FORMATIVE ASSESSMENTS THAT SOLIDIFY STUDENT LEARNING

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Learning Goals

By the end of this session, you will:

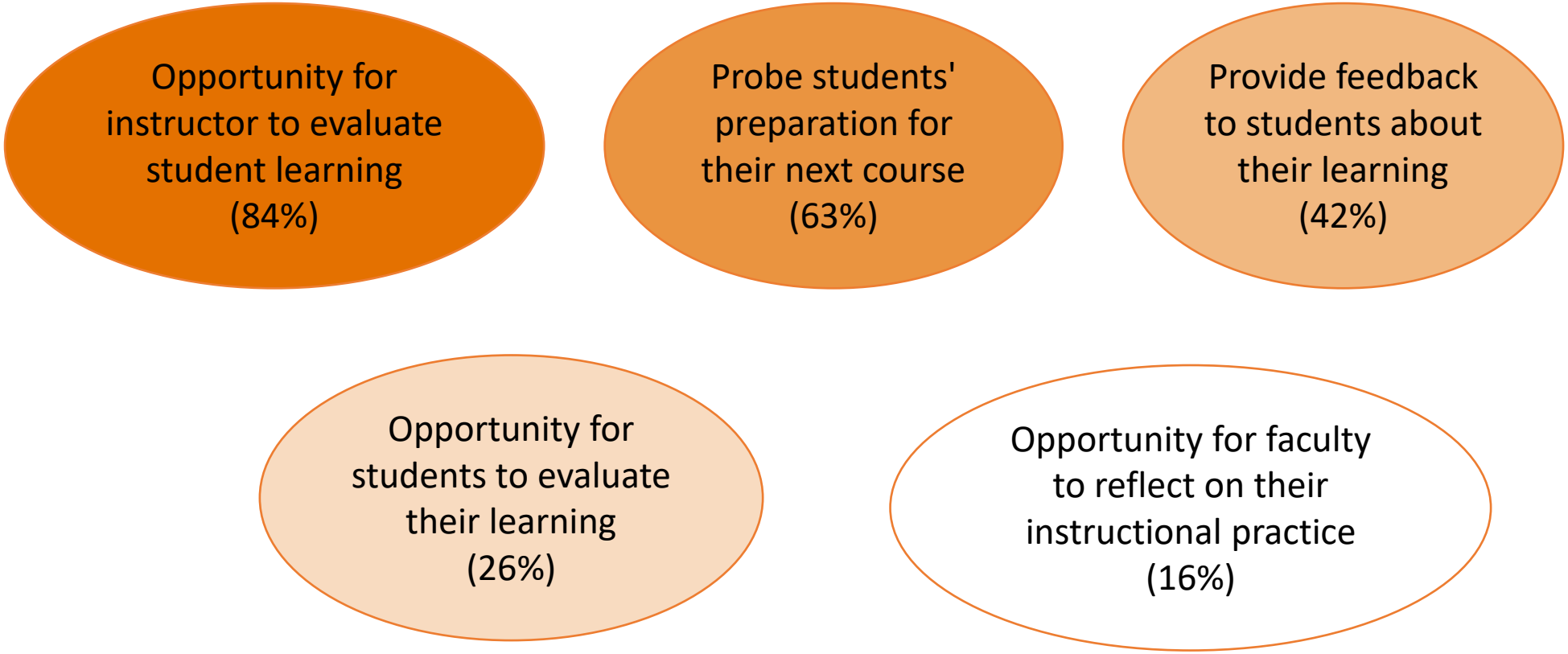
be able to **describe and implement a formative assessment strategy**

be able to **describe the benefits of this strategy** from the students and instructor's perspectives

know where to find resources to help implement this assessment strategy

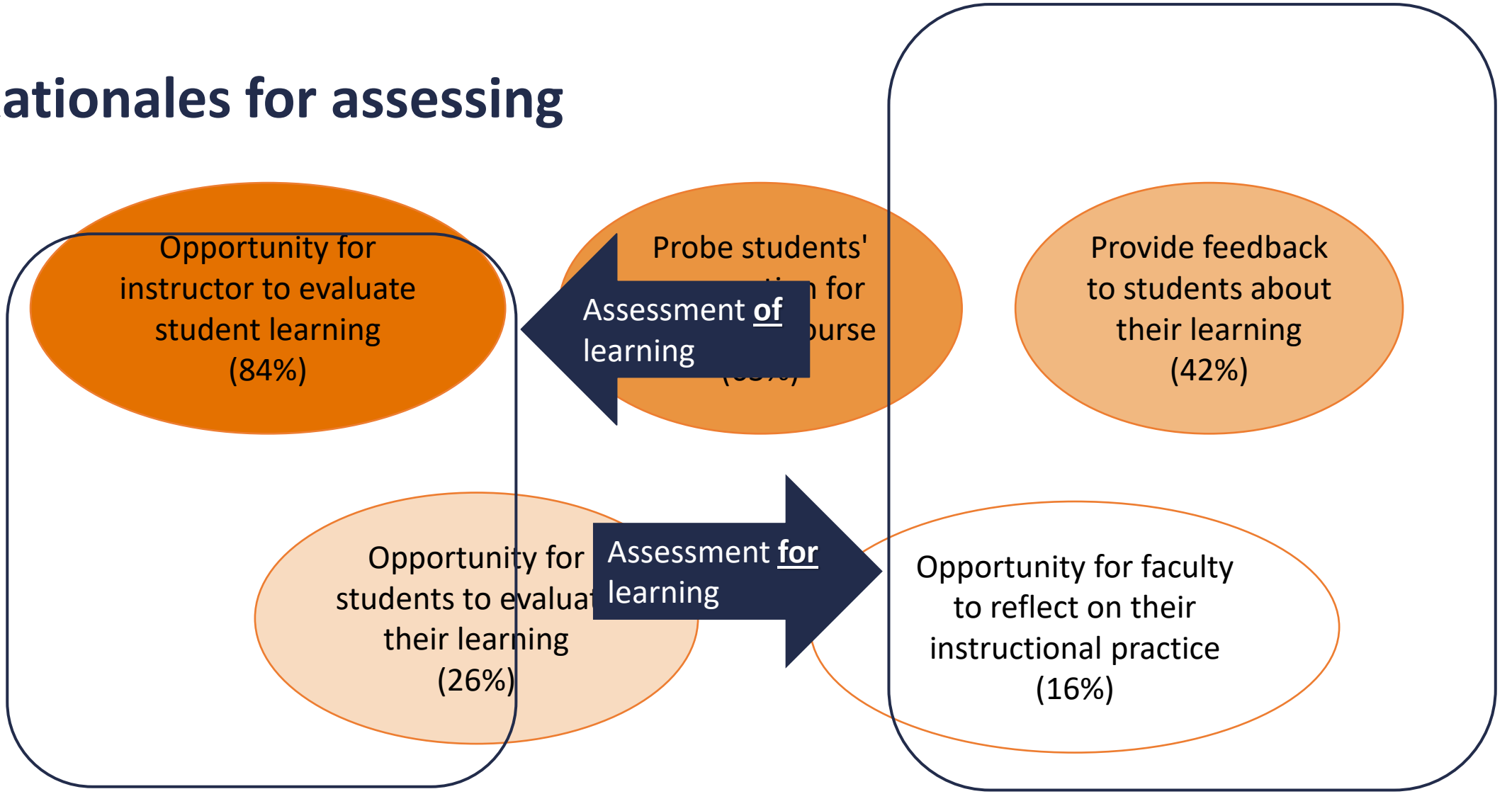
Why do we assess?

