American Chemical Society
New Faculty Workshop

Introduction to "Active" Learning

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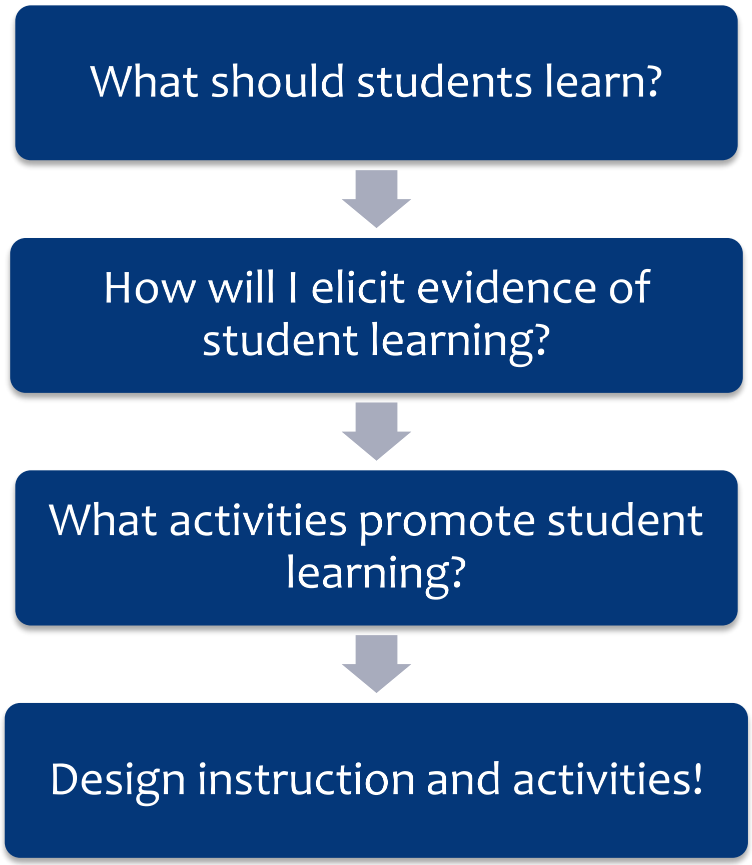
Chemistry for Life®

Designing a teaching tidbit



Consider what students should know and be able to *do* with that knowledge.

Constructive alignment of these ideas results in a coherent curriculum.

Biggs, J. Aligning teaching and assessing to course objectives. *Teaching and Learning in Higher Education: New Trends and Innovations* **2003**, 2, 1–9.

Designing a teaching tidbit

What should students learn?

↓

How will I elicit evidence of student learning?

↓

What activities promote student learning?

↓

Design instruction and activities!

Consider what students should know and be able to *do* with that knowledge.

Active learning can support students in learning to do things with their knowledge.

Don't worry, we'll get back to assessment tomorrow!

What is active learning?

- In your breakout rooms, open the Google Document assigned to your group number.
- Discuss and record your thoughts about:
  - What does the term *active learning* mean to you?
  - How do you know when *active learning* is occurring?
  - How do you know when *active learning* is not happening?

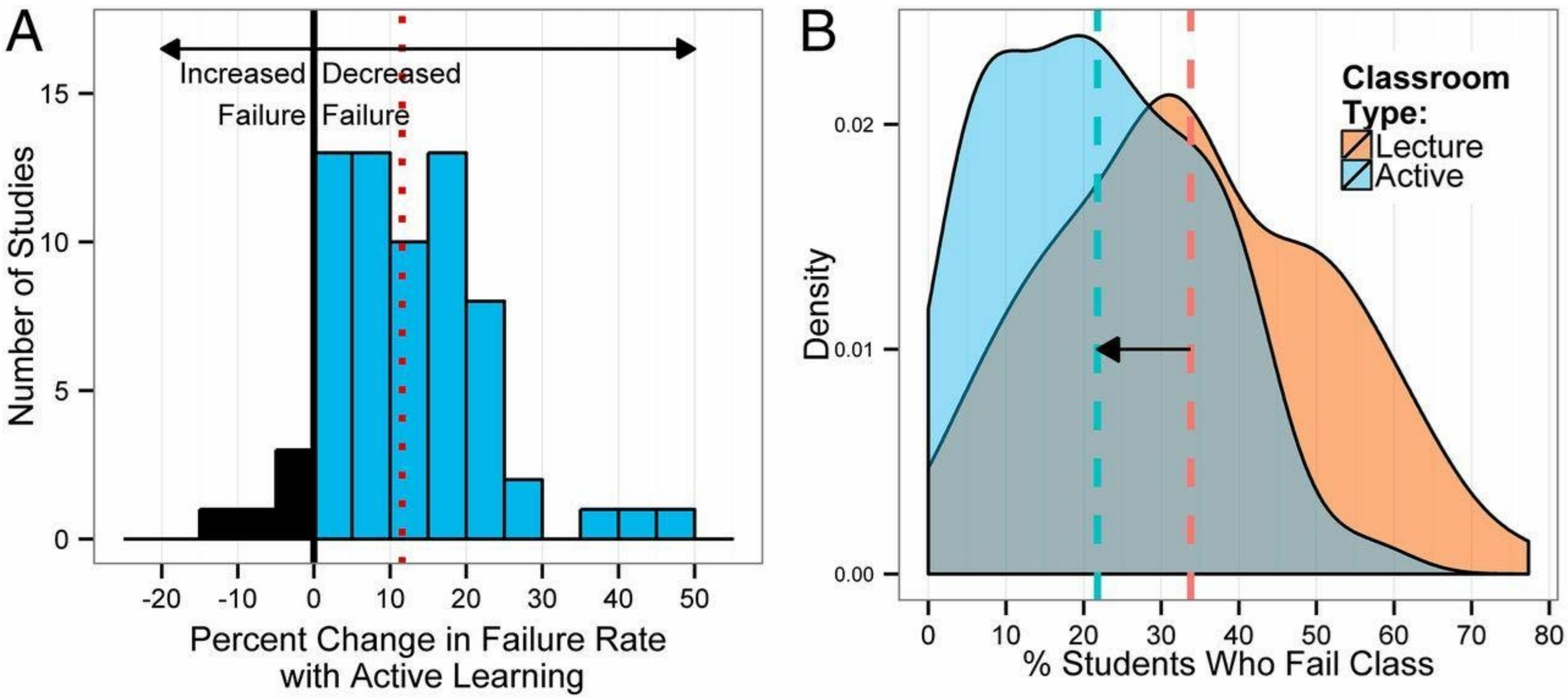
Active learning means different things to different people.

