Cottrell Scholars Collaborative
New Faculty Workshops in Chemistry

Assessment: Measuring Learning

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ACS Chemistry for Life®

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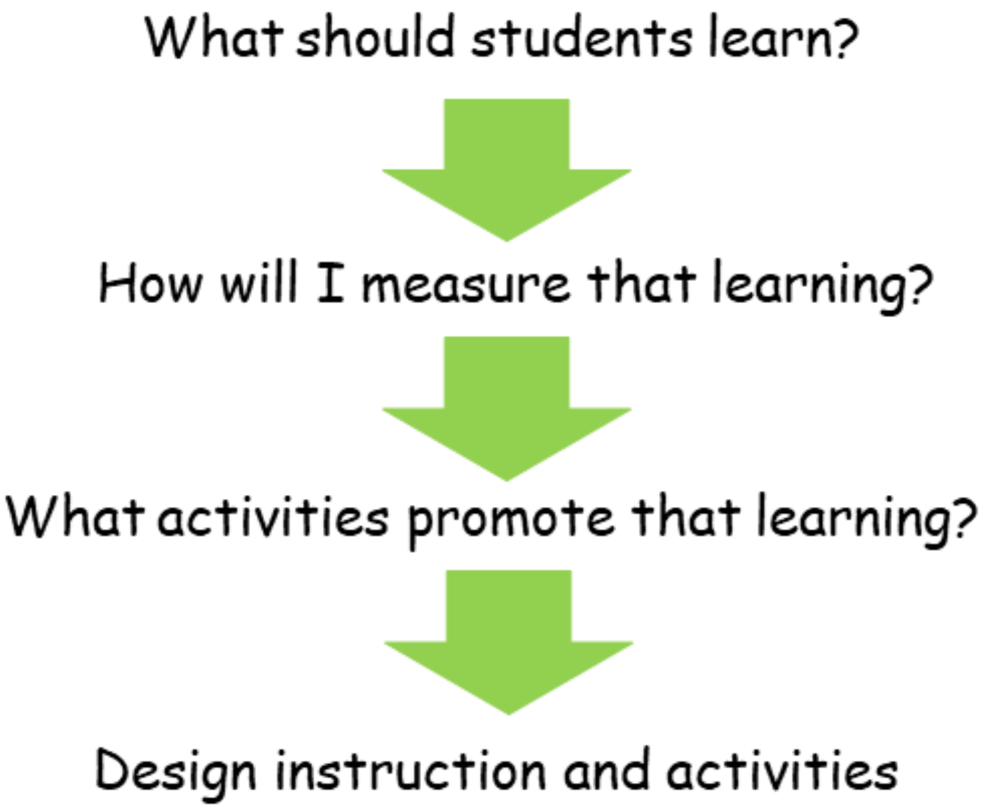
Integrating Discovery and Education to Advance Science

You've likely heard these words before…

- **formative**
  - implemented during the learning process
- **summative**
  - for evaluation and are at the end of the learning experience
  - graded exams, quizzes, laboratory reports, etc.

- **the lines between these two types are very blurry**
- **assessment isn't solely useful for evaluation**

Assessment is critical for design and learning.



Consider what you should students be able to do with their knowledge.

How can you support students in attaining that goal?

image: http://www.celt.iastate.edu/

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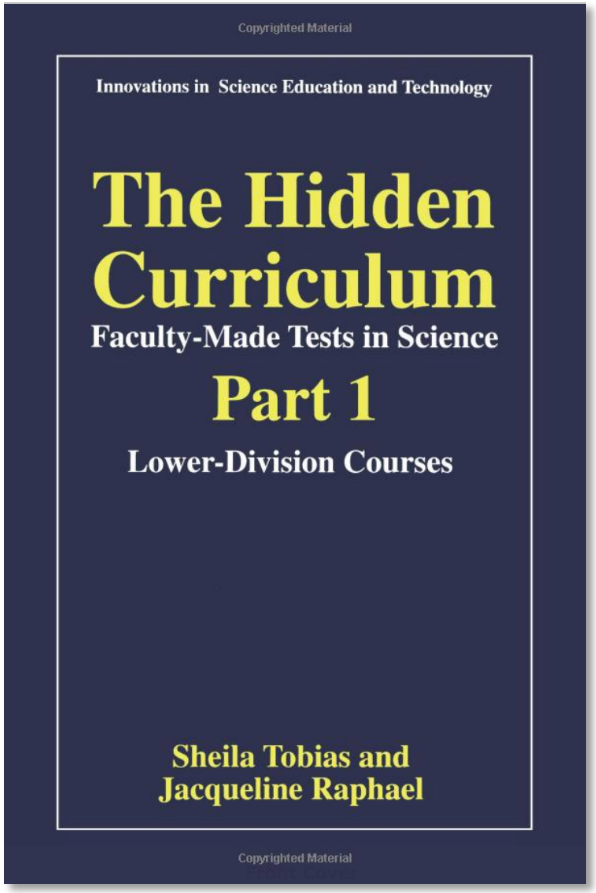
Assessment

- *The Hidden Curriculum*

- assessments transmit our *learning agenda* to our students; they are "a latent curriculum"

- if assessments are not aligned with learning goals, then efforts at effective instruction are ignored by the learners for whom they are intended



Tobias, S. & Raphael, J. (1995) *Journal of College Science Teaching*, 24(4), 240-244.

