Pathways to Transforming Student Learning and Persistence Through Course Design

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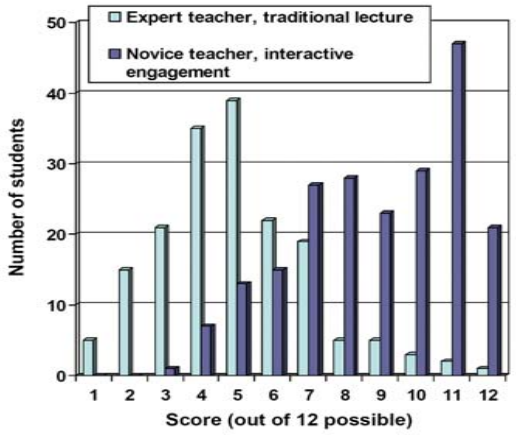
Let's ponder a case-study in teaching and learning

Why was the measured learning different between the classes?

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

We will revisit and answer these questions.



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

Clicker

Which of these statements is closest to what you're thinking right now about why you are attending this session

A. The organizers expect me to be here and may think less of me if I don't participate
B. It is useful for me to learn about teaching to succeed in my anticipated career
C. I'll go along because I don't want my post-doc colleagues to show me up with their participation
D. Teaching is part of my identity so I look forward to opportunities to learn more about teaching
E. I really enjoy workshops on teaching; this is how I'd really like best to spend my time this morning

Clicker

I have goals that guide my plans to develop as a researcher.

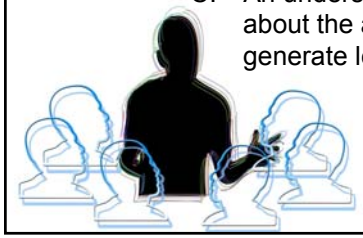
A. Strongly agree
B. Somewhat agree
C. Somewhat disagree
D. Strongly disagree

I have goals that guide my plans to develop as a teacher.

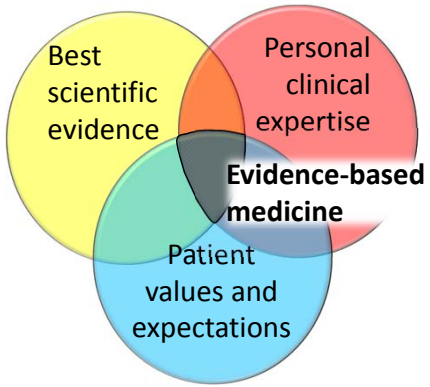
A. Strongly agree
B. Somewhat agree
C. Somewhat disagree
D. Strongly disagree

My abilities and perceptions of how to be an effective teacher are *mostly* based on:

A. My past experiences as a teacher
B. How I have been taught and the courses/instructors that I liked the most
C. An understanding of what research shows about the approaches to teaching that generate learning

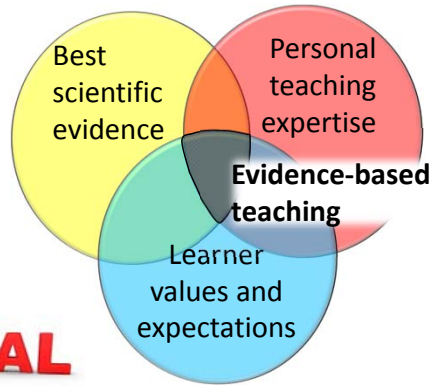


The prevailing professional view to practicing medicine …



(based on Sackett et al., 1997)

… can be applied to being a professional educator.



Primary objective: Initiate or develop your pathway to being an effective evidence-based teacher

Let's provide some individual context for today's learning opportunity

Sketch the design of a topic you want to teach to your students.

First step: Envision the topic and the learning objectives

Evidence-Based Design of a Learning and Teaching Opportunity (p. 11)

Complete items 1 and 2

The Roadmap:

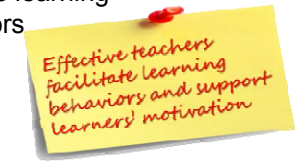
Establish context for "what teaching is"

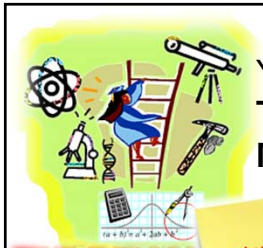
The "inclusiveness problem" in higher education – especially in STEM

Why active learning is superior to lecture learning

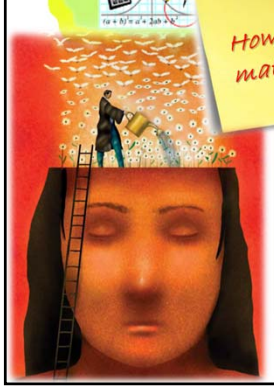
Designing for effective learning behaviors

Designing for effective learning motivation



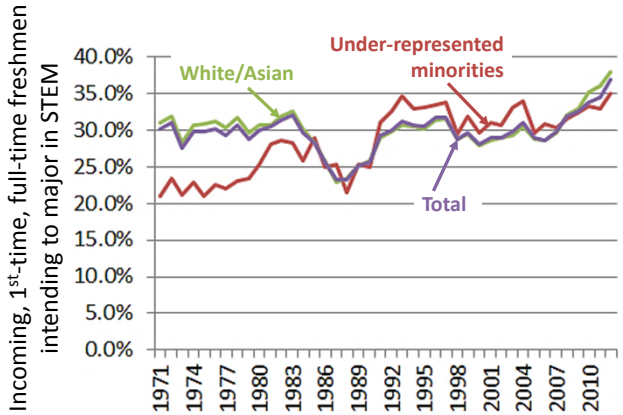


You may be part of the **S**cience, **T**echnology, **E**ngineering, and **M**athematics education imperative



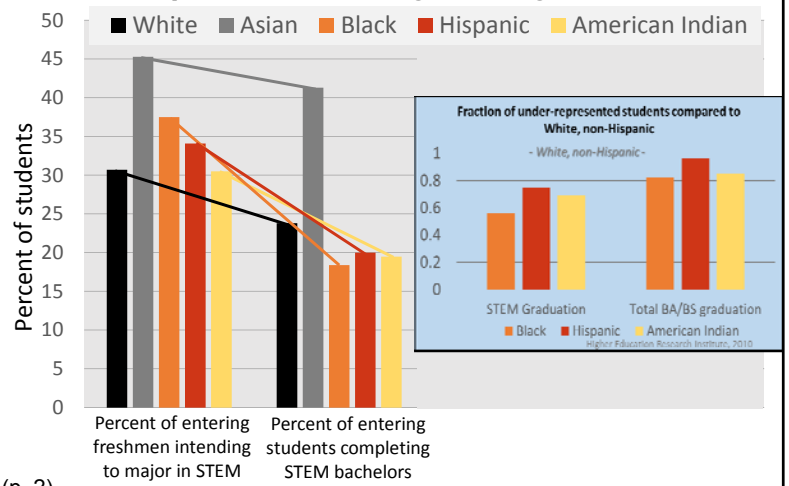
Departures from STEM – Where does the pipeline leak the most?