- some define active learning by stating what active learning is not:
  - antithetical to lecture
  - antithetical to "passive learning"

This isn't particularly helpful when you want to know what to do in your own classrooms.

Lombardi, D.; Shipley, T. F. The curious construct of active learning. *Psychological Science in the Public Interest* **2021**, 22(1), 8–43.

Even when ill-defined, active learning is associated with more desirable student outcomes.

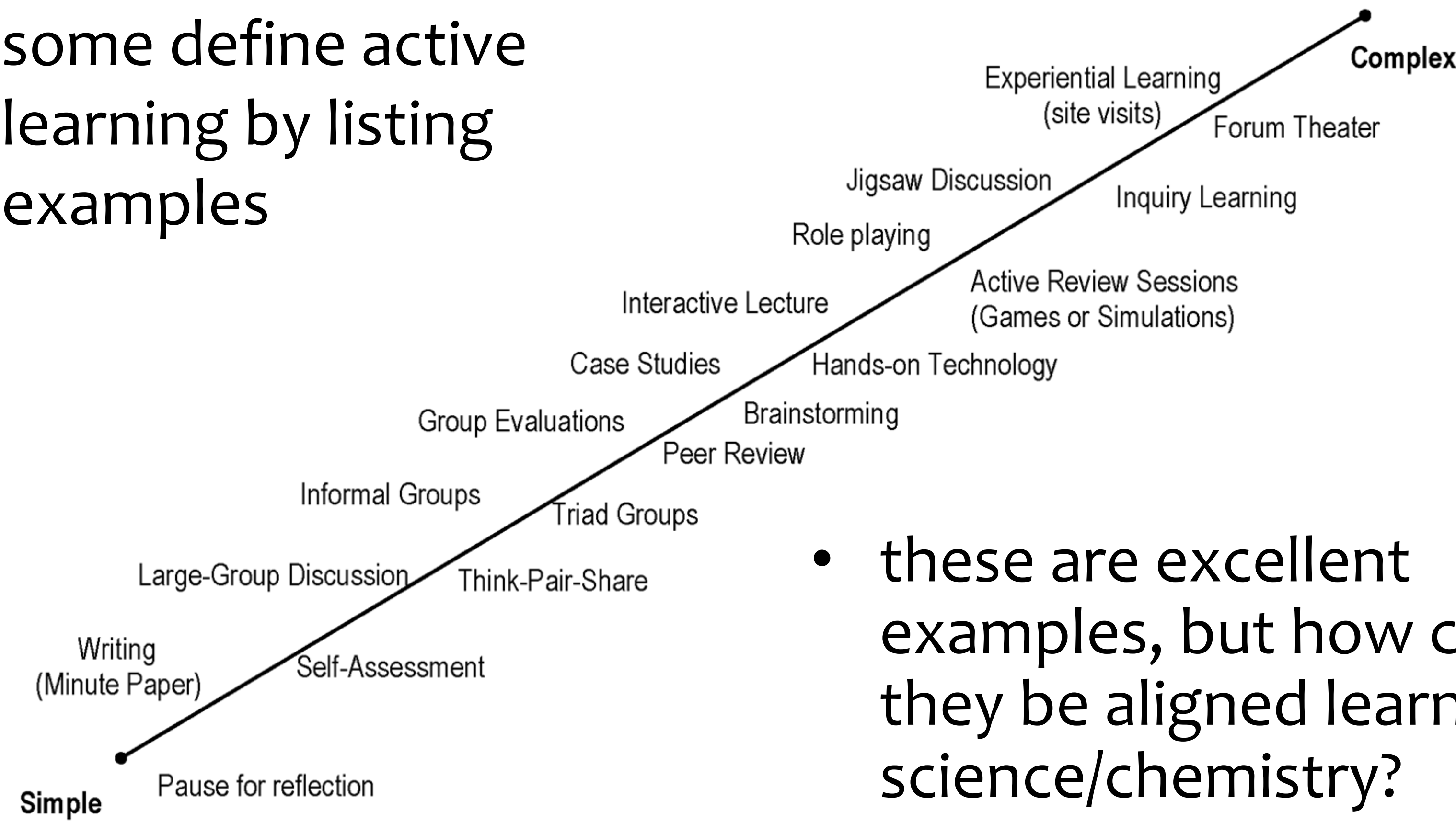


- *active learning* was defined in this work as anything other than continuous exposition by the instructor

Freeman, S.; Eddy, S. L.; McDonough, M.; Smith, M. K.; Okoroafor, N.; Jordt, H.; Wenderoth, M. P. Active learning increases student performance in science, engineering, and mathematics. *Proceedings of the National Academy of Sciences, USA* **2014**, *111*(23), 8410–8415.