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Assessment

We should be teaching students how to think; instead we are primarily teaching them what to think. This misdirection of effort in education is the inevitable consequence of an overemphasis on objectively measurable outcomes. In brief, we are more concerned with what answers are given than with how they are produced.

(Lochhead & Clement, 1979)

Lochhead, J. & Clement, J., Eds. (1979). *Cognitive Process Instruction: Research on Teaching Thinking Skills. Philadelphia, PA: Franklin Institute Press.*

Consider this learning objective

- be able to recognize a one-cent ($0.01) coin from the United States of America

Please go to menti.com!

Were you expecting something different?

Were you expecting this?

A

C

B

D

Your students might be expecting this…

A

C

B

D

Managing Expectations

- Much of assessment is managing expectations.
  - those which you have of your students and those which your students have of you
- Consider assessment as a *contract*, of sorts.
  - This can help to build *trust*.

"Students who believe that their teachers want them to succeed and design assignments that will help them succeed will work harder and persevere longer than students who see their teachers as indifferent or trying to 'weed them out.'"

Chew, S. L.. and Cerbin, W. J. Teaching and Learning: Lost in a Buzzword Wasteland. https://www.insidehighered.com/views/2017/12/05/need-theory-learning-opinion

How is student learning assessed?

- How is ***research*** assessed?

research goal:
indication of what is the outcome for the research (*e.g.*, NIH Specific Aims)

research performance:
What will the researcher do (*i.e.*, perform) that permits the observation of those research outcomes?

evidence of research success:
specification of <u>evidence</u> that researchers have accomplished a specific aim or objective

How is student learning assessed?

- Assessing ***learning*** isn't much different.

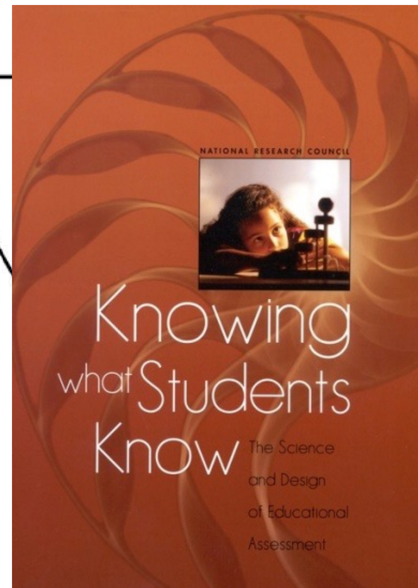
learning goal:
the intended outcome for student learning—can (and should!) include content, practices, and concepts

learning performance:
What will the student do (*i.e.*, perform) that permits the observation of the learning? This is connected to a specific *task* that is provided to students.

evidence of learning:
the acceptable <u>evidence</u> that students have learned a specific piece of content—the evidence is obtained through observations students and their work on tasks derived from learning performances

Assessment as an Evidence-Based Argument

observation:
tasks or situations that prompt students to say, do, or create something that demonstrates important chemistry knowledge and/or skills



interpretation:
how observations constitute evidence about the chemistry knowledge and skills being assessed

cognition: how students represent knowledge and develop competence in chemistry

National Research Council. *Knowing What Students Know*; The National Academies Press: Washington, D.C., 2001.

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Cognition: Learning is an active process

Students are not blank slates.

The National Research Council. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press: Washington, DC, 2000.

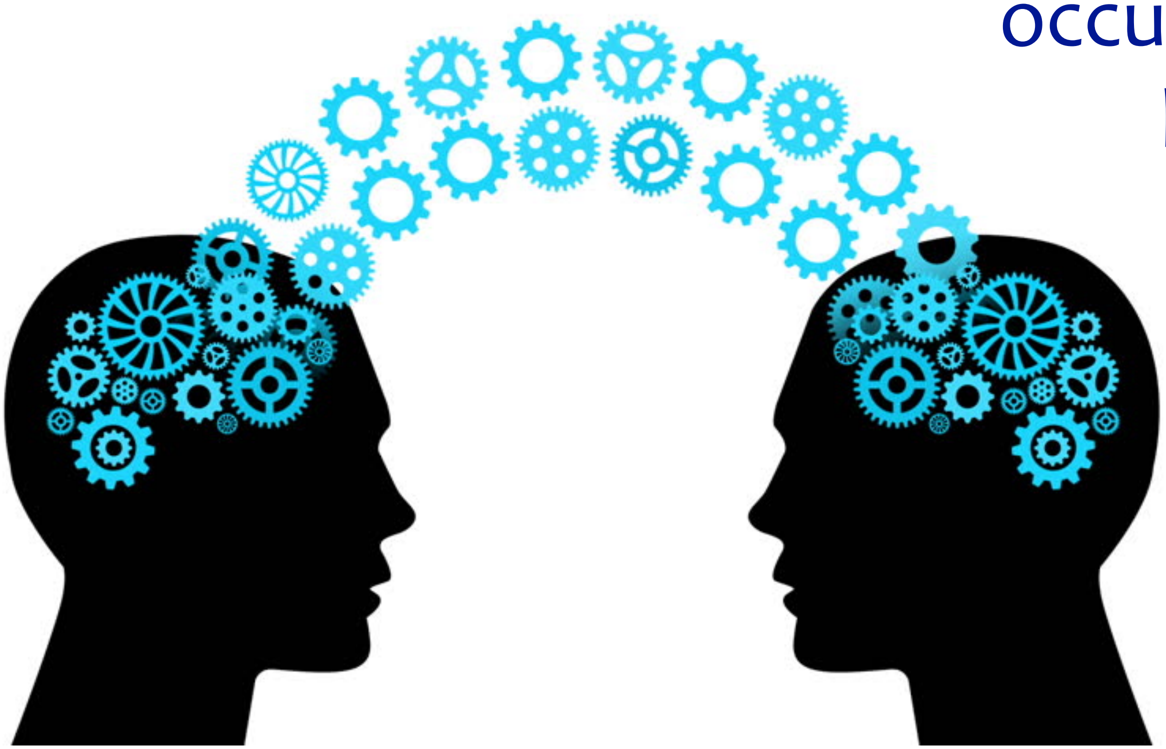
Cognition: Learning is an active process