The pipeline from high-school to college is improving in total, and increasing in diversity



Higher Education Research Institute

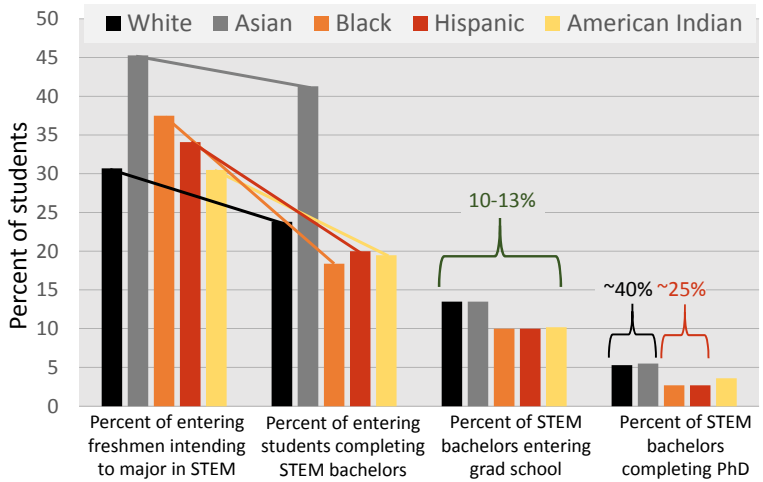
Black, Hispanic, and American Indian students are under-represented among STEM graduates



(p. 2)

Garrison, 2013, *CBE-Life Sci. Ed.*

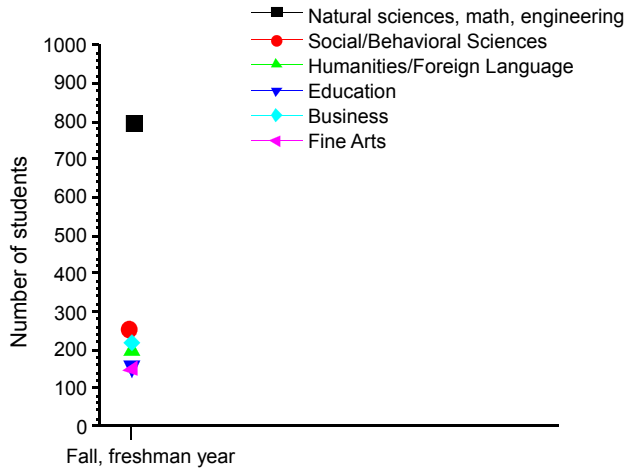
Black, Hispanic, and American Indian students are under-represented among STEM-PhD recipients



Garrison, 2013, *CBE-Life Sci. Ed.*

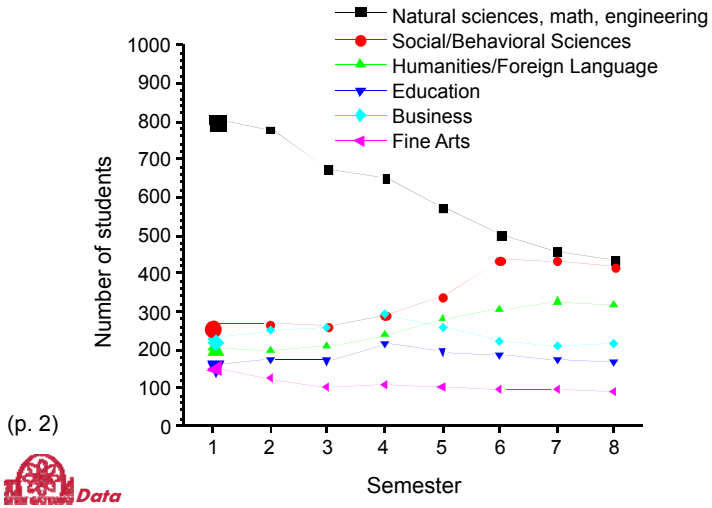
The diversity pipeline leaks *within* the pipes, more than at the transitions

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



Data

But - STEM disciplines suffer the greatest attrition at UNM



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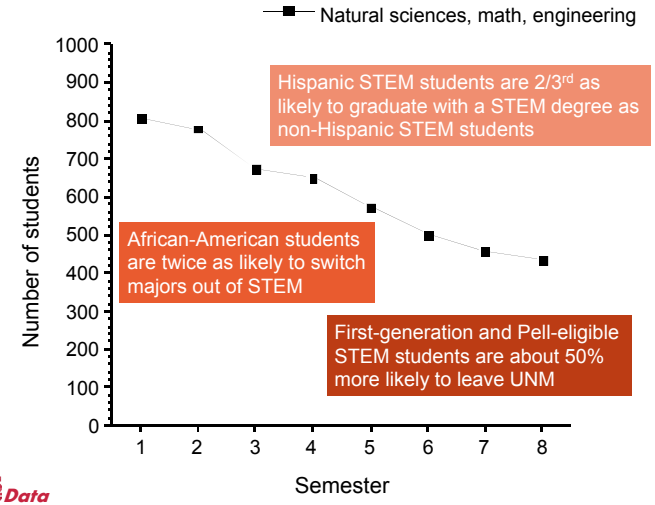
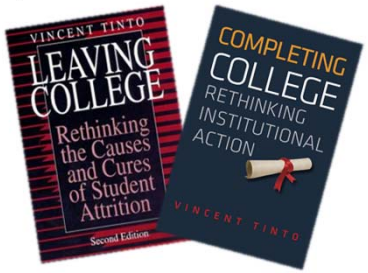


Data

"… 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**."



Vincent Tinto

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

"**It now appears that all traditionally taught college courses are markedly (though unintentionally) biased against many non-traditional students**. Thus, v
teach merely in traditional ways we probably d
strongly on grounds quite different from those
Easily accessible changes in how we teach have shown repeatedly to foster dramatic changes ir performance with no change in standards."

How we teach, matters!

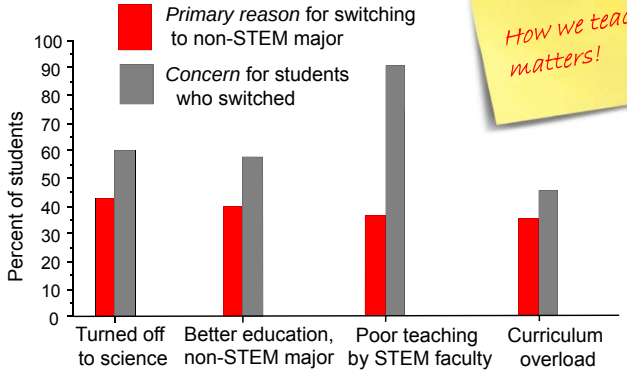
Also read "Dysfunctional illusions of rigor …" (p. 15-20)

Craig Nelson

C.E. Nelson, 1996, *American Behavioral Scientist*, 40(2):165

Faculty instructional and curricular choices are the reasons that continuing students leave STEM majors.

How we teach, matters!



(p. 3)

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

"If I was behind or you know, like did not understand a concept, I WOULD NOT like to ask questions because I felt like I'd ask something and then it'd be like obvious or I'd look dumb or something."

"You sit there, you listen to the professor and you take your test…it is definitely an old-school teaching method."