Rationales for assessing

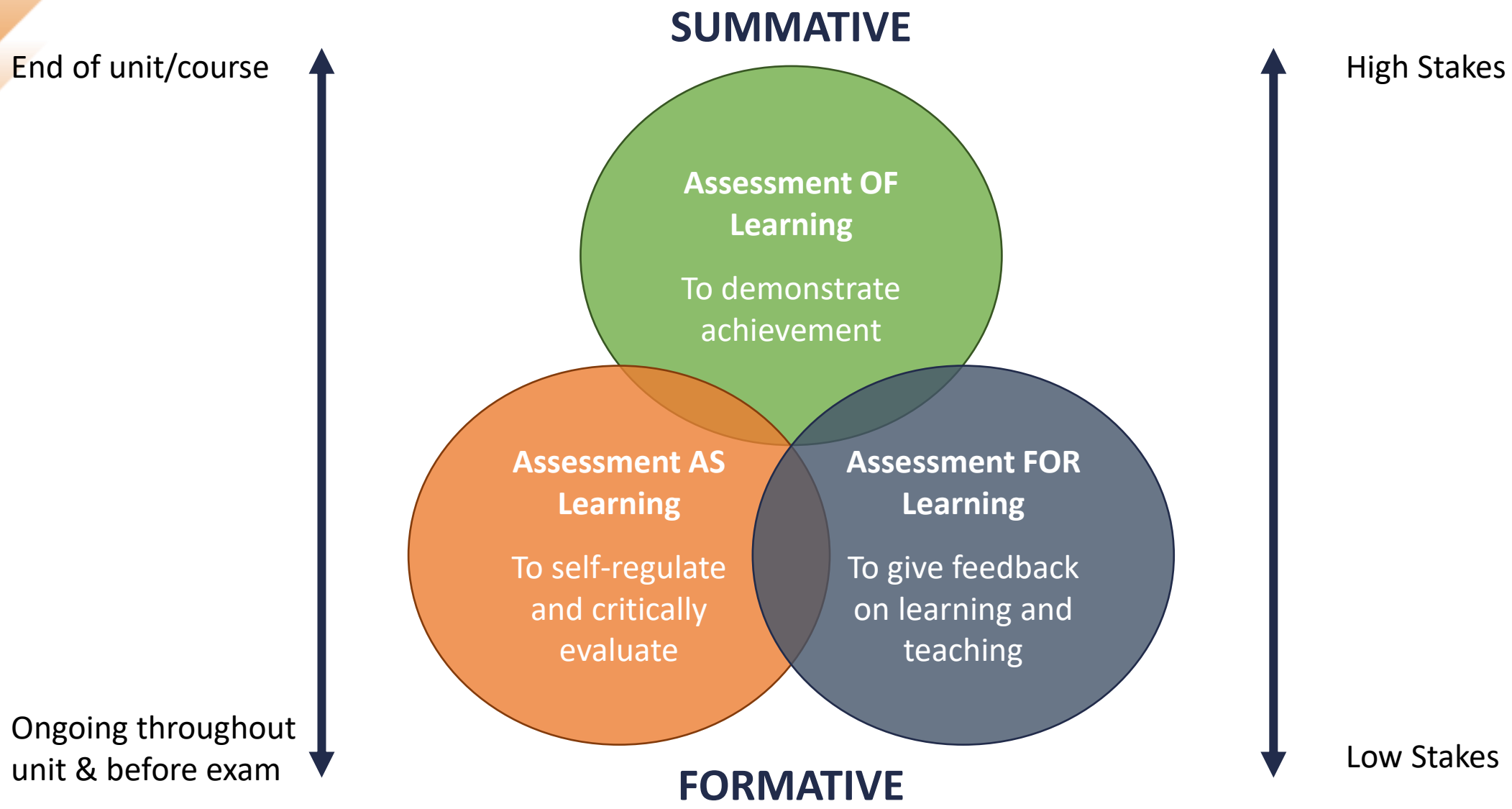


Preliminary results from analysis of interviews conducted with 19 general chemistry instructors across different types of institutions

Rationales for assessing

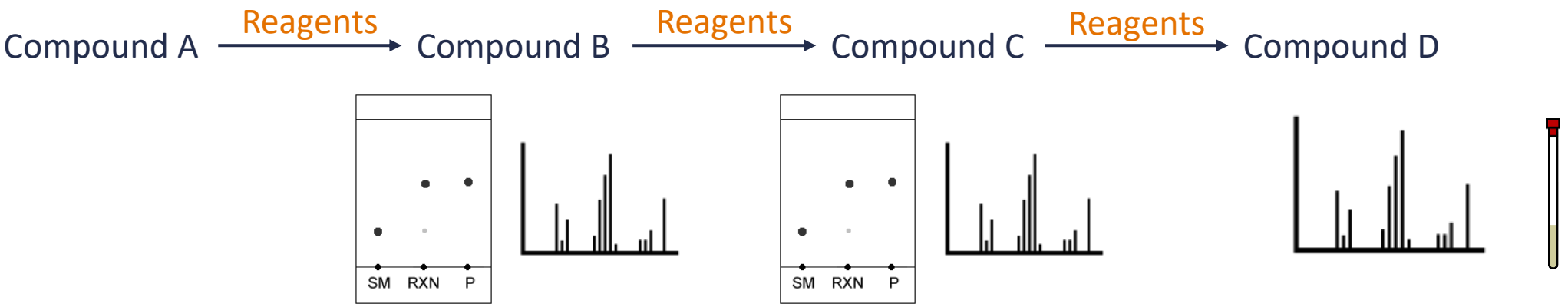


Preliminary results from analysis of interviews conducted with 19 general chemistry instructors across different types of institutions



Earl, L. M., & Manitoba School Programs Division. (2006). Rethinking classroom assessment with purpose in mind: Assessment for learning, assessment as learning, assessment of learning. Manitoba https://www.harapnuik.org/?p=8475

Assessment FOR Learning aligns with our practices in the lab!