Active Learning means different things to different people.

- some define active learning by listing examples



- these are excellent examples, but how can they be aligned learning science/chemistry?

Figure taken from: https://crlt.umich.edu/sites/default/files/Active_Learning_Continuum_CRLT.pdf

Descriptions of these examples are available in today's Google folder.

Active Learning means different things to different people.

- still others consider active learning in the context of how students learn:
  - help learners construct knowledge and understanding; help learners “sense make”
  - deepen learners’ engagement with the learning process

Let’s discuss learning and engagement a bit to make sure we’re thinking about these ideas consistently.

Lombardi, D.; Shipley, T. F. The curious construct of active learning. *Psychological Science in the Public Interest* **2021**, 22(1), 8–43.

Learning is *cognitive*.

Students are not blank slates.

National Academies of Sciences, Engineering, and Medicine. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press, **2000**.

Learning is *cognitive*.

Knowledge and understanding are **constructed** in the mind of the learner.

National Academies of Sciences, Engineering, and Medicine. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press, **2000**.

Learning is *cognitive*.

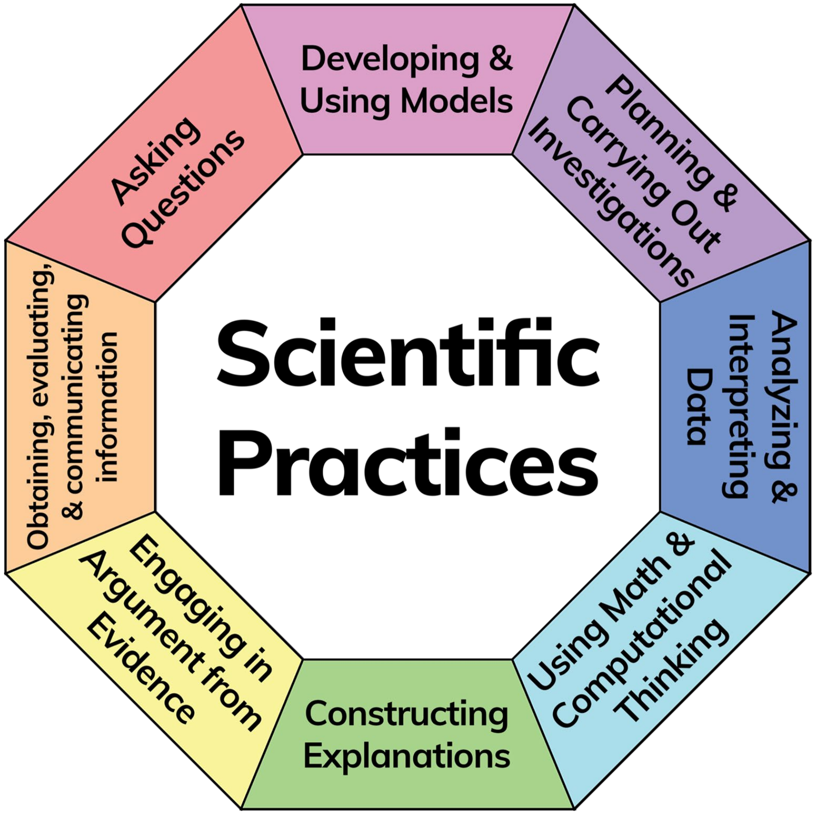
Cognitive engagement stems from a willingness to engage in effortful thinking, purposiveness, strategy use, and self-regulation in the learning process.

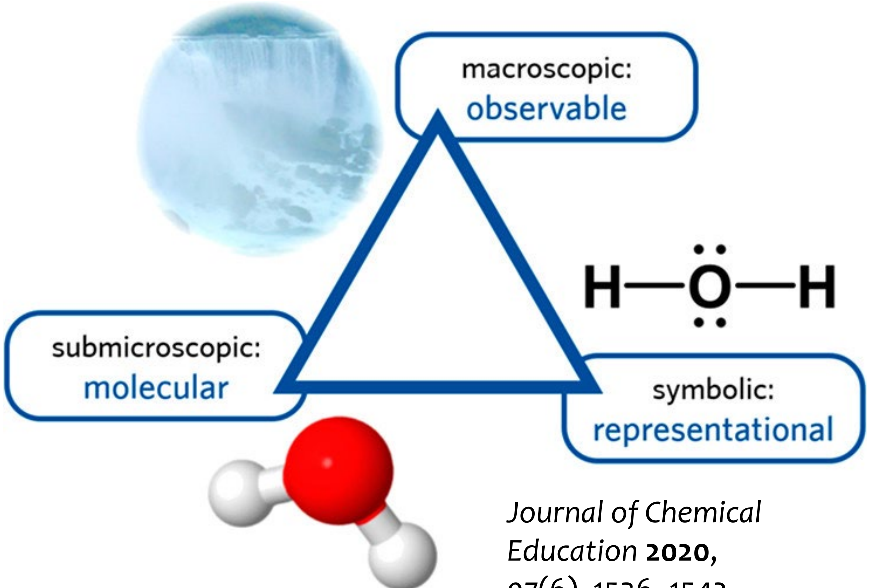
Sinatra, G. M.; Heddy, B. C.; Lombardi, D. The challenges of defining and measuring student engagement in science. *Educational Psychologist* **2015**, *50*(1), 1–13.