Knowledge is constructed in the mind of the learner.

The National Research Council. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press: Washington, DC, 2000.

Cognition: Learning is an active process

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



The National Research Council. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press: Washington, DC, 2000.

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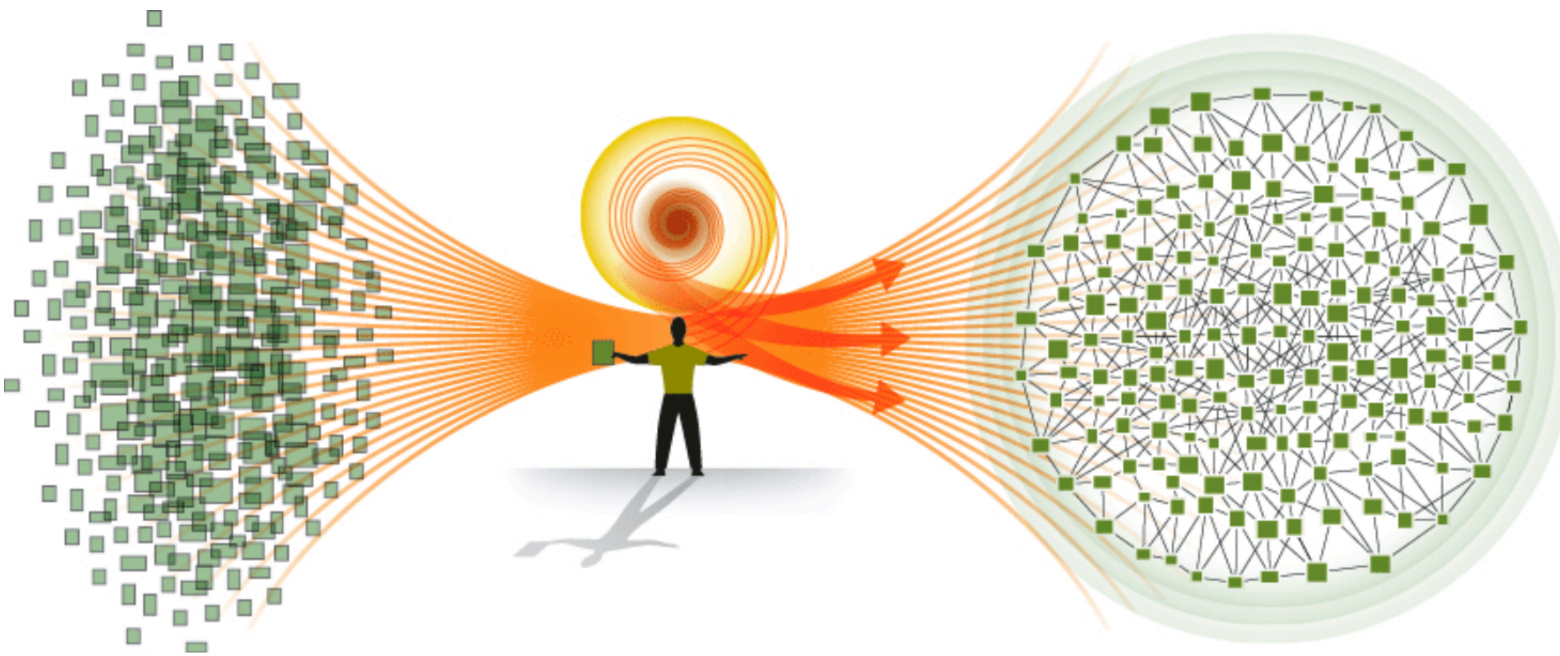
Cognition: Learning is an active process