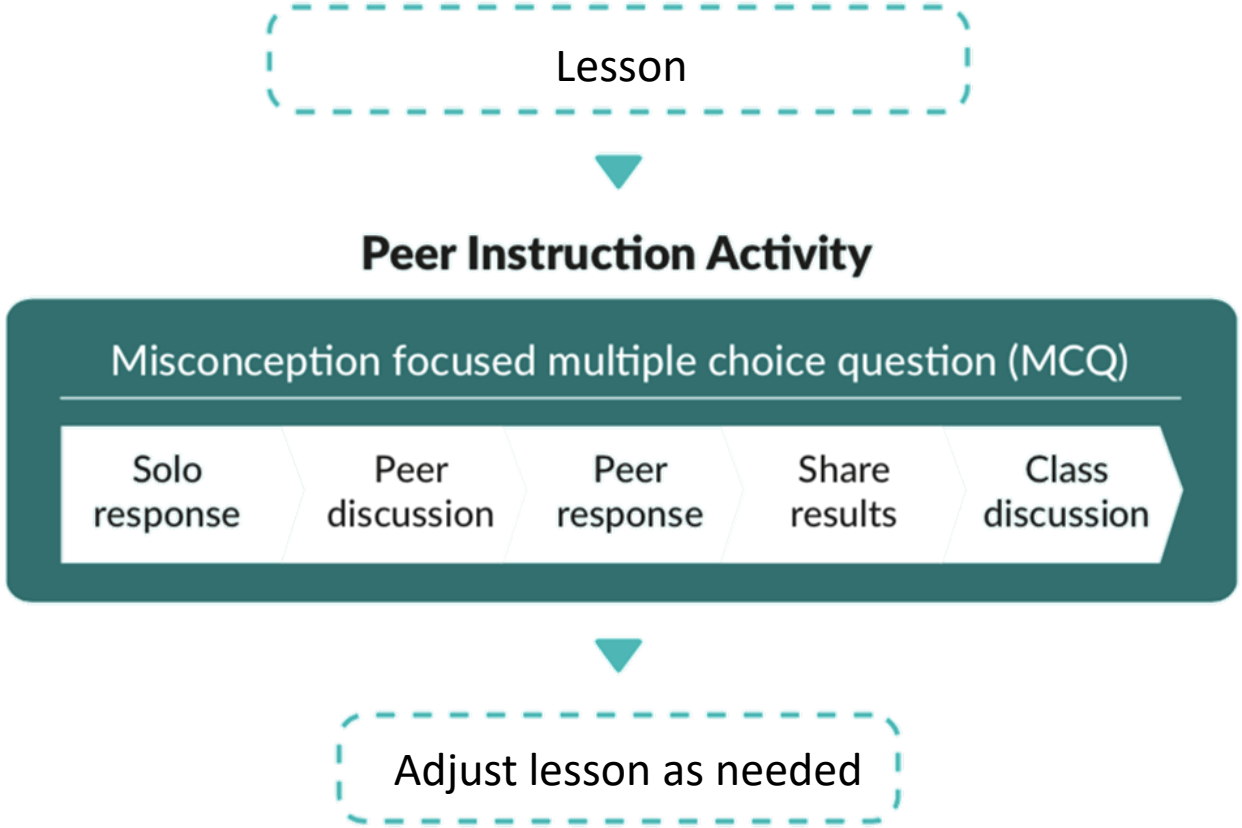
Assessment FOR Learning: Key influencing factors

1. Providing effective feedback to students.
2. Students' active involvement in their own learning.
3. Adjusting teaching to take into account the results of assessment.
4. Recognizing the profound influence of assessment on students' motivation and self-esteem - both crucial influences on learning.
5. Ensuring students assess themselves and understand how to improve.

Black, P., & Wiliam, D. (1998). Inside the black box: Raising standards through classroom assessment. London: School of Education, King's College.

What is an example of assessment FOR learning?

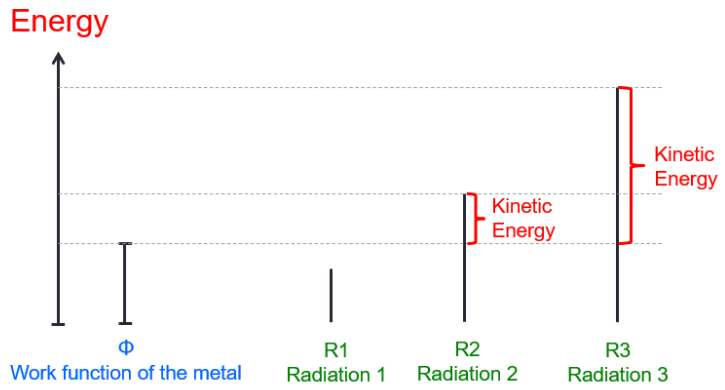
Assessment FOR Learning Strategy: Peer Instruction



Mazur, E. (1999). Peer instruction: A user's manual., Prentice–Hall, Upper Saddle River, NJ
https://blog.teachcomputing.org/quick-read-4-peer-instruction/

Think about it!

- Which radiation will lead to the fastest electron?



Lesson on photoelectric effect

Peer Instruction Activity

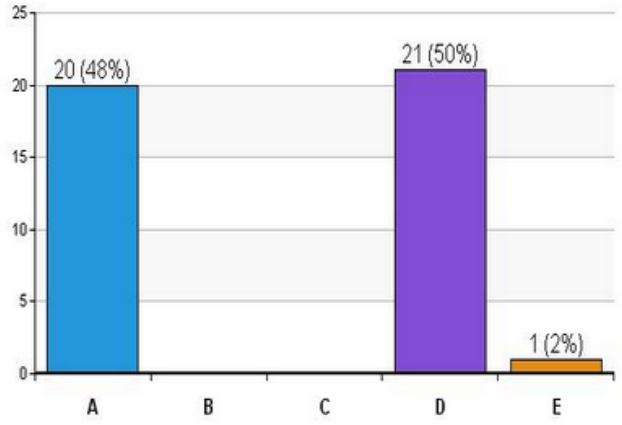
Misconception focused multiple choice question (MCQ)

Solo response → Peer discussion → Peer response → Share results → Class discussion

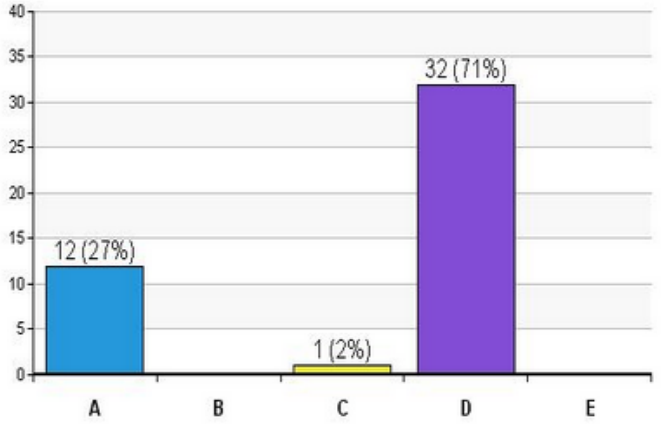
Clicker Question

- Which of the following metal has the highest work function?