How do we construct knowledge and understanding in chemistry?

- In your breakout rooms, open the Google Document assigned to your group number.
- Discuss and record your thoughts about:
  - How do we as practicing chemists construct knowledge and understanding?
  - With what kinds of practices do we engage in order to do this?
  - With what existing knowledge bases do we engage in order to accomplish this?

How do we construct knowledge and understanding in chemistry?





Journal of Chemical Education **2020**, 97(6), 1536–1542.

National Academies of Sciences, Engineering, and Medicine. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press, **2000**.

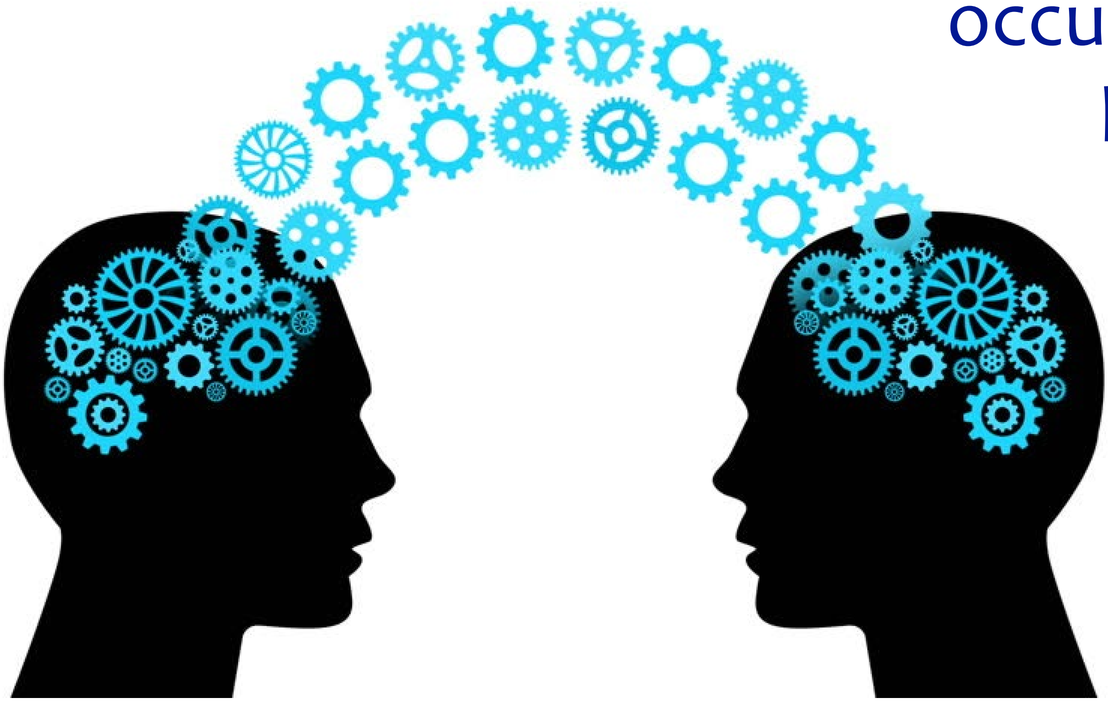
Johnstone, A. H. Why is science difficult to learn? Things are seldom what they seem. *Journal of Computer Assisted Learning* **1991**, 7(2), 75–83.

Learner knowledge construction and engagement should parallel such in the discipline.

- active learning in chemistry involves higher levels of engagement with:
  - direct experiences of chemical phenomena
  - scientific data providing evidence about chemical phenomena
  - models that serve as representations of phenomena
  - chemistry-specific practices that guide interpretation of observations, analysis of data, and construction and application of models

Lombardi, D.; Shipley, T. F. The curious construct of active learning. *Psychological Science in the Public Interest* **2021**, 22(1), 8–43.