"I would have stayed *if I felt like I belonged.*

"…it was dread, it was dry…there was no enthusiasm to be there."

"And yo… and it was just like the biggest blow to your self-esteem you ever had…you would come out of there just hating your life, feeling like a moron after taking those tests."

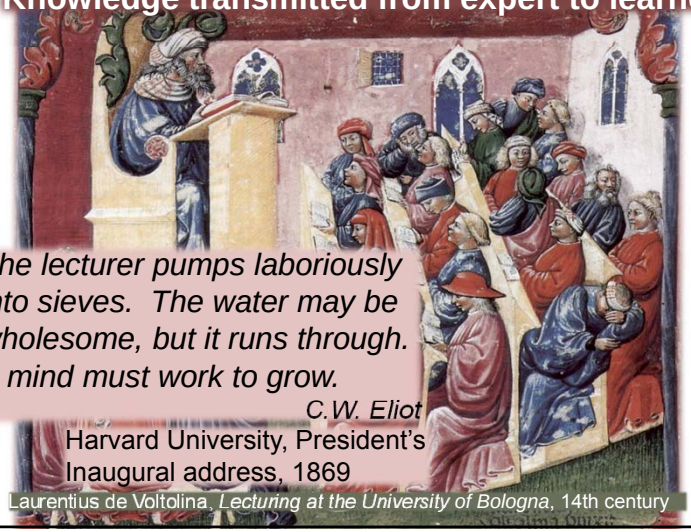
"I don't fit the mold, you know?..."

"You're just a number, a nobody, you're not gonna really learn anybody's name"

"…the strongest sense of community was in my ceramics classes…we all had to work together…there's just a lot of teamwork and community involved."

(p. 3)

Learning as solitary experience
Knowledge transmitted from expert to learner



The lecturer pumps laboriously into sieves. The water may be wholesome, but it runs through. A mind must work to grow.

C.W. Eliot
Harvard University, President's Inaugural address, 1869

Laurentius de Voltolina, *Lecturing at the University of Bologna*, 14th century

Learning as a social experience
Knowledge as constructed, not simply delivered

Raphael, *School of Athens*

Case Study:
University of Washington, Introductory Biology

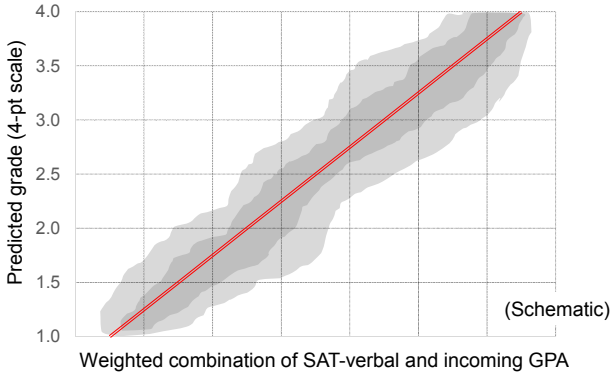
Scott Freeman

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

(p. 4)

Student preparation predicts course grade

Case Study – University of Washington, Introductory Biology



Haak et al., 2011, Increased Structure and active learning reduce the achievement gap in introductory biology, *Science*, 332 (6034): 1213

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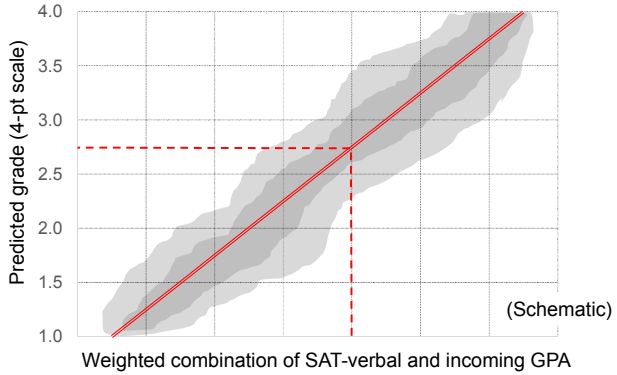

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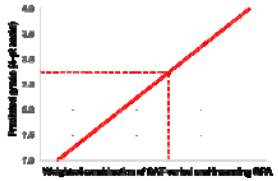
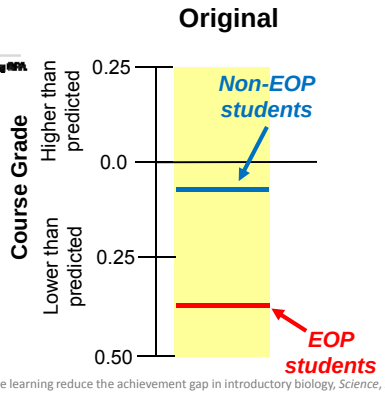
Traditional approach discriminates students with comparable preparation





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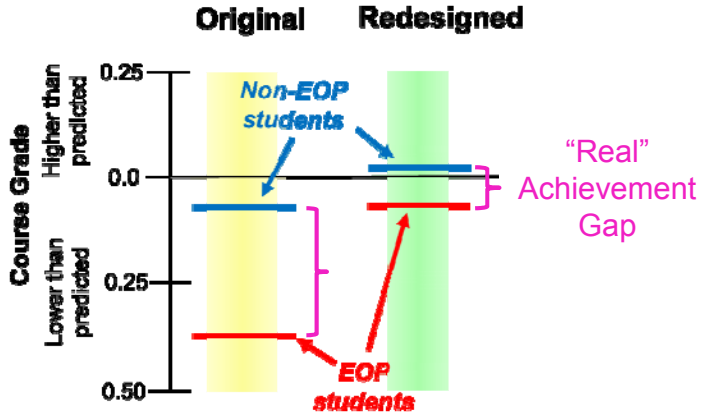
Course redesign increases student learning and decreases achievement gap in majors' biology



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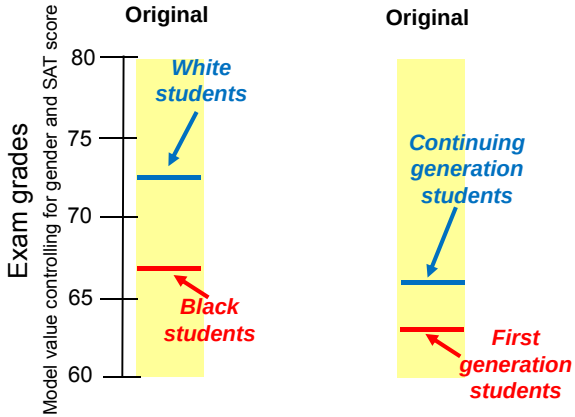
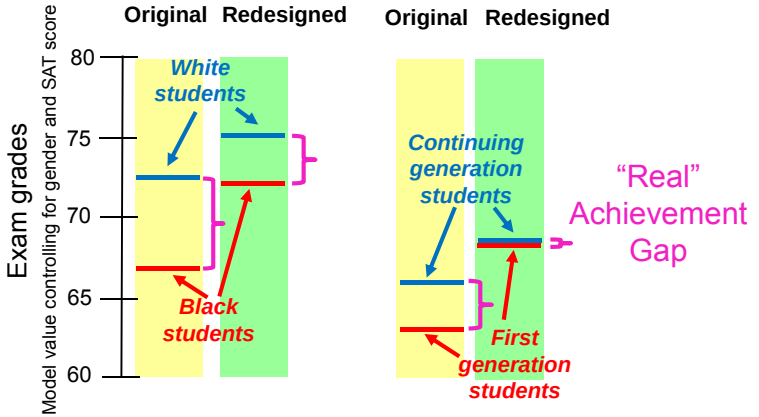
Case Study: University of North Carolina, Introductory Biology