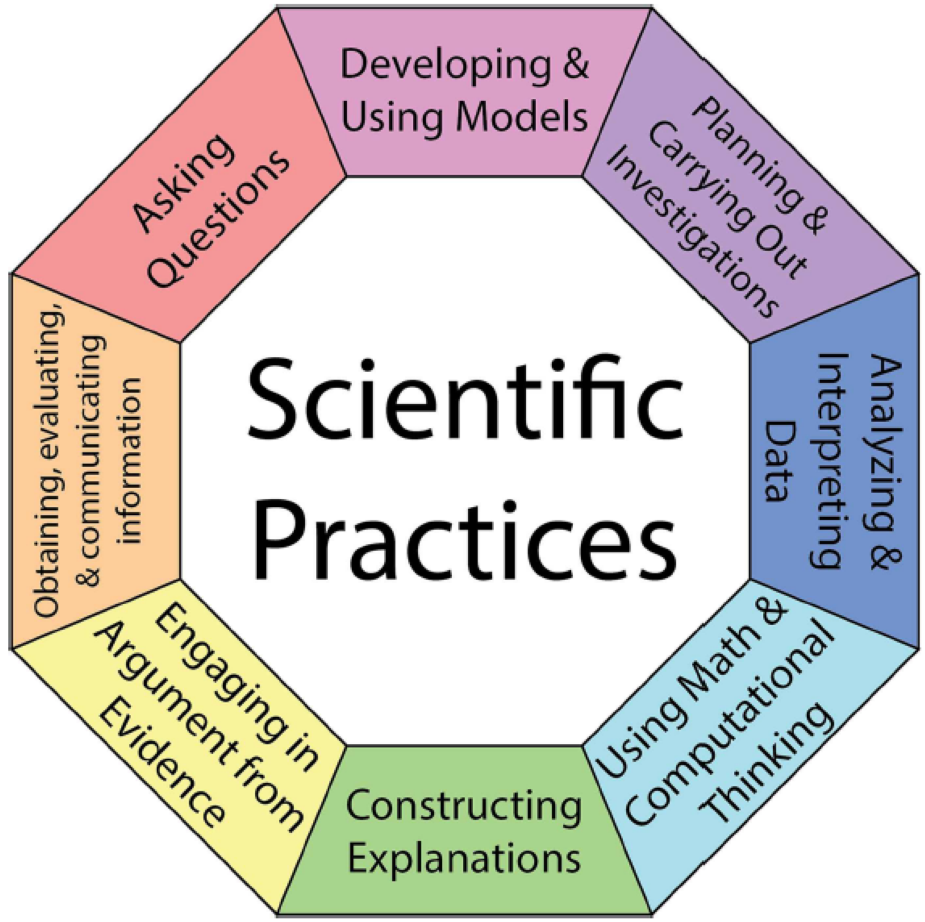


Expert knowledge is organized, contextualized and useful; novice knowledge is relatively disorganized, dynamic, and useful in scaffolded situations.

The National Research Council. *How People Learn: Brain, Mind, Experience, and School: Expanded ed.*, 2nd ed.; National Academies Press: Washington, DC, 2000.

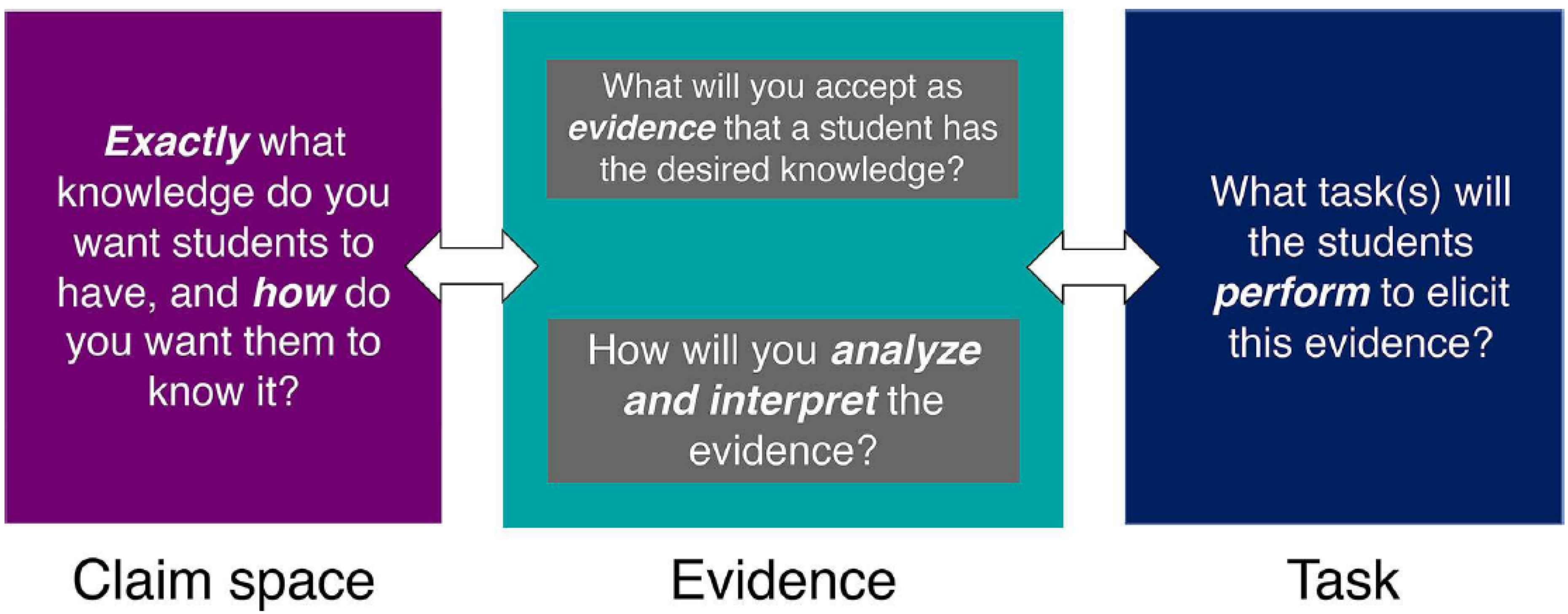
Observation: Designing Learning Tasks

- Think about what you your students to ***do*** with their knowledge.
- consider scaffolding
  - what skills must students posses?
  - what tasks will effectively permit students to engage in the practices?