A. Sodium	532nm
B. Zinc	290 nm
C. Copper	279 nm
D. Platinum	199 nm
E. Calcium	441 nm



Solo responses



Peer responses

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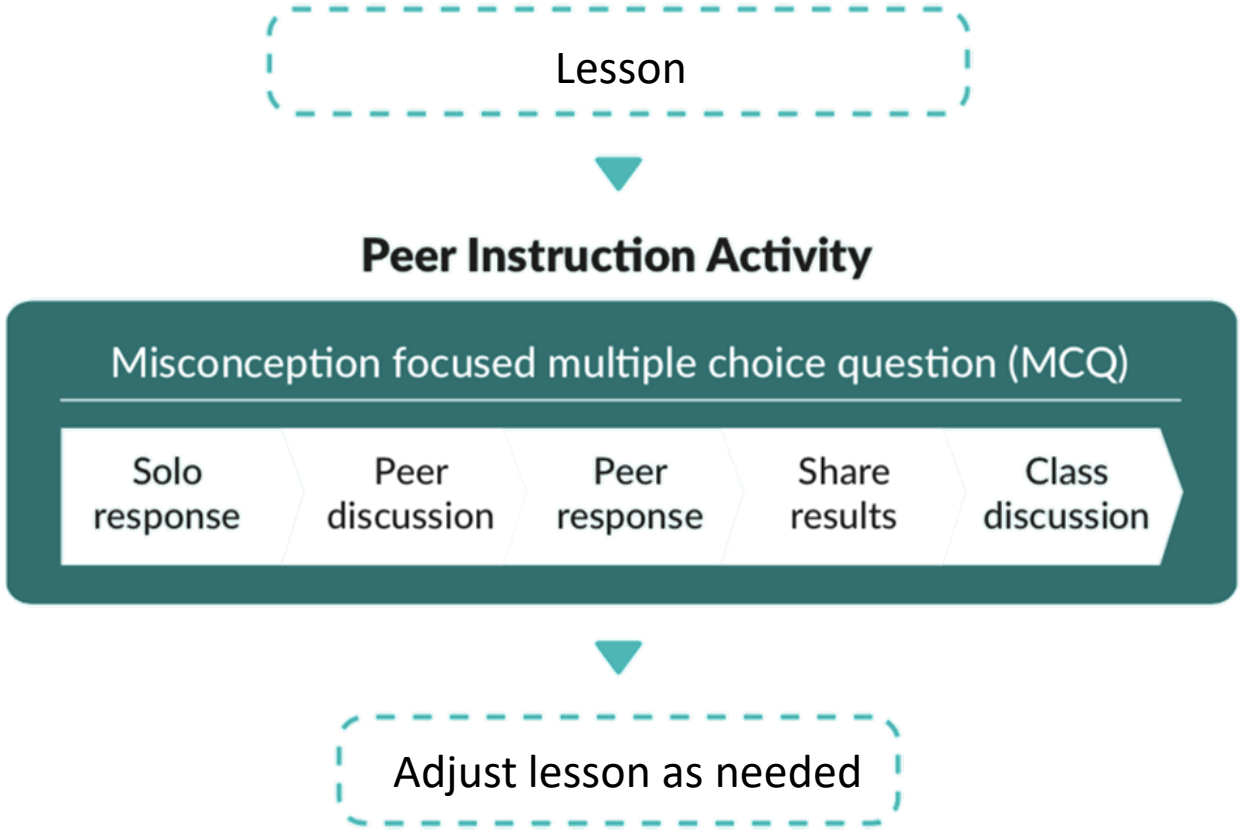
Assessment FOR Learning Strategy: Peer Instruction



1. Providing feedback to students.
2. Students' active involvement
3. Adjusting teaching
4. Recognizing the influence of assessment on students' motivation and self-esteem
5. Ensuring students assess themselves and understand how to improve.

Adapted from https://blog.teachcomputing.org/quick-read-4-peer-instruction/

What are the evidence supporting Peer Instruction?

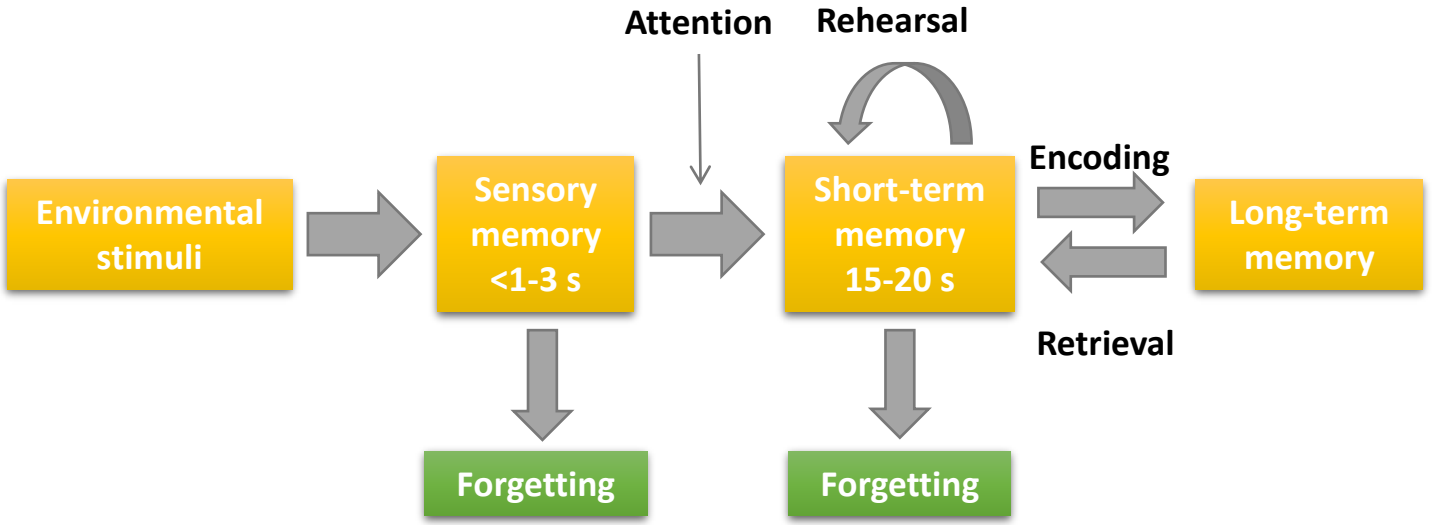
Peer Instruction is supported by extensive empirical evidence

1. Peer Instruction is effective in promoting students' conceptual understanding in a variety of STEM disciplines and courses across various institutions.
2. Peer Instruction can enhance both qualitative and quantitative problem-solving skills.
3. Peer Instruction increases retention and lowers failure rates.
4. Students have neutral to positive views on PI and seem to recognize its value over traditional teaching.

Vickrey, T., Rosploch, K., Rahmanian, R., Pilarz, M., & Stains, M. (2015). based implementation of peer instruction: A literature review. CBE—Life Sciences Education, 14(1), es3.

Peer Instruction aligns with principles on how people learn

The human brain can only process small chunk of information at a time.