(p. 4) Eddy et al., Getting Under the Hood: How and for Whom Does Increasing Course Structure Work?, *CBE-Life Sci. Ed.*, Fall 2014

Course redesign increases student learning and decreases achievement gap in majors' biology



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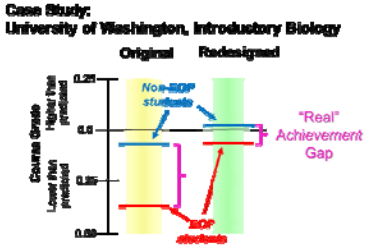
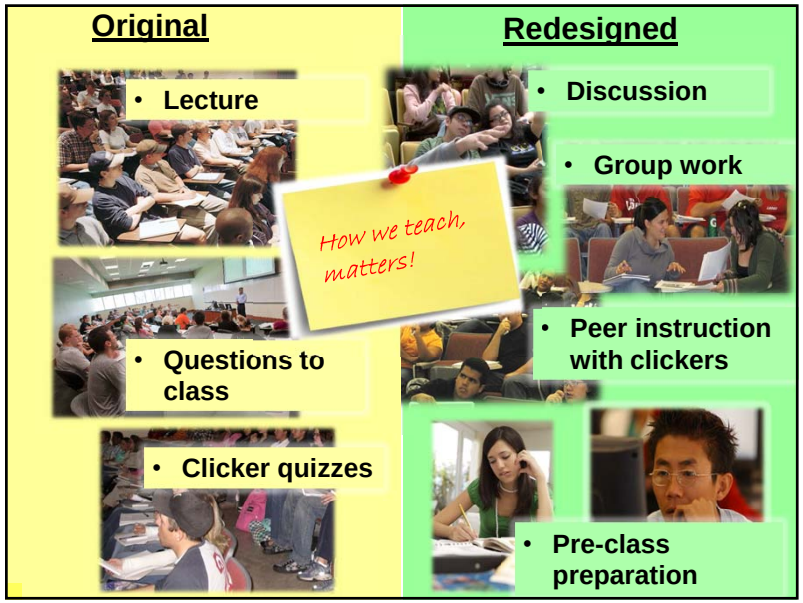


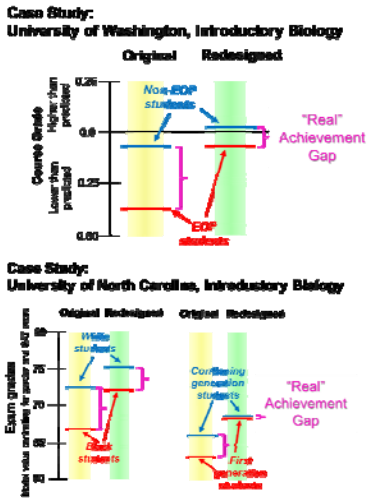
What do you think was different in the "original" and "redesigned" courses?



In the words of a UNM student, speaking to teachers:

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

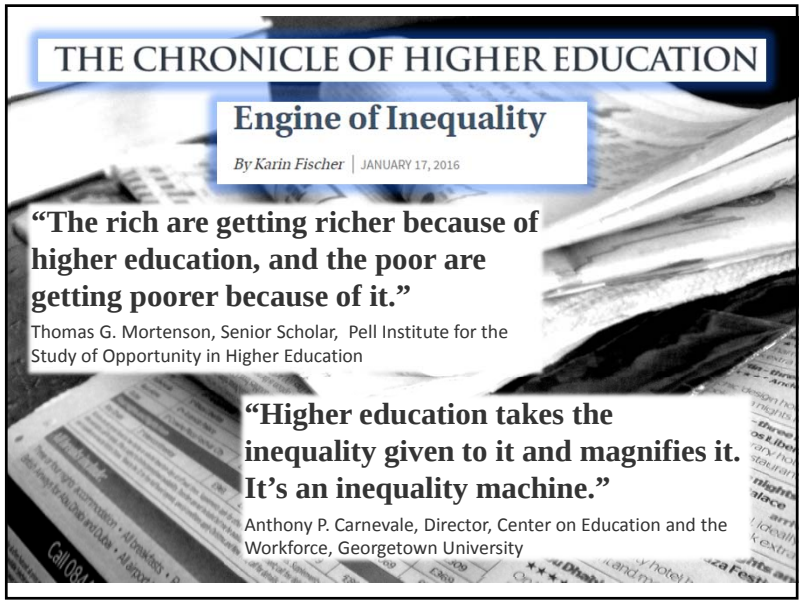
"Don't re-teach yourself. Standing at the front of the room talking and writing on the board is you re-enforcing what *you* know. *Engage* your students… we need to *work* with the material, *talk* about it, *think* about it, *not listen to you* all of the time."



So… why did the original course designs "discriminate strongly on grounds quite different from those we intend?"

(Craig Nelson)

"I don't fit the mold, you know?…" *(UNM Student who departed STEM)*



Cultural mismatch theory explains the chasm between universities and the growing numbers of first-generation students

"The culture of higher education itself plays a pivotal role to … produce social class inequalities among students because they are built and organized according to taken for granted, middle- and upper-class cultural norms, unwritten codes, or 'rules of the game.'"

Stephens, 2012, *Journal of Personality and Social Psychology*, 102(6): 1178-1197


Nicole Stephens

Motivation for attending college correlates to socioeconomic status

Student motives for attending college:

Independent:	*Values Ways of Knowing*	**Interdependent:**
• Expand my knowledge of the world • Become an independent thinker • Explore new interests • Explore my potential in many domains • Learn more about my interests • Expand my understanding of the world		• Help my family out after I'm done with college • Be a role model for people in my community • Bring honor to my family • Show that people with my background can do well • Give back to my community • Provide a better life for my own children

Continuing-generation students

First-generation students

(p. 5)

Stephens, 2012, *Journal of Personality and Social Psychology*, 102(6):1178-1197

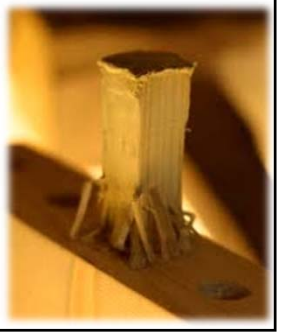
University culture fits better with continuing-generation students

Most closely reflects your institution's expectations for college students:

Independent:		**Interdependent:**
• Being independently motivated	⟷	• Being motivated by others' high expectations
• Working independently	⟷	• Working collaboratively in groups
• Conducting independent research	⟷	• Conducting collaborative research
• Paving their own innovative pathways	⟷	• Following in the footsteps of accomplished others
• Challenging the norms or rules	⟷	• Considering the norms or rules
• Developing personal opinions	⟷	• Appreciating the opinions of others

"Tier 1" (USN&WR)

Stephens, 2012, *Journal of Personality and Social Psychology*, 102(6):1178-1197



"I don't fit the mold, you know?..."