National Research Council. *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*; The National Academies Press: Washington, D.C., 2012.

Evidence-Centered Design



R. J. Mislevy, G. D. Haertel, Implications for Evidence-Centered Design for Educational Testing. *Educ. Meas-Issues Pra.* **2006**, 25, 6–20.

What happened with this assessment task?

Exactly what knowledge do you want students to have, and ***how*** do you want them to know it?

Claim space

What will you accept as ***evidence*** that a student has the desired knowledge?

How will you ***analyze and interpret*** the evidence?

Evidence

What task(s) will the students ***perform*** to elicit this evidence?

Task

Think–Pair

Be able to recognize a one-cent ($0.01) coin from the United States of America.

What can we change?

Exactly what knowledge do you want students to have, and ***how*** do you want them to know it?

Claim space

What will you accept as ***evidence*** that a student has the desired knowledge?

How will you ***analyze and interpret*** the evidence?

Evidence

What task(s) will the students ***perform*** to elicit this evidence?

Task

SHARE!

Be able to recognize a one-cent ($0.01) coin from the United States of America.

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Enough coins… here's some chemistry!

Learning Performance

Using appropriate representations, explain why the structure of a substance give rise to its observed physical properties.

1. The normal boiling point of 2-propanol, $(CH_3)_2CHOH$, is 83 °C, while that of acetone, $(CH_3)_2C{=}O$, is 56 °C. What is the principal reason for the greater boiling point of 2-propanol?

A. The O-H bond in 2-propanol is stronger than the C-H bonds in acetone.
B. 2-Propanol experiences greater London dispersion forces than acetone.
C. 2-Propanol experiences stronger dipole-dipole interactions than acetone.
D. 2-Propanol experiences stronger hydrogen bonding than acetone.*

Stowe, R. L., Cooper, M. M. Assessment in Chemistry Education. *Isr. J. Chem.* **2019**, *59*, 1–11.

Does this task elicit adequate evidence?

Learning Performance

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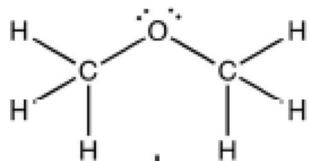
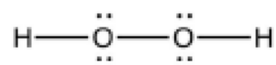
Demand evidence of understanding!

4. One of the two compounds listed below is a liquid at room temperature. **Choose this compound**, the **evidence** that informed your prediction, and the **reasoning** that links your prediction to the evidence you selected.

Compound:



I.



II.

Evidence:

III. Compound I is heavier than compound II.
IV. Compound I has more hydrogens and can form more hydrogen bonds than II.
V. Compound II has both hydrogens and oxygens capable of hydrogen bonding.

Reasoning:

VI. Heavier molecules are more likely to cluster together and form liquids because they are attracted to each other strongly by London dispersion forces.
VII. Molecules capable of hydrogen bonding are strongly attracted to each other and tend to cluster together to form liquids.

A. I, III, VI
B. I, IV, VII
C. II, V, VII*
D. Not enough information

Stowe, R. L., Cooper, M. M. Assessment in Chemistry Education. *Isr. J. Chem.* **2019**, *59*, 1–11.

Constructed Response Items

- Consider including directions about what you want students to do with their knowledge!

Consider the acid ionization reaction of carbonic acid (H_2CO_3), which has a pK_a of 6.4:

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

1. What is the condition for chemical equilibrium at the molecular level?
2. Using what you know about chemical equilibria and **reaction rates**, explain why adding sodium bicarbonate ($NaHCO_3$) shifts equilibrium to the left, favoring reactants. Your answer should include discussion of what is happening at the molecular level to control the relevant reaction rates. (Note: Restating Le Châtelier's principle does not answer this question)

Selected Response Items

- Items can still elicit evidence of student understanding!

Consider the acid ionization reaction of carbonic acid (H_2CO_3), which has a pK_a of 6.4:

$$H_2CO_3(aq) + H_2O(l) \rightleftharpoons HCO_3^-(aq) + H_3O^+(aq)$$

How would the composition of the system change as it returns to equilibrium following the addition of sodium bicarbonate ($NaHCO_3$)?

I. The concentration of H_2CO_3 would increase and the concentrations of HCO_3^- and H_3O^+ would decrease.
II. The concentration of H_2CO_3 would decrease and the concentrations of HCO_3^- and H_3O^+ would increase.
III. There will be no change.

Why?

IV. The reaction shifts to the left.
V. The reaction shifts to the right.
VI. More collisions between the reactants will decrease the rate of the forward reaction.
VII. More collisions between the products will increase the rate of the reverse reaction.

A. I and IV   B. I and VII*   C. II and IV   D. II and VI   E. I and VI

Assessment: An Evidentiary Argument

<u>for the instructor</u>

- grading information (a basis of a claim that the student does, or does not, know things)
- information on how well a learning experience is performing

<u>Assessment</u>

Using an **observation** that we **interpret** in a standardized way to provide **evidence** for a **claim** about what students are thinking with respect to chemistry.