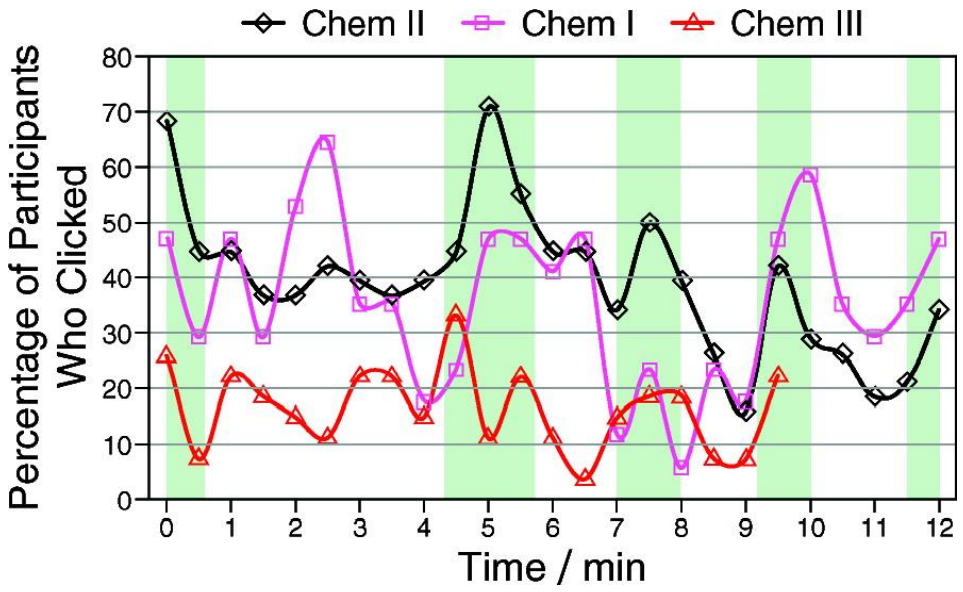


Atkinson, R. C., & Shiffrin, R. M. (1968). Human memory: A proposed system and its control processes. In Psychology of learning and motivation (Vol. 2, pp. 89-195). Academic Press.

Peer Instruction aligns with principles on how people learn

The human brain can only process small chunk of information at a time.

Within a 12 min lecture segment, students pay attention intermittently for about 7.5 min.

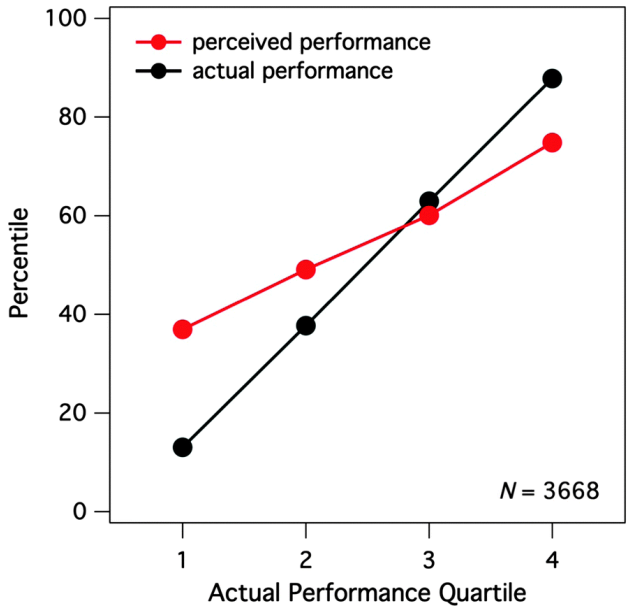


Bunce, D. M., Flens, E. A., & Neiles, K. Y. (2010). How long can students pay attention in class? A study of student attention decline using clickers. *Journal of Chemical Education*, 87(12), 1438-1443.

Peer Instruction aligns with principles on how people learn

It is challenging for human to accurately evaluate their competence.

"Low-performing students tend to overestimate their own performance while high-performing students tend to underestimate their performance."



Pazicni, S., & Bauer, C. F. (2014). Characterizing illusions of competence in introductory chemistry students. *Chemistry Education Research and Practice*, 15(1), 24-34.

Peer Instruction aligns with principles on how people learn

Individuals are likely to learn more when they learn with others than when they learn alone.

Meaningful learning is facilitated by articulating explanations.

Michael, J. (2006). Where's the evidence that active learning works? *Advances in Physiology Education*, 30, 159–167

How to effectively implement Peer Instruction?

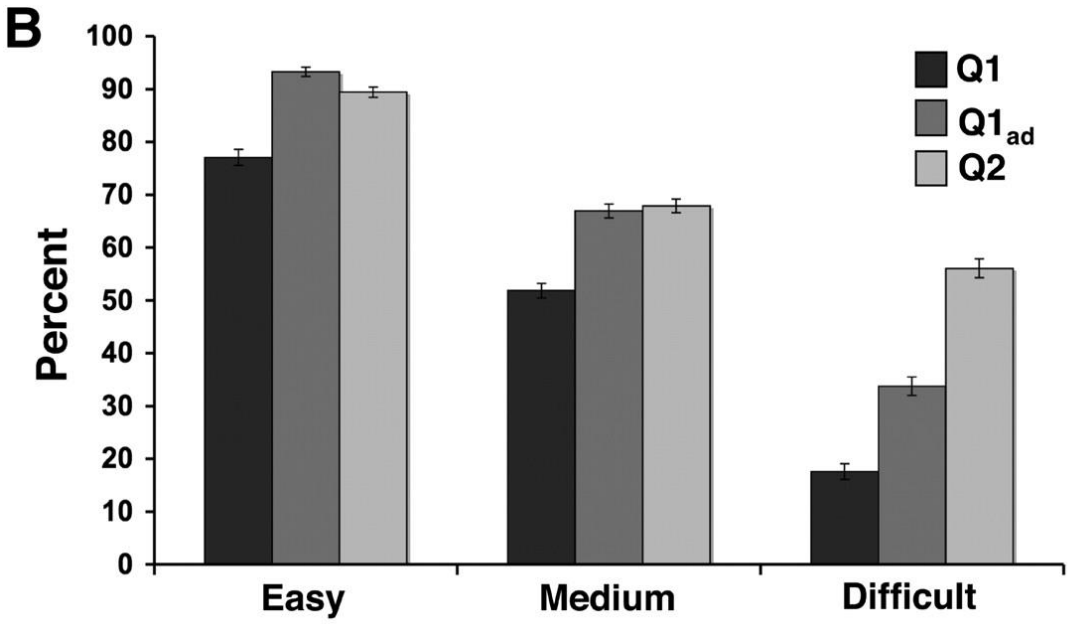
Peer Instruction versus clicker question

Clicker question

Peer Instruction

Peer Instruction is NOT a clicker question!

Questions should be challenging enough to provoke interest and discussion. More difficult questions promote greatest growth.



Q1: One question was voted on individually

$Q1_{ad}$: the same question was voted on again after peer discussion

Q2: A second isomorphic question addressing the same concept as the first question was voted on individually

Smith, M. K., Wood, W. B., Adams, W. K., Wieman, C., Knight, J. K., Guild, N., & Su, T. T. (2009). Why peer discussion improves student performance on in-class concept questions. *Science*, 323(5910), 122-124.