Cultural mismatch affects *learning* achievement

Student motives for attending college:

Independent:	+ correlation with grades	- correlation with grades	Interdependent:

Continuing-generation students

First-generation students

"Tier 1" (USN&WR)

Stephens, 2012, *Journal of Personality and Social Psychology*, 102(6):1178-1197

Pause to reflect …. What do you think?

The Roadmap:

Establish context for "what teaching is"

The "inclusiveness problem" in higher education – especially in STEM

Why active learning is superior to lecture learning

Designing for effective learning behaviors

Designing for effective learning motivation

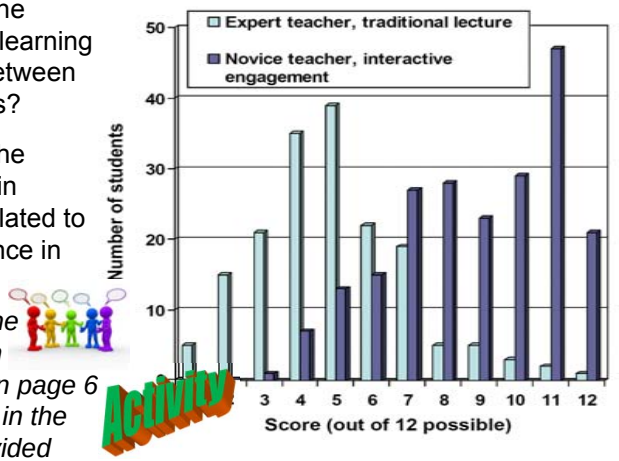
Effective teachers facilitate learning behaviors and support learners' motivation

Returning to the case-study in teaching and learning

Why was the measured learning different between the classes?

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

Examine the information provided on page 6 and reflect in the space provided



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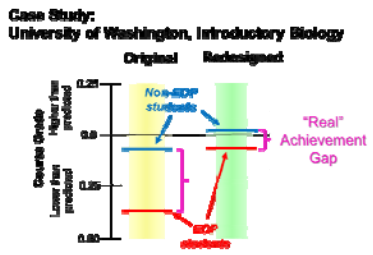
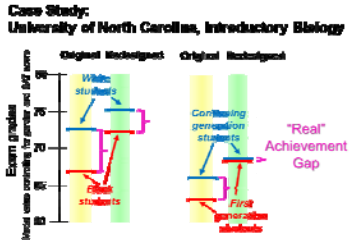




Redesigns benefit all students … *Why?*

The most effective learning triggers all neural learning centers

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

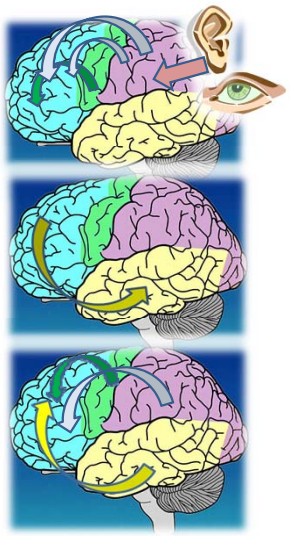
(after Zull, 2002, *The Art of Changing the Brain)*

There are three, inter-related memory-forming processes

Encoding
Incoming stimulus converted into a "memory trace"

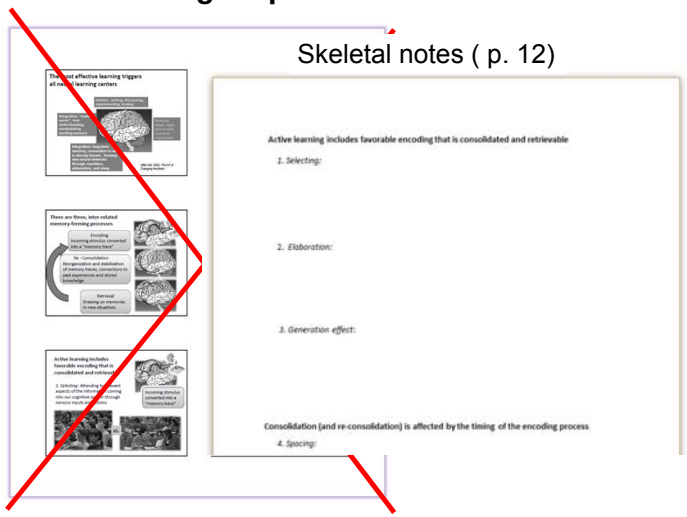
Re - Consolidation
Reorganization and stabilization of memory traces; connections to past experiences and stored knowledge

Retrieval
Drawing on memories in new situations



Note-taking helps to encode memories

Skeletal notes (p. 12)



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

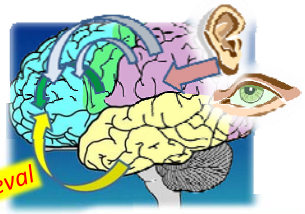
Incoming stimulus converted into a "memory trace"

VS.

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"

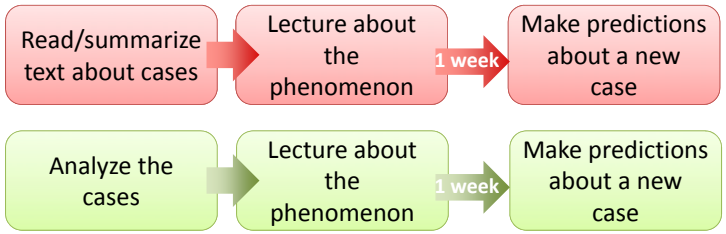
VS.

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

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

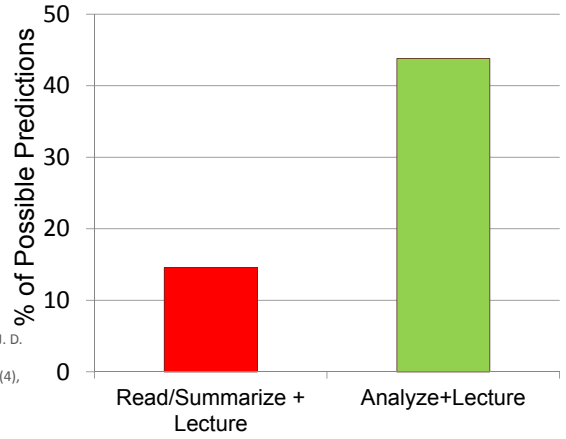
B. Learner attempts to solve problems and/or answer questions about a new topic *after* the professor explains it in class.