<u>for the student</u>

- demonstration (evidence) of learning
- feedback on whether things have been learned
- feedback on performance to understand outcome (grade)
- guidance on what to do differently (correction / validation)

Deploying Assessments

- five key strategies
  - clarify learning and performance expectations
  - elicit evidence of student understanding
  - provide feedback to learners
  - facilitate peer learning
  - promote student ownership of learning
- most learning activities can accomplish one or more

Black, P., William, D. Developing a theory of formative assessment. *Educ. Asse. Eval. Acc.* **2009,** *21*, 5–31.

Deploying Assessments

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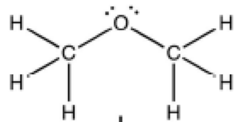

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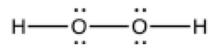

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A. I, III, VI
B. I, IV, VII
C. II, V, VII*
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Learning Performance

Using appropriate representations, explain why the structure of a substance give rise to its observed physical properties.

– clarify expectations
– elicit evidence of student understanding
– provide feedback
– facilitate peer learning (?)
– promote student ownership of learning (?)

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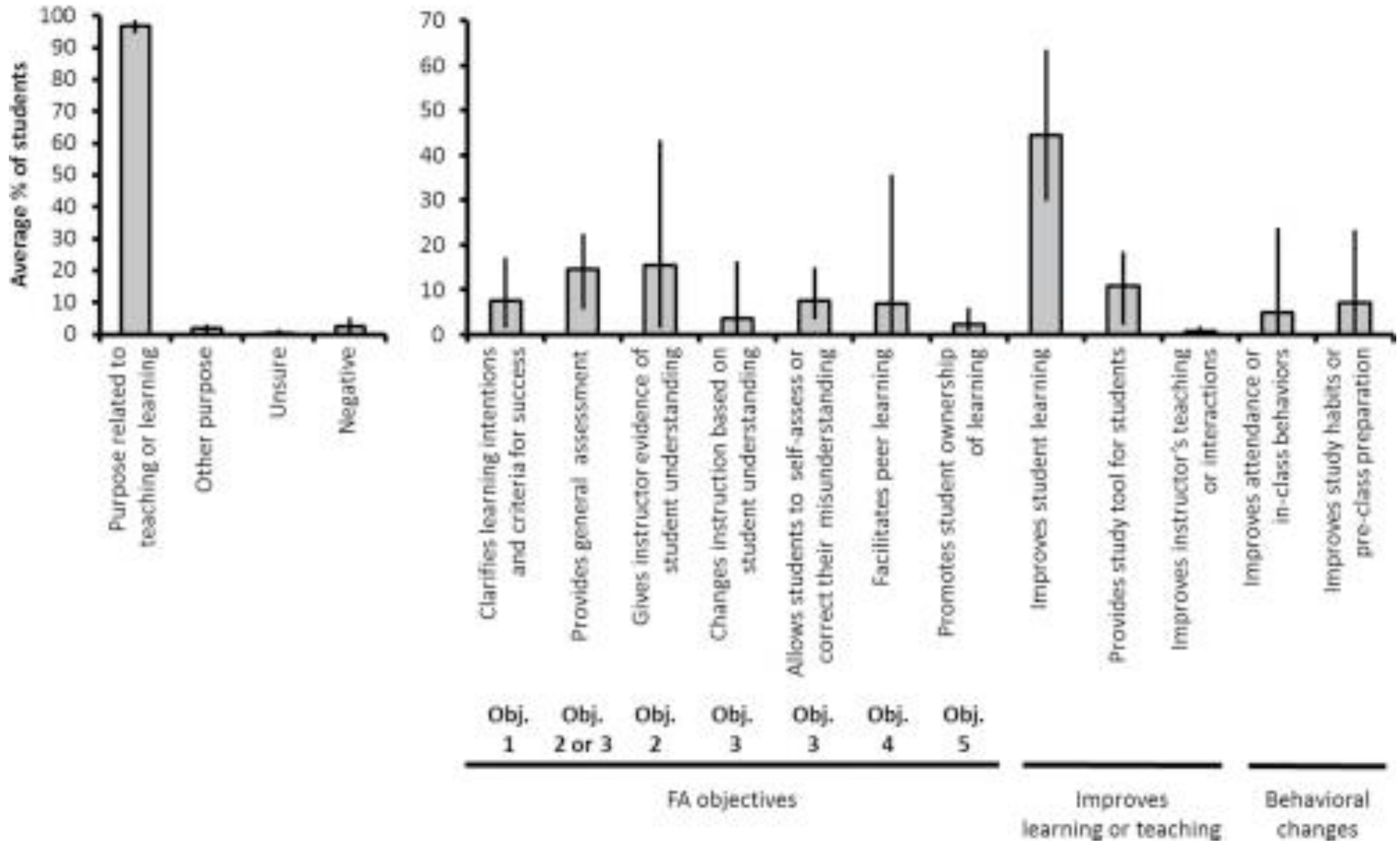
“Why is your instructor doing this?”