Recall

The volume of a gas is inversely proportional to the pressure of a gas is known as

A. Avogadro's Law
B. Ideal Gas Law
C. Charles's Law
D. Boyle's Law
E. Dalton's Law

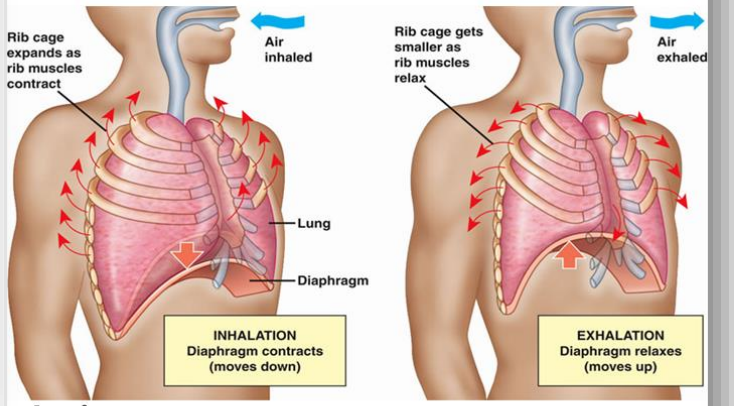
Algorithmic

A chamber has a pressure of 1.5 atm at a volume of 1.4 L. What is the pressure when the piston compresses the sample to a volume of 0.60 L?

A. 3.5 L
B. 0.64 L
C. 1.8 L
D. 1.6 L
E. 0.29 L

Conceptual

The thoracic cavity expands during inhalation. In comparison to the atmosphere, would you expect lung pressure to



A. increase
B. decrease
C. stay the same

Algorithmic competence ≠ Conceptual understanding

Traditional Stoichiometry

For a mixture of 2 mol H_2 and 2 mol O_2 reacting according to the following equation, what is the limiting reagent, and how many moles of the excess reactant would remain after the reaction is completed?

$$2H_2 + O_2 \rightarrow 2H_2O$$

	Limiting Reagent	Excess Reactant Remaining
(a)	O_2	1 mol O_2
(b)	O_2	1 mol H_2
(c)	H_2	1 mol O_2
(d)	H_2	1 mol H_2

(e) No reaction occurs since the equation does not balance with 2 mol H_2 and 2 mol O_2.

Conceptual Stoichiometry

The reaction of element X (□) with element Y (○) is represented in the following diagram. Which of the equations best describes this reaction?

(a) $3X + 8Y \rightarrow X_3Y_8$
(b) $3X + 6Y \rightarrow X_3Y_6$
(c) $X + 2Y \rightarrow XY_2$
(d) $3X + 8Y \rightarrow 3XY_2 + 2Y$
(e) $X + 4Y \rightarrow XY_2$

Sawrey, B. (2006). Concept learning versus problem solving: revisited. *Journal of Chemical Education*, 67(3), 253-254

Algorithmic competence ≠ Conceptual understanding

Table 1. Rate of Student Success

	N	Conceptual Question	Traditional Question	Level of Significance
Gas Laws				
All Students	285	31.23%	87.72%	≪0.001
Upper 27% of class[a]	77	44.16%	96.10%	≪0.001
Lower 27% of class[a]	77	14.29%	80.52%	≪0.001
Stoichiometry				
All Students	323	11.46%	66.25%	≪0.001
Upper 27% of class	87	20.69%	90.80%	≪0.001
Lower 27% of class	87	3.45%	45.98%	≪0.001

[a] The upper and lower 27% of the class refer to overall performance on the entire 25-item multiple-choice exam.

Sawrey, B. (2006). Concept learning versus problem solving: revisited. *Journal of Chemical Education*, 67(3), 253-254

Probing for conceptual understanding

Venn Diagrams: Students compare, distinguish between

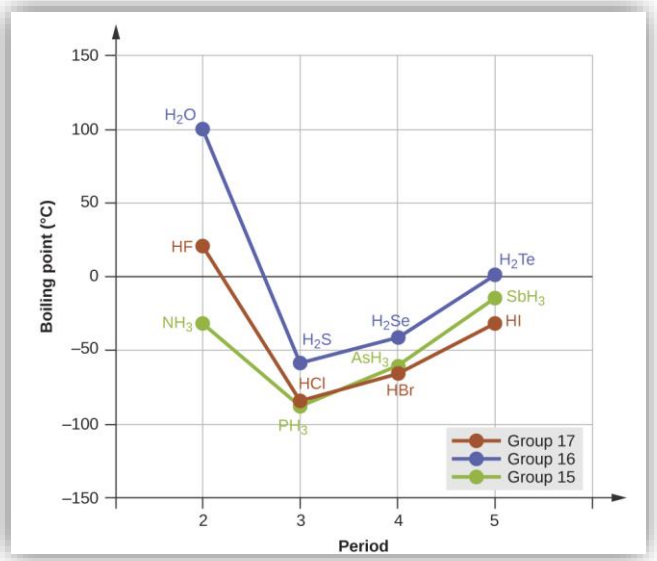
Graphical: Students estimate, examine, interpret