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



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



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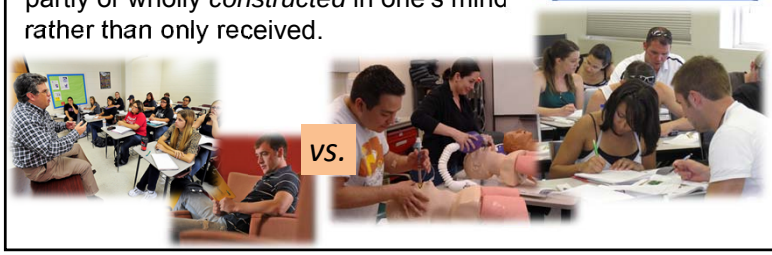
Active learning includes favorable encoding that is consolidated and retrievable

1. *Selecting*
2. *Elaboration*

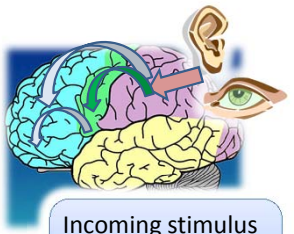
Incoming stimulus converted into a "memory trace"

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



Active learning includes favorable encoding that is consolidated and retrievable

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



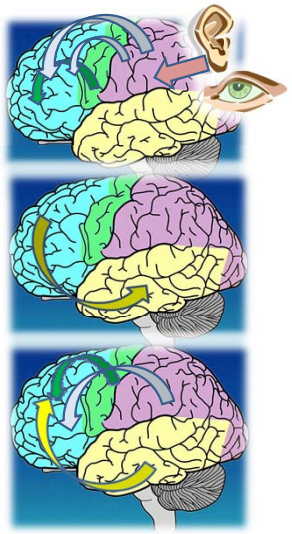
Incoming stimulus converted into a "memory trace"

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?

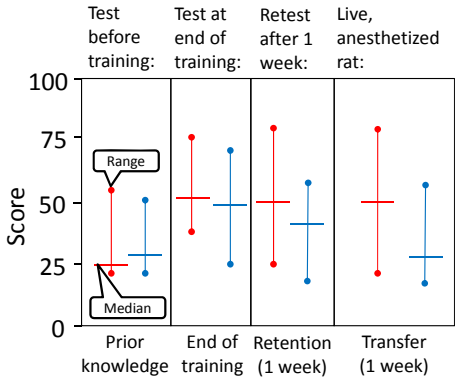
A. *Spaced learning* in short time increments across a long time interval.
B. *Massed learning* in a single, long learning session

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

Residents were taught microvascular anastomosis in either:

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

Suturing blood vessels under a microscope



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

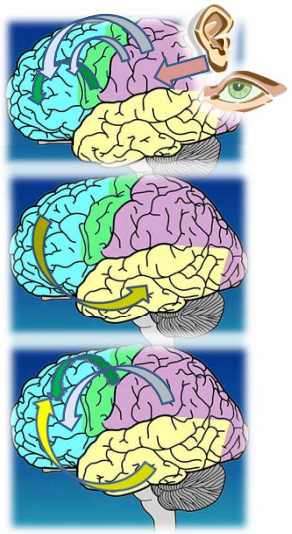
1. *Selecting*
2. *Elaboration*
3. *Generation effect*

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

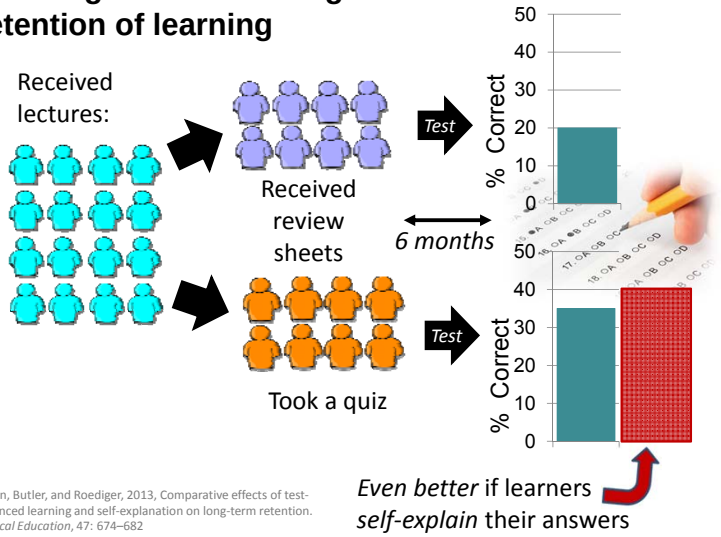


Clicker Q

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.

Quizzing beats reviewing for retention of learning



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

Even better if learners *self-explain* their answers

Retrieval is part of learning as well as testing

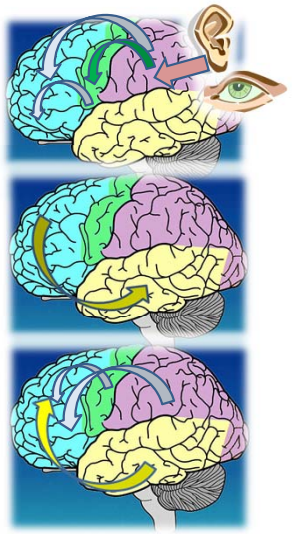
1. *Selecting*
2. *Elaboration; including self-explanation*
3. *Generation effect*
4. *Spacing*

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
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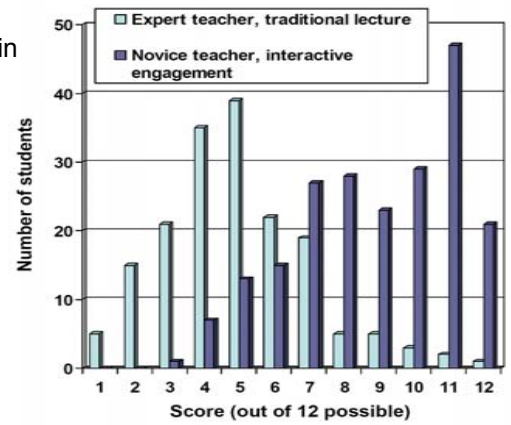
Returning to our case-study in teaching and learning

Can you apply the principles to explain the learning differences in the physics classes?

Activity

Examine the information provided on page 6 and reflect in the space provided



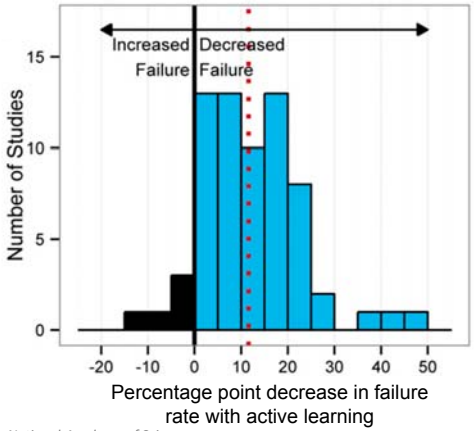
Deslauriers et al., 2011, Improved learning in a large-enrollment physics class, *Science*, 332: 862

Failure rates under traditional lecturing in STEM courses increases 55% over the rates observed under active learning

Average failure rates in lecture courses
34%

Average failure rates in active-learning courses
22%

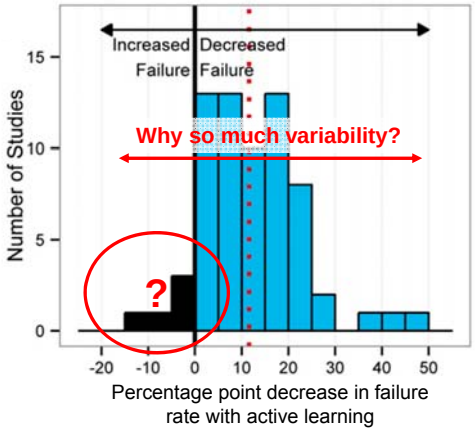
(p. 7)



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

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

Effective teachers facilitate learning behaviors and support learners' motivation



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

Rank (high to low) the depth and retention of learning anticipated from each activity

1. 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.	2. 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.
3. 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.	4. 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.