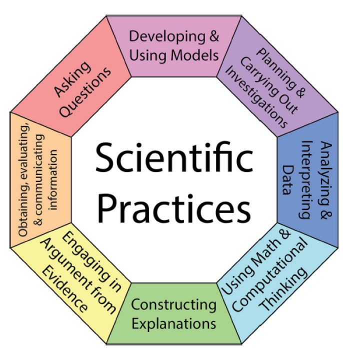
Brazeal, K. R., Brown, T. L., Couch, B. A. Characterizing students perceptions of buy-in toward common formative assessment techniques. *CBE Life Sci. Educ.* **2016**, *15*(4), ar73.

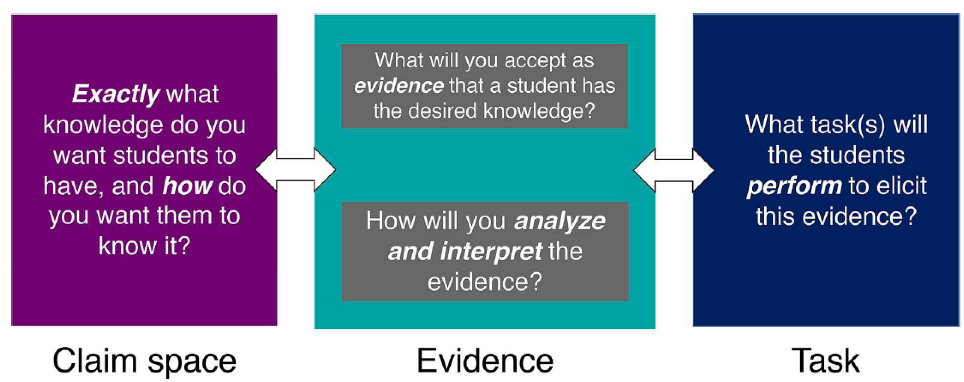
Assessment isn't just "in-class"

timing	formative assessment
pre-class	JiTT
	pre-class online homework assignments
in-class	clicker questions
	in-class activities
post-class	post-class online homework assignments homework assignments or quizzes

Let’s Develop an Assessment Strategy!

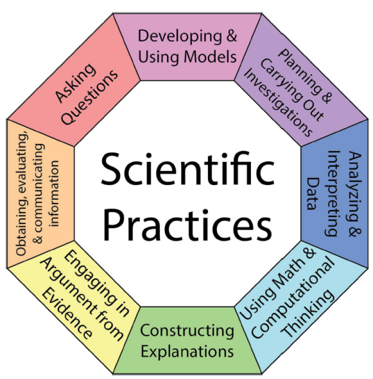
- consider your learning goal(s) from the first session
- Is this stated in such a way as to articulate what you want students to do with their knowledge? If not, do so!
- What skills must students possess in order to engage in tasks related to this learning goal?
- Outline a practice-based task that is meant to elicit evidence of student understanding.
- How would you interpret what students are contributing?

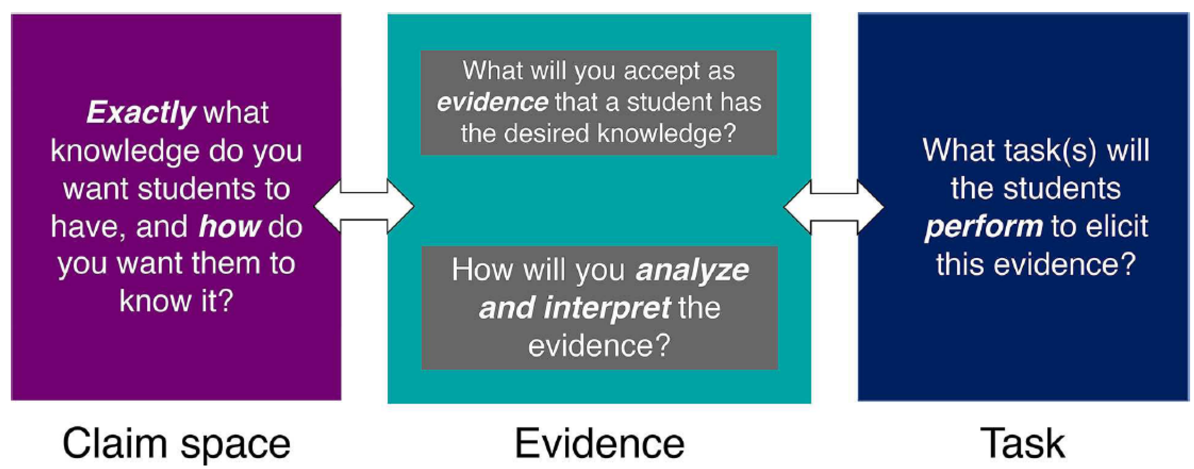




Let’s Develop an Assessment Strategy!

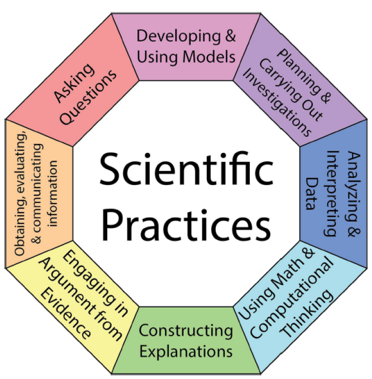
- *learning objective*: draw Lewis structures for compounds of main group elements.
- *learning performance*: provide critiques of a friend’s Lewis structure work based on the number of valence electrons, octet valence electron patterns, formal charge, and the potential need for multiple resonance forms.