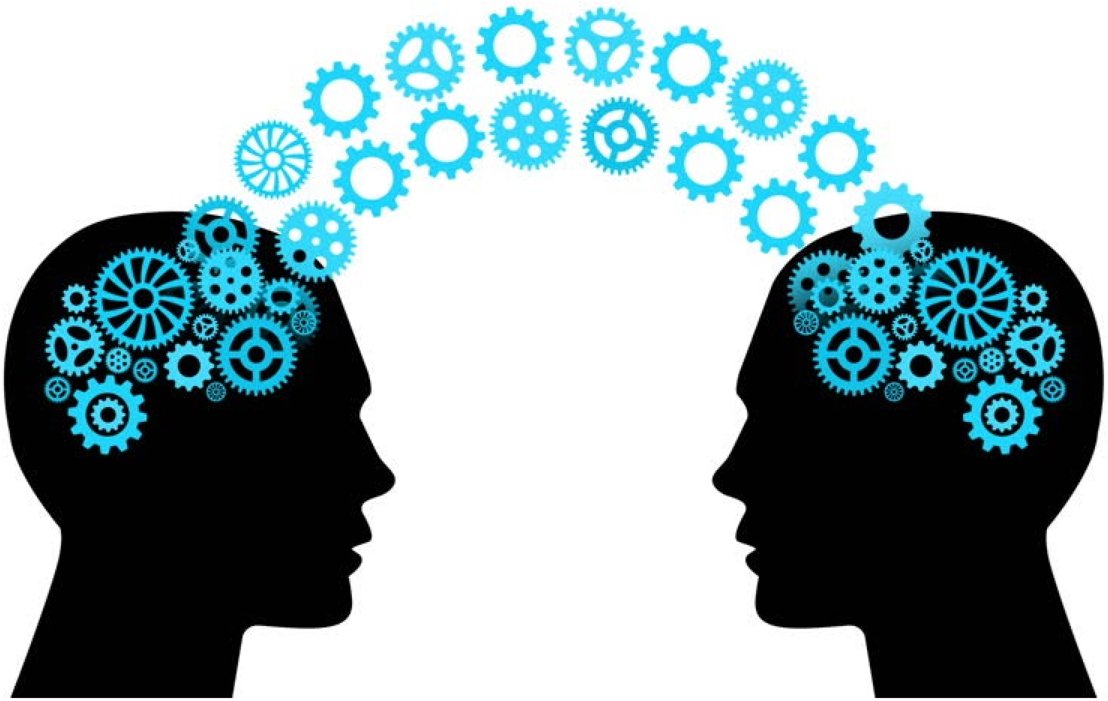
Learning is *social*.



Knowledge construction occurs in, and is shaped by, social contexts.

National Academies of Sciences, Engineering, and Medicine. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press, **2000**.

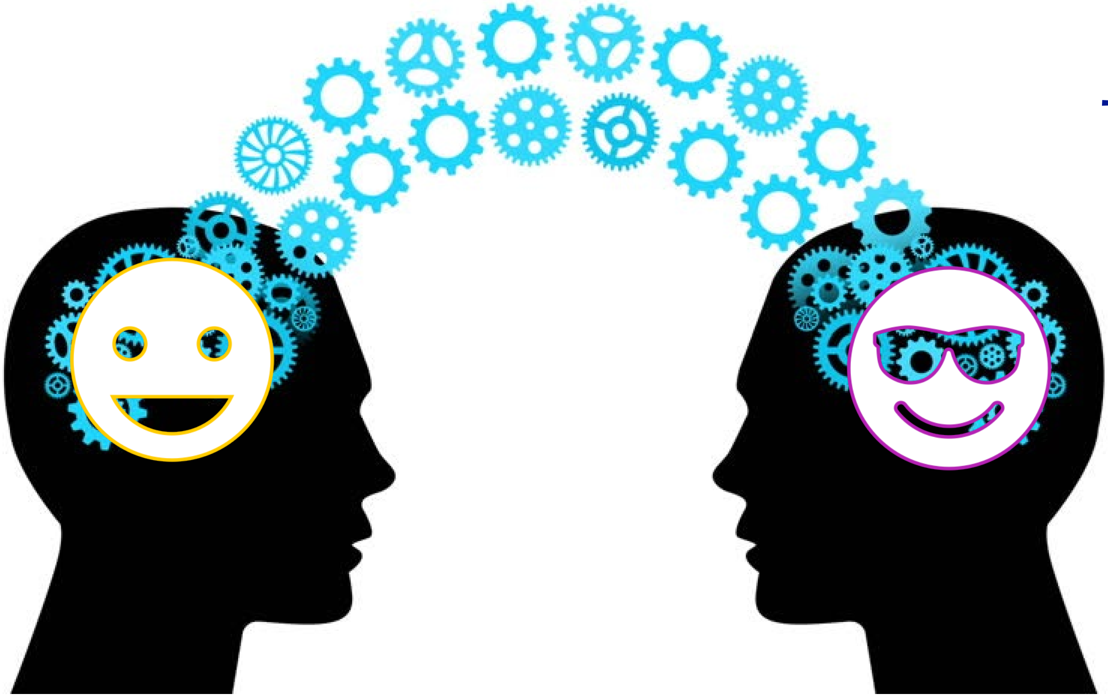
Learning is *social*.



Social-behavioral engagement involves participation in learning activities with classmates.

Sinatra, G. M.; Heddy, B. C.; Lombardi, D. The challenges of defining and measuring student engagement in science. *Educational Psychologist* **2015**, *50*(1), 1–13.

