# PRACTICES, TOOLS, AND EVIDENCE FOR IMPROVING LARGE INTRODUCTORY SCIENCE AND MATH COURSES:

# THE WORKING SESSION:

# PEER INSTRUCTION AND LEARNING GOALS

Kick-off Retreat: IC2 PROJECT

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# Outline / Framing

- This is your workshop & we can discuss whatever you wish
- Importance of Interactive Engagement (IE)
- An Examples of IE
- An Approach to Learning Outcomes
- *Why* these work depends upon *how* we use them
- Things we can talk about:
  - Goals in teaching (for learning)
  - Assessments
  - Beyond Content
  - Inclusion

# What were some goals *today*?

## think about teaching like a scholar

**Learning:** **Students *construct* knowledge**

**Teaching:** **Research based methods**

**Context:** **Interactive Engagement, Beliefs, Social Context**

Which of the following statements do you agree with? (if perhaps with some caveats)

A) Good teachers are born, not made

B) Teaching is an art, not a science

C) Teaching is a way to get the lecture notes of the prof into the notebook of the student (without passing through the mind of either)

D) *more* than one of the above

E) None of the above

*Why* talk to your neighbors?

# What are you wanting to get from this workshop?

A. *Sell me on it!* I'm curious and trying to decide whether to use clickers
B. *Get me started!* I know I want to use them but want some tips to get started/use clickers well
C. *Let's go deeper!* I have been using clickers and am looking for ideas to take my practice further
D. Other

# Warm Up: Your questions about Peer Instruction

- What are your big questions, or challenges, in using Peer Instruction?

# What are our objectives in class?

| **Novice** | | **Expert** |
|---|---|---|
| **Formulas & "plug 'n chug"** | **content** | **Concepts & Problem Solving** |
| **Pieces** | **structure** | **Coherence** |
| **By Authority** | **process** | **Independent** (experiment) |
| **Drudgery** | **affect** | **Joy** |

**think** about science like a scientist
**think** about education like a scholar

**Adapted from: Hammer (1997) COGNITION AND INSTRUCTION** (physics),

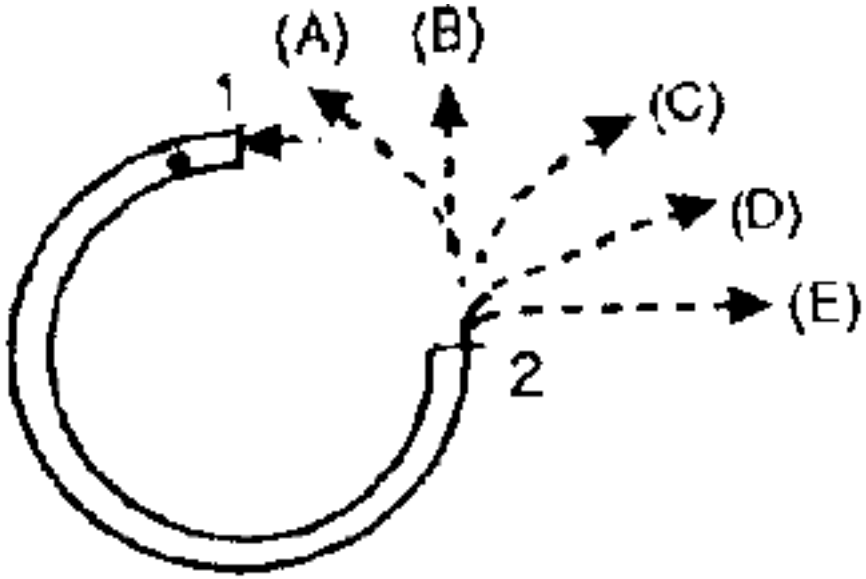
# A possible “tipping point”

- **Force Concept Inventory***
- Multiple choice survey, (pre/post)
- Experts (