(p. 8)

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

Interactive
Collaborating in Dialogue

Constructive
Generating, Producing

Active
Selecting, Manipulating

Passive
Receiving

(p. 9-10)

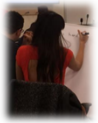
Chi, 2009, *Topics in Cognitive Science*, 1(1); Chi & Wiley, 2014, *Educational Psychologist*, 49(4)

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

Interactive
Collaborating in Dialogue

Constructive
Generating, Producing

Active
Selecting, Manipulating



Passive
Receiving

Depth of learning:

Interactive > Constructive > Active > Passive

Chi, 2009, *Topics in Cognitive Science*, 1(1); Chi & Wiley, 2014, *Educational Psychologist*, 49(4)

Classify with ICAP?

1. 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.	2. 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.
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Interactive

Constructive

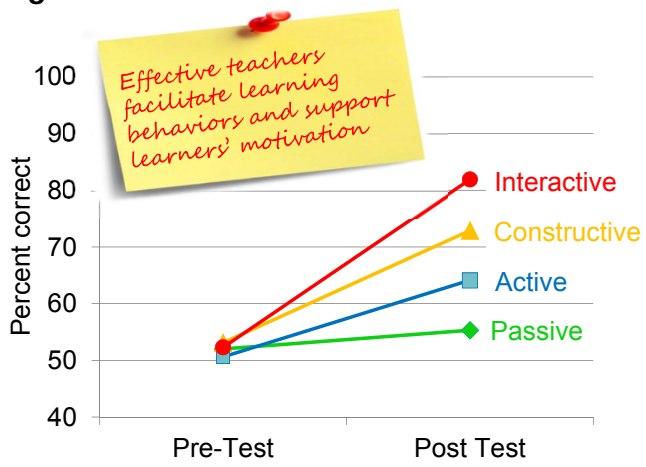
Passive

Active

ICAP hypothesis:

Interactive > Constructive > Active > Passive

ICAP hypothesis is supported by learning-achievement data

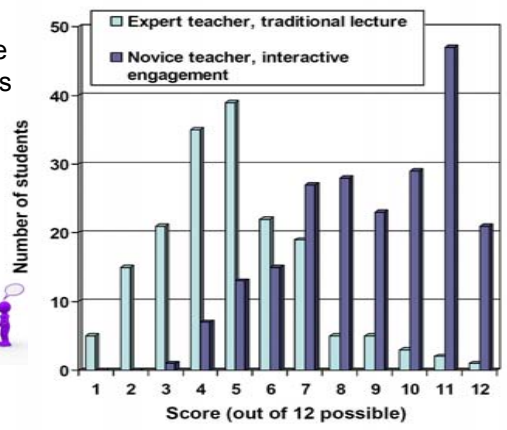


Menekse et al., 2013, *J. of Engineering Education*, 102(3): 346-374

Returning to our case-study in teaching and learning

Can you apply ICAP to explain the learning differences in the physics classes?

Examine the information provided on page 6 and reflect in the space provided



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

Evidence-Based Design of a Learning and Teaching Opportunity (p. 11)

Complete items 3 and 4

The Roadmap:

Establish context for "what teaching is"

The "inclusiveness problem" in higher education – especially in STEM

Why active learning is superior to lecture learning

Designing for effective learning behaviors

Designing for effective learning motivation

Effective teachers facilitate learning behaviors and support learners' motivation

Write down something that you do because you really enjoy doing it.

Trade cards 3 times

Raise your hand if the activity on the card you are holding refers to …

… physical exercise activity

… creative work

… playing a sport

… playing a musical instrument

… watching performances
(film, TV, theater, concert …)

… puzzles, video games

… reading for pleasure

… research work

… prepare to teach

… physical exercise activity

… creative work

… playing a sport

… playing a musical instrument

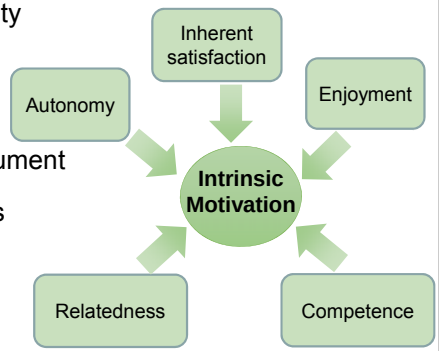
… watching performances
(film, TV, theater, concert …)

… puzzles, video games

… reading for pleasure

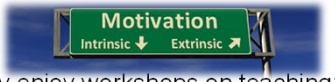
… research work

… prepare to teach



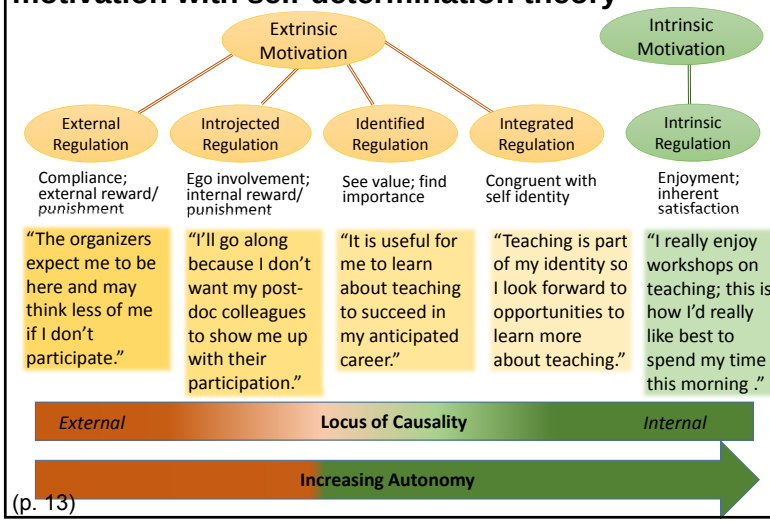
Returning to your motivation to be here right now:

A. The organizers expect me to be here and may think less of me if I don't participate
B. It is useful for me to learn about teaching to succeed in my anticipated career
C. I'll go along because I don't want my post-doc colleagues to show me up with their participation
D. Teaching is part of my identity so I look forward to opportunities to learn more about teaching