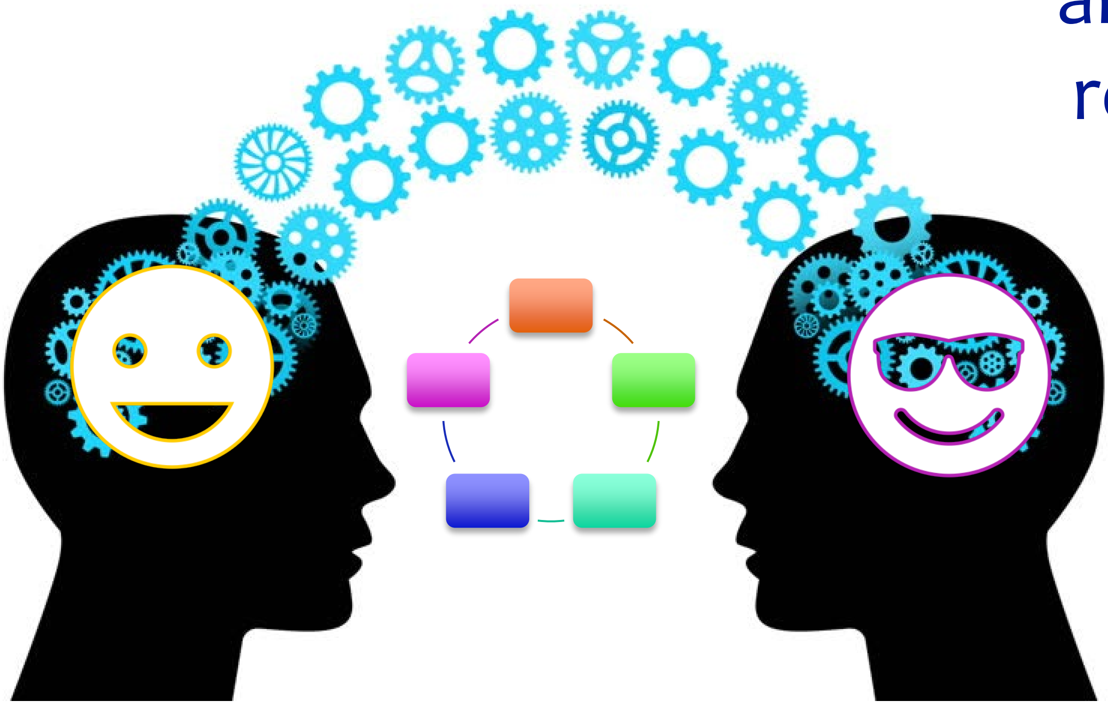
Learning is *emotional*.



Emotional engagement involves positive feelings, a sense of belonging, and perceptions of learning tasks as valuable.

Sinatra, G. M.; Heddy, B. C.; Lombardi, D. The challenges of defining and measuring student engagement in science. *Educational Psychologist* **2015**, *50*(1), 1–13.

Learning is *agentic*.



Learner recognize and implement their role as constructors of knowledge for both themselves and their peers.

Sinatra, G. M.; Heddy, B. C.; Lombardi, D. The challenges of defining and measuring student engagement in science. *Educational Psychologist* **2015**, *50*(1), 1–13.

For our NFW work, we will define *active learning* as…

- a classroom situation in which the instruction and instructional activities explicitly afford students *agency* in learning and sensemaking
- to be an *agent* is to intentionally make things happen by one's actions
  - intentionality
  - forethought
  - self-reactiveness
  - self-reflectiveness

How do we make this happen in a chemistry classroom?

Bandura, A. Social cognitive theory: An agentic perspective. *Annual Review of Psychology* **2001**, 52(1), 1–26.

Supporting agency in the chemistry classroom.

- intentionality
  - guide students in seeing how learning activities related to course assessment goals
- forethought
  - help students in setting goals for learning activities
- self-reactiveness
  - support students in class to achieve goals
- self-reflectiveness
  - permit students to reflect on their learning

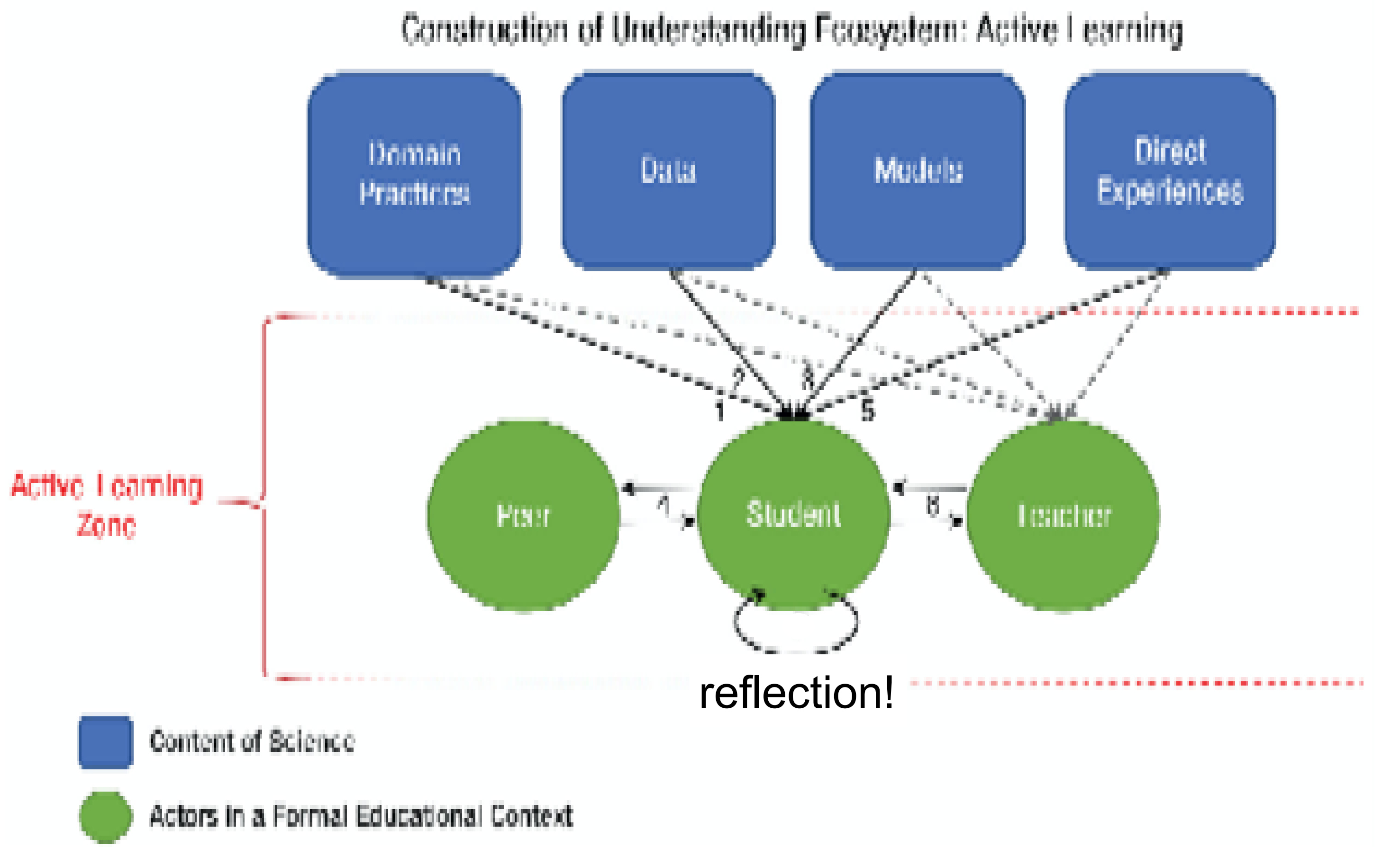
Bandura, A. Social cognitive theory: An agentic perspective. *Annual Review of Psychology* **2001**, 52(1), 1–26.