Pictorial: Interpret, explain, determine relationships

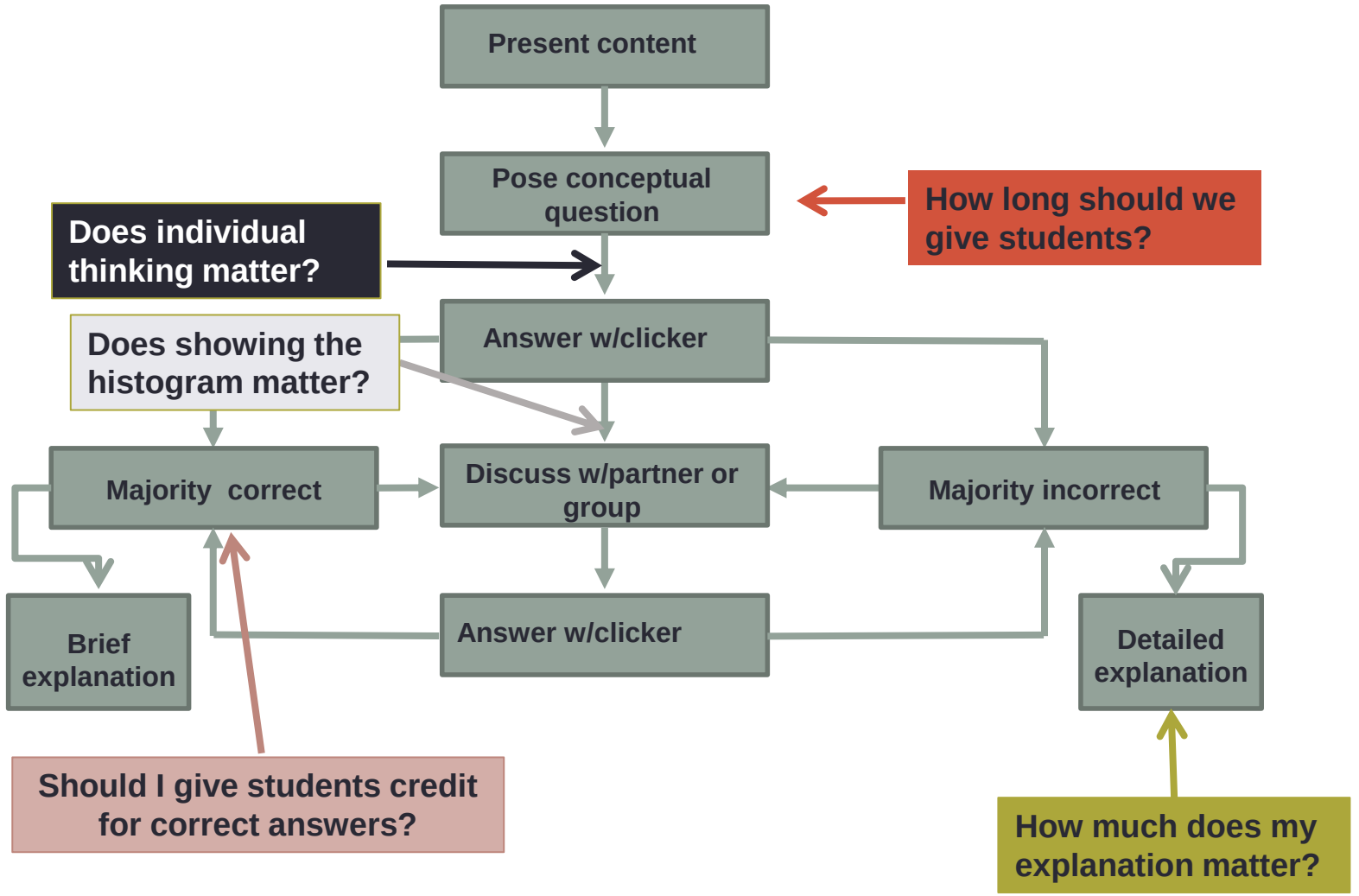
Perturbation of a system: Predict, relate, assess

Simulations

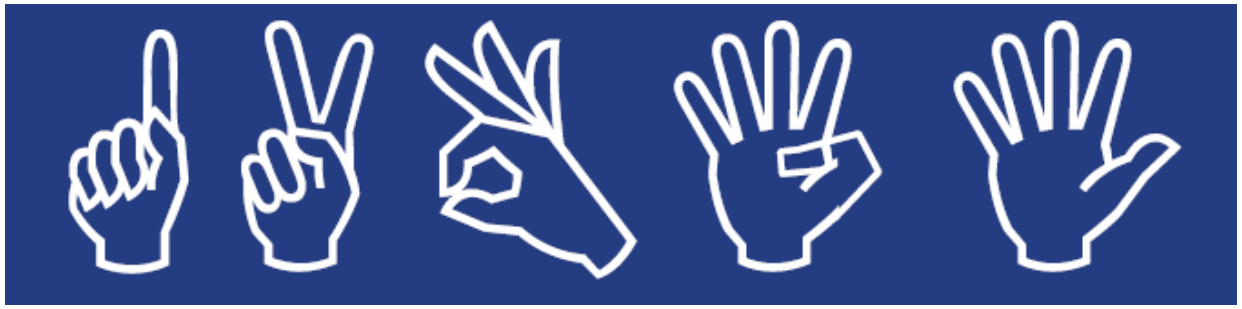
Others – categorization, distinguishing, prioritizing/ranking,



https://opentextbc.ca/chemistry/chapter/10-1-intermolecular-forces/
https://phet.colorado.edu/



Voting methods



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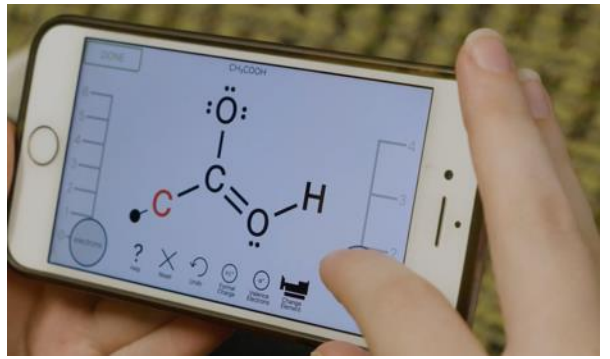


Learning Catalytics

What are the typical pitfalls with Peer Instruction?

Ensure alignment between your assessments classroom activities and learning goals!

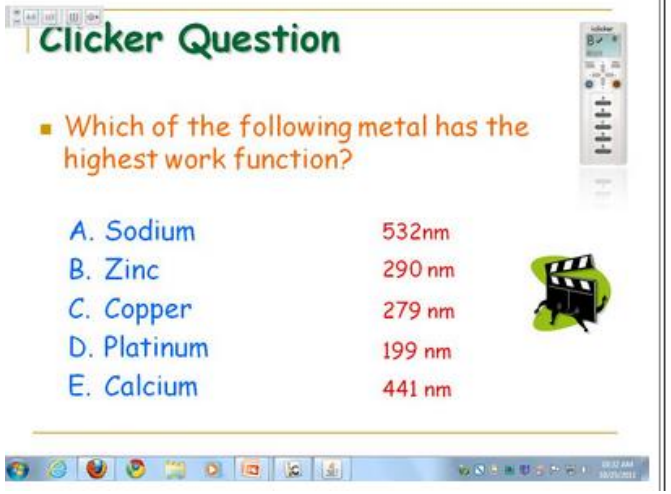
https://educationaltechnology.net/how-can-we-align-learning-objectives-instructional-strategies-and-assessments/

Students' resistance

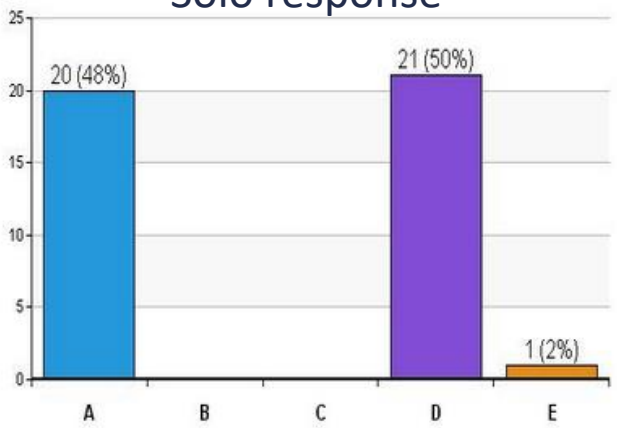
Explain why you are using this strategy on the syllabus, on day one, and several more times throughout the first third or so of the semester.