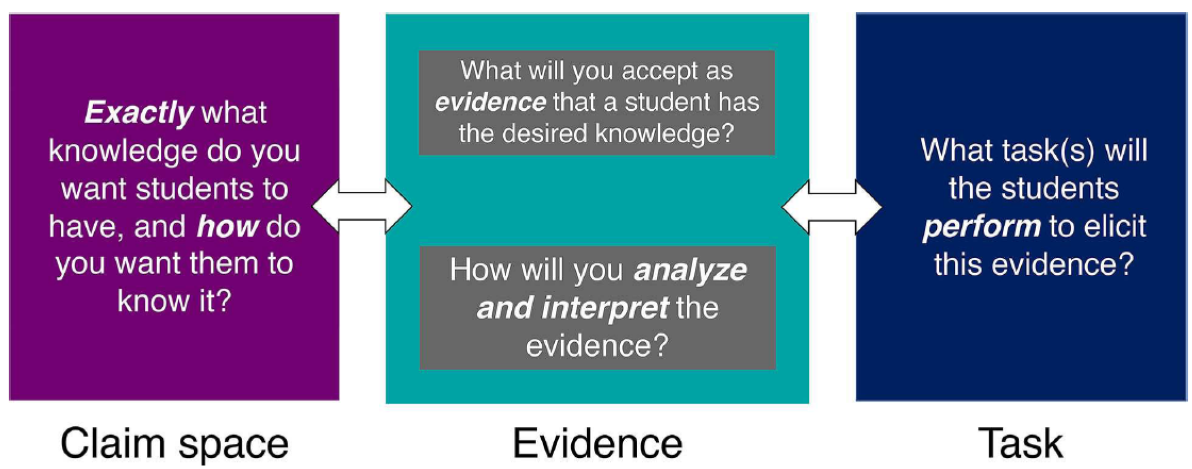




Let’s Develop an Assessment Strategy!

- *assessment strategy*: students receive Lewis structures (preferably from exams from previous semesters), many of which have errors; students instructed to comment on what is good/bad about the structures provided.
- *interpretation*: students should be be using the various Lewis structure criteria when applicable





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Let's Develop an Assessment Strategy!

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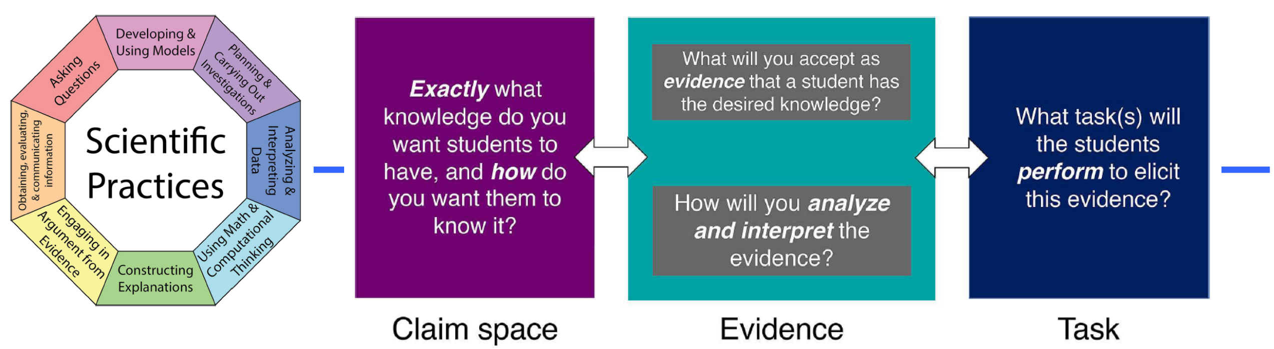

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Next Steps

- Tomorrow, you'll be taking your learning objectives/ performances and creating "active" learning activities.
  - If you have a learning performance rooted in a scientific practice, great! (Almost) any activity you design will be active!
  - If you don't have a learning performance yet, take some time this evening to consider assessment as evidence.
- Tomorrow, you will leverage your assessment strategies to formulate learning activities (both formative assessments and activities that focus on introductory scaffolding).

There are no magic bullets!

critical components of effective practice

- prior knowledge shapes learning
- learning is a process of actively constructing knowledge
- experts organize knowledge and approach problems differently than students
- metacognition can help students learn
- students who can transfer their knowledge to new situations learn more readily
- interactions with others can promote learning

assessment strategies

- clarify learning and performance expectations
- elicit evidence of student understanding
- provide feedback to learners
- facilitate peer learning
- promote student ownership of learning

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Mintzes, J. J. (2019). From Constructivism to Active Learning in College Science. In J. J. Mintzes & E. M. Walter (Eds.), Active Learning in College Science: The Case for Evidence-*Based Practice* (x-x). Place: Springer.

Assessment and diversity

- Assessment can foster inclusive classrooms.
- Assessments provide constructive feedback in a open and welcoming environment, which can encourage students that lack confidence and are intimated by direct criticism.
- Using multiple different assessment methods provides different learning environments for a diverse population of learners.
- Assessment methods can enable students to take responsibility for their learning in their own ways.