Remember!
Social engagement in learning is important.

- some noteworthy examples
  - peer-led team learning (PLTL)
  - flipped classrooms
  - think-pair-share
  - peer instruction
  - interactive lecture demonstrations
  - concept mapping

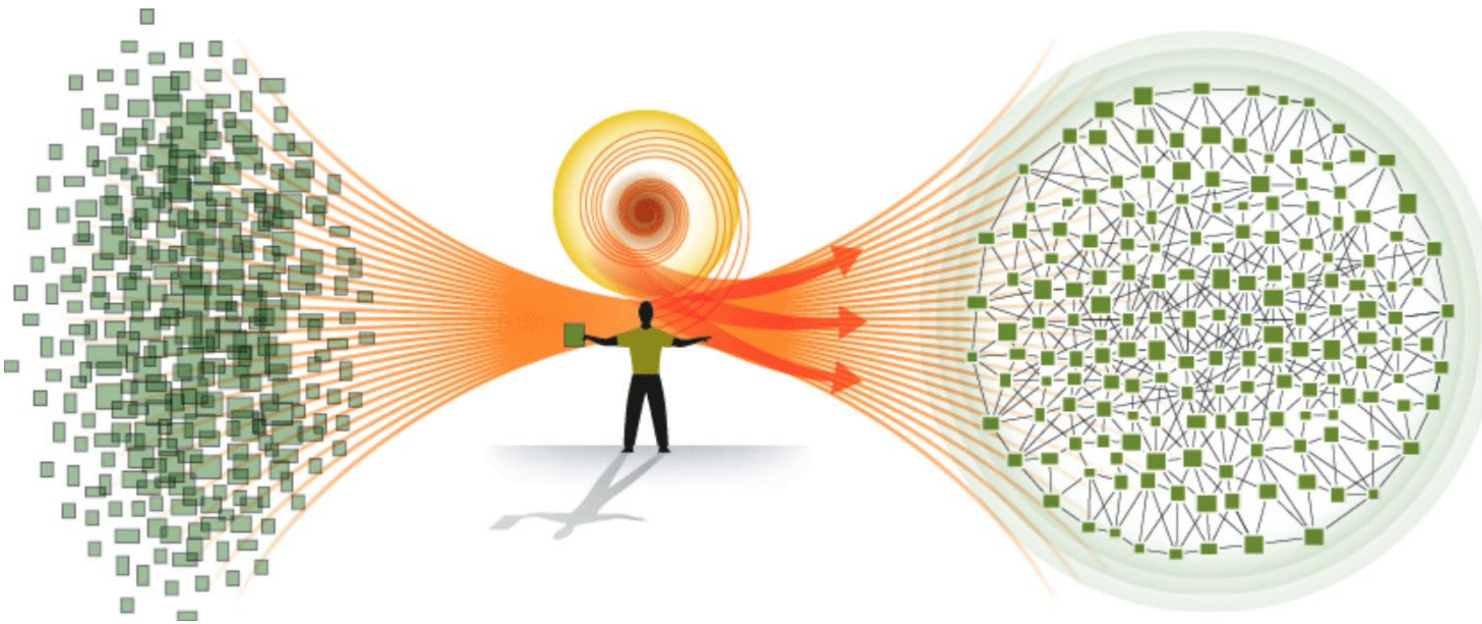
Research on these various collaborative approaches has generally shown improvements in learning.

A roadmap for active learning activities: *Construction of Understanding Ecosystem*



Lombardi, D.; Shipley, T. F. The curious construct of active learning. *Psychological Science in the Public Interest* **2021**, 22(1), 8–43.

Instructor guidance and scaffolding are critical for making knowledge construction more effective.



- expert knowledge is organized, contextualized and useful
- novice knowledge is relatively disorganized, dynamic, and useful in *scaffolded* situations

National Academies of Sciences, Engineering, and Medicine. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press, **2000**.

Let's reflect a bit!