Students' resistance

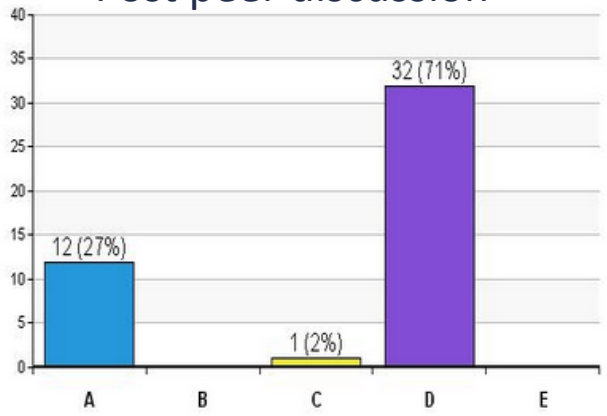
Emphasize how much they learn when working together compare to when just listening to you.



Solo response



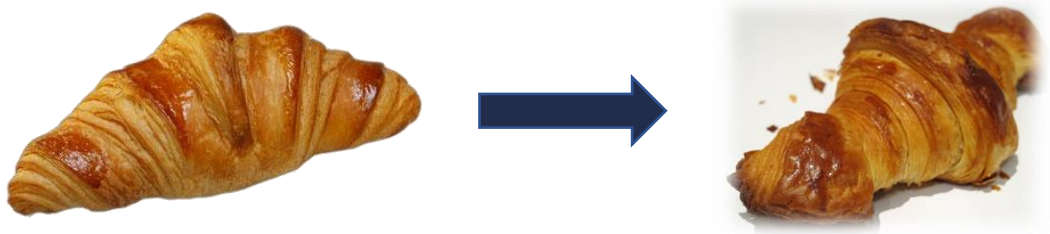
Post peer discussion



Issues with fidelity of implementation

No one size fits all but adaptations should be purposeful and tested.

	Peer Instruction (N=195)
I used it basically as described by the developer.	16.9%
I made some relatively minor modifications	35.9%
I used some of the ideas, but made significant modifications	41.0%
I am not familiar enough with the developer's description to answer this question	6.2%
All users	100%



Henderson, C., & Dancy, M. H. (2009). Impact of physics education research on the teaching of introductory quantitative physics in the United States. *Physical Review Special Topics-Physics Education Research*, *5*(2), 020107.
Andrews, T. M., Leonard, M. J., Colgrove, C. A., & Kalinowski, S. T. (2011). Active learning not associated with student learning in a random sample of college biology courses. *CBE—Life Sciences Education*, *10*(4), 394-405.

Monitoring during peer discussion is essential!

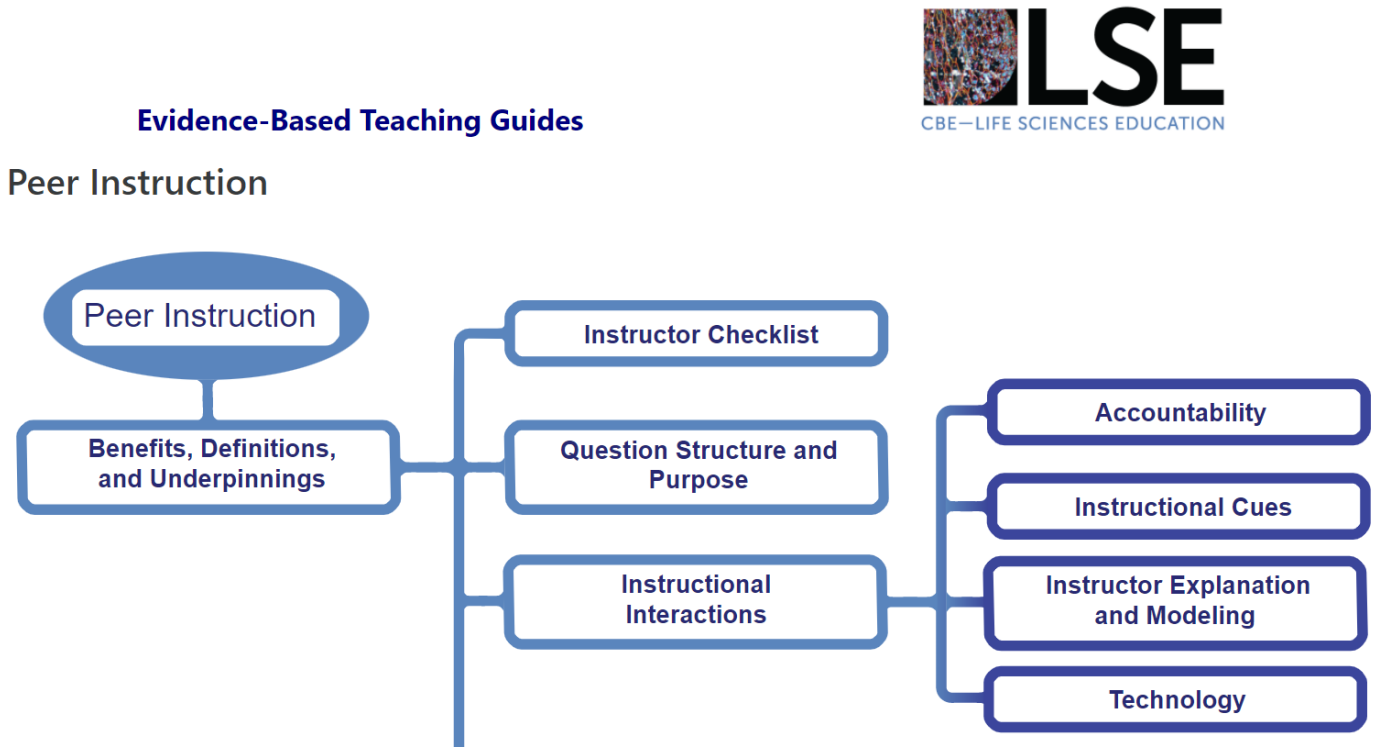
- Enhance your understanding of student thinking
- Enhance student-instructor relationship especially in large classes
- It makes teaching a lot more fun!

Greg Nathan | University Communication | UNL

Gehrtz, J., Brantner, M., & Andrews, T. C. (2022). How are undergraduate STEM instructors leveraging student thinking?. *International Journal of STEM Education*, 9(1), 1-20.
https://www.auburn.edu/cosam/aulap/
https://news.unl.edu/newsrooms/today/article/biology-education-research-earns-couch-national-award/

What resources exist to help me implement Peer Instruction?

Details on Peer Instruction



https://lse.ascb.org/evidence-based-teaching-guides/peer-instruction/

Questions for Peer Instruction

- Aktiv: www.aktiv.com

- Vicente Talanquer – Chemical Thinking Interactives: https://sites.google.com/site/ctinteractives/

- Stacey Lowery Bretz' concept inventories: https://sites.google.com/miamioh.edu/bretzsl/research/assessment-tools?authuser=0

- PhET simulations – translated in numerous languages: https://phet.colorado.edu/

Thank you!

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