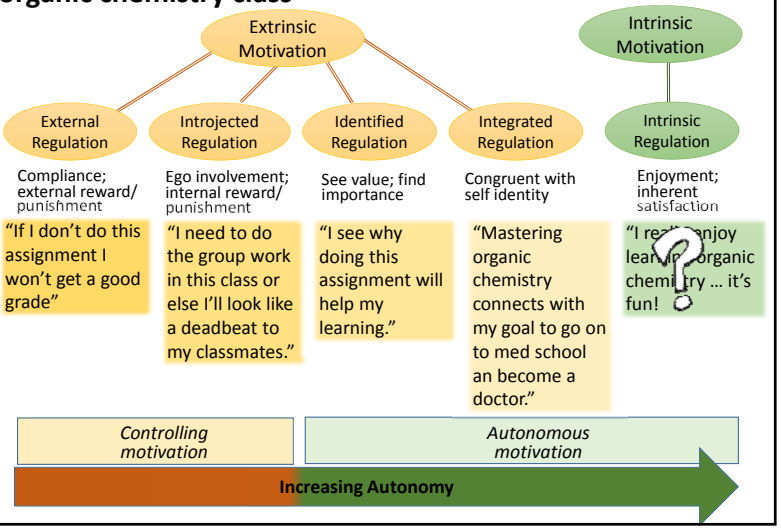
E. I really enjoy workshops on teaching; this is how I'd really like best to spend my time this morning

Exploring the spectrum of extrinsic motivation with self-determination theory

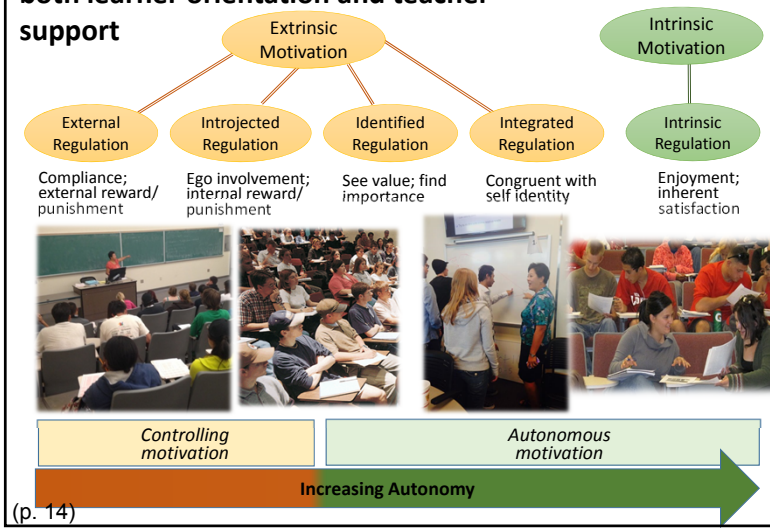


(p. 13)

Motivation to complete assignments in organic chemistry class

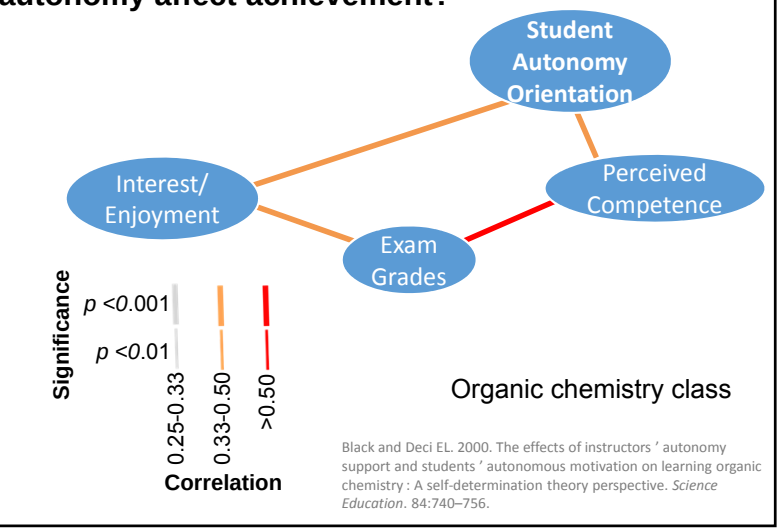


Autonomous motivation depends on both learner orientation and teacher support



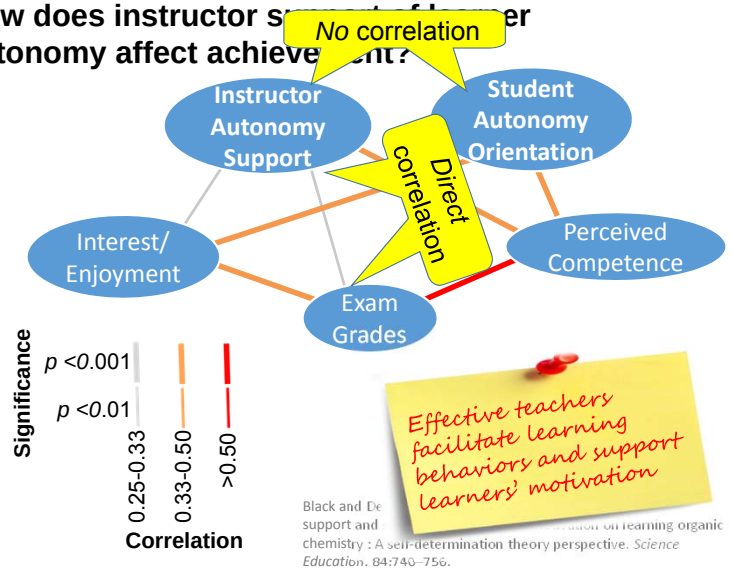
(p. 14)

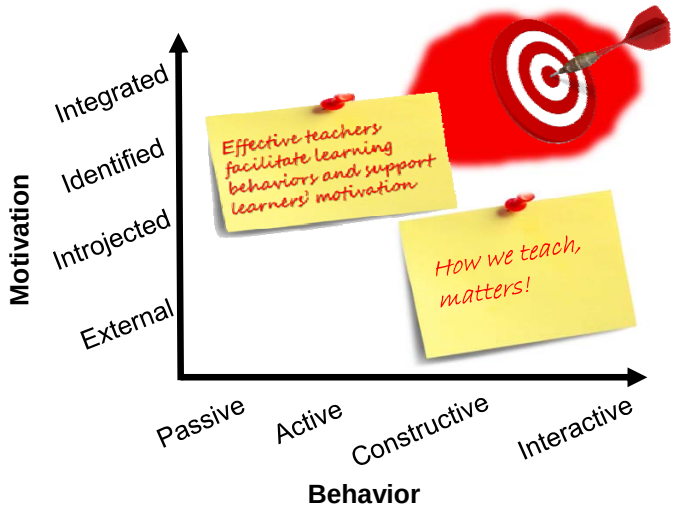
How does instructor support of learner autonomy affect achievement?



Black and Deci EL. 2000. The effects of instructors ' autonomy support and students ' autonomous motivation on learning organic chemistry : A self-determination theory perspective. *Science Education*. 84:740–756.

How does instructor s… autonomy affect achieve…?





Question: **Given that a large tree grows from a tiny seed, where does *most* of the *dry* mass (not including water) of the tree come from?**

Choose your answer:

A From water
B From the soil
C From the air
D It's already in the seed

Question: **Given that a large tree grows from a tiny seed, where does *most* of the *dry* mass (not including water) of the tree come from?**

Choose your answer:

A From water
B From the soil
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D It's already in the seed

Photosynthesis!

Carbon dioxide in the atmosphere is converted into carbohydrate plant tissue, while producing oxygen that we breathe.

Peer instruction with clickers promotes interactive learning and assesses learning