- In your breakout rooms, open the Google Document assigned to your group number.
- Discuss and record your thoughts about:
  - In what ways has your understanding of active learning changed over the last 45 minutes?
  - What ideas remain unclear?
  - What questions do you have?

Lecturing "versus" active learning

- there is no active/passive dichotomy in learning
- we prefer a continuum to describe the classroom:

lecturing

focusing on using knowledge to DO things (predict/explain/ model/interpret data)

"people also learn by observing . . . others' behavior, attitudes, or emotional expressions, with or without actually imitating the behavior or skill"

construction of understanding activities

National Academies of Sciences, Engineering, and Medicine. *How people learn II: Learners, contexts, and cultures*. The National Academies Press, **2018**.

Smith, M. K.; Wood, W. B.; Krauter, K.; Knight, J. K. Combining peer discussion with instructor explanation increases student learning from in-class concept questions. *CBE—Life Sciences Education* **2011**, *10*(1), 55–63.

Indirect benefit of actively involving peers.

- active-learning strategies can result in more equitable outcomes for underrepresented biology students

  Haak, D. C.; HilleRisLambers, J.; Pitre, E.; Freeman, S. *Science* **2011**, *332*(6034), 1213–1216.

  Eddy, S. L.; Hogan, K. A. *CBE—Life Sciences Education* **2014**, *13*(3), 453–468.

  Ballen, C. J.; Wieman, C.; Salehi, S.; Searle, J. B.; Zamudio, K. R. *CBE—Life Sciences Education* **2017**, *16*(4), Article 56.

- K–12 project-based curricula can promote equitable outcomes among underrepresented minority groups

  Geier, R.; Blumenfeld, P. C.; Marx, R. W.; Krajcik, J. S.; Fishman, B.; Soloway, E;, Clay-Chambers, J. *Journal of Research in Science Teaching* **2008**, *45*(8), 922–939.

- when peers are from marginalized groups, other disempowered students can see themselves as part of the discipline

We'll discuss equity and inclusion in teaching and learning in just a bit!

For when you are preparing your *teaching tidbit…*

- choose a piece of content that is appropriate for a construction-of-understanding activity
  - your learning objective should be for students to DO something with the content, rather than just have it

develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy	*vs.*	calculate an enthalpy change for a reaction using the following equation: $\Delta_r H^\circ = H^\circ(\text{products}) - H^\circ(\text{reactants})$
This is chemistry.		*This is math.*

Resources available for preparing your *teaching tidbit…*

Teaching Tidbit

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Construction of Understanding Activity Worksheet

1. What piece of content do you want to use for your teaching tidbit?
2. State this content in terms of a learning objective that outlines what a student should be able to *do* with their knowledge.
3. In what ways is this piece of content appropriate for a construction-of-understanding activity? (Note: if it's not, you probably should choose another piece of content.)
   a. Are there chemical phenomena that can be explored with the ideas underpinning this content?
   b. Can data or observations be provided to illustrate/represent the phenomenon? Can these data or observations be interpreted via a model that is central to the content?
   c. Can general scientific or chemistry-specific practices be used to guide interpretation of observations, analysis of data, and construction and application of models?
      i. causal/mechanistic reasoning that describes both why and how phenomena occur
      ii. relating atomic and molecular structure to observable properties
      iii. discussing stability and change in terms of energy
      iv. connecting macroscopic observations with nanoscale particle behavior
4. How do you plan to scaffold (*i.e.*, break the activity up into manageable steps) so that students have all the appropriate resources to complete the activity and construct an understanding of the content?
5. How do you plan to empower students to work collaboratively? Will one of the "standard" collaborative models work (see accompanying resource)? Or does the content require something different?
6. How will the activity incorporate opportunities for students to reflect on their learning?
7. All in all, how does your activity afford students agency in their learning and sensemaking?

Teaching Tidbit

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Scaffolding Student Engagement with Scientific Practices

Analyzing and Interpreting Data

- learning activity poses a scientific question, claim, or hypothesis to be investigated
- an early prompt provides a representation of the data (*e.g.*, table or graph, or list of observations) provided to answer the question or test the claim or hypothesis, and asks students to make meaning of the data representation
- later prompts provide an analysis of the data or support students in analyzing the data using a particular chemistry specific lens or practice
- final prompts support students in interpreting the results or assessing the validity of the conclusions in the context of the scientific question, claim, or hypothesis

Asking Questions

- learning activity provides an event, observation, phenomenon, data, scenario, or model
- prompts support students in developing an empirically testable question about the given event, observation, phenomenon, data, scenario, or model

Constructing Explanations and Engaging in Argument from Evidence

- learning activity gives an event, observation, or phenomenon
- early prompts support students in making a claim based on the given event, observation, or phenomenon
- subsequent prompts support students in identifying scientific principles or evidence (in the form of data or observations) to support the claim
- final prompts support students in providing reasoning about why the scientific principles or evidence support the claim

Developing and Using Models

- learning activity gives an event, observation, or phenomenon for the student to explain or make a prediction about
- early prompts provide a representation and ask students to make meaning of the representation, or support students in constructing a representation
- subsequent prompts support students in explaining or making a prediction about the event, observation, or phenomenon
- final prompts support students in providing chemically sound reasoning that links the representation to their explanation or prediction

This resource was adapted from:
PLOS ONE **2016**, *11* (9), e0162333. DOI: 10.1371/journal.pone.0162333

Active learning is a classroom situation in which the instruction and instructional activities explicitly afford students *agency* in learning and sensemaking.