:


Gradebook

Enabled

Gradebook Setup

Incoming & Exiting Edit

Incoming

Students will pick up where they left off.

Trigger a progress assessment

✓ Carry over Objective grades

✓ Exclude students whose initial assessment was **30** or more days ago

Exiting

Keep a record of student data if the student was enrolled **15** days or more.

Share Class Access

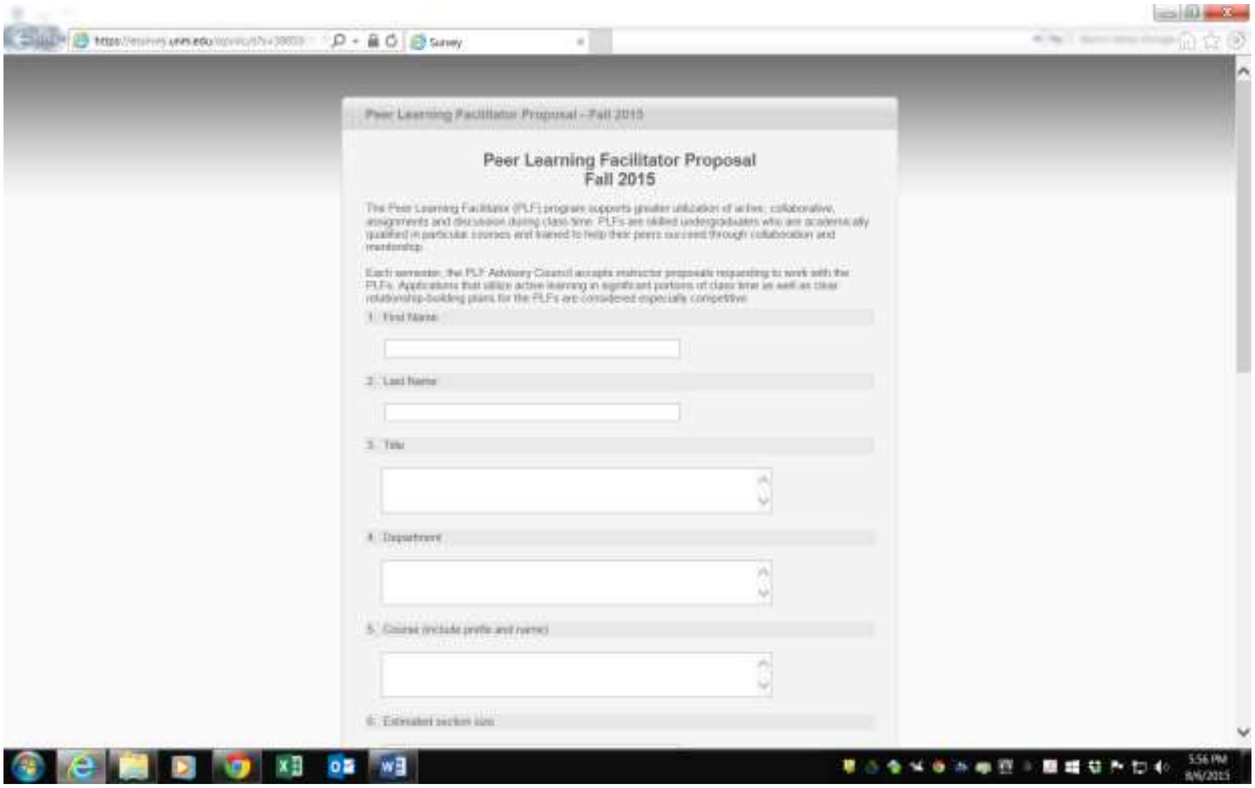
Share Access to this Class

Student Groups

Create a Student Group

You can always come back to Class Summary and change the setting by going under the "Class Administration" menu and choose "Class Summary". This section contains all options of a class setting.

Appendix Peer Led Facilitator (PLF)



Peer Learning Facilitator Proposal - Fall 2015

Peer Learning Facilitator Proposal
Fall 2015

The Peer Learning Facilitator (PLF) program supports greater utilization of active, collaborative, assignments and discussion during class time. PLFs are skilled undergraduates who are academically qualified in particular courses and trained to help their peers succeed through collaboration and mentorship.

Each semester, the PLF Advisory Council accepts instructor proposals requesting to work with the PLFs. Applications that utilize active learning in significant portions of class time as well as clear relationship-building plans for the PLFs are considered especially competitive.

1. First Name
2. Last Name
3. Title
4. Department
5. Course (include prefix and name)
6. Estimated section size

STEM Gateway
Course Redesign Teaching Professional Development Program:

Looking Back and Planning Forward

- What is the team’s plan for revising elements of the redesign before the upcoming fall semester?
- Who needs to be included as the project implementation expands?
- What tasks will team members undertake during the summer?
- How can you disseminate what you’ve learned during the redesign?

STEM GATEWAY
Project for Inclusive
Undergraduate STEM Success

DEPARTMENT OF EDUCATION
UNITED STATES OF AMERICA

Wrapping Up and Moving Forward – STEM Gateway Course Redesign – The Second Summer

At the conclusion of the funded-year for STEM Gateway Course Redesign Projects, teams assess successes and challenges from the redesign work and plan an improved pathway forward in the coming academic year. These expectations match the commitments that STEM Gateway has with the Department of Education's funding support.

As a part of this end-of-year wrap up, each team leader will also prepare a short report that accomplishes the following:

1. *Abstract:* A brief ~ 1 page summary summarizing the report (project motivation and goals, summary, assessment, improvement, expansion, sustainability, and challenges). This abstract will be shared with department Deans and Chairs for our annual share-out meeting.
2. *Project motivation and goals:* A brief explanation of the motivation of the redesign project and the goals that were established at the outset (along with any modification of goals that were developed during the year)
3. *Project summary:* Summarize the instructional redesign components (this will likely come from the proposal along with modifications that may have been made)
4. *Assessment:* Present any and all data obtained as part of the originally stated or modified assessment plan that are related to students' (a) learning (e.g., outcomes assessment data, pre/post-test or concept-inventory results), (b) success (e.g., grades), and/or (c) attitudes (e.g., surveys). These data should be briefly interpreted.
5. *Improvement:* Provide a summary of the curricular and pedagogical changes you are planning to make in light of the collected assessment data and your teaching experiences.
6. *Expansion:* Outline your plan for continuation of the redesign project, which should include (a) an indication of the approximate number of sections of the course that will be taught using the redesign in Fall 2016 and Spring 2017 and (b) who the likely instructors will be and/or how those instructors will be recruited. If, compared to Spring 2016, there will be no increase, or there is a decrease, in the number of sections taught with the redesign, then please provide a rationale.
7. *Sustaining*: A plan for sustaining the curricular and pedagogical innovations of the redesign. This section should include (a) achievements and/or intentions for accessible curation and dissemination of redesigned instructional components, (b) plans for continued work by the team to assess outcomes and make adjustments for continuous improvement, and (c) plans for assuring successful, self-efficacious implementation of the redesigned course elements by instructors who were not part of the original team.
8. *Challenges:* List the major challenges to your redesign project. Indicate, if appropriate, who assisted or could assist your team in overcoming the obstacles you face.

All team members should participate in these processes and teams are encouraged to commit to some face-to-face meeting time for that purpose. STEM Gateway redesign project staff will attend a session with each team at the beginning or very early during these summer activities, at any time during the summer at the request of the team leader (or individually with team members), and will also meet with each team leader after submission of the report.

Please submit your report by August 14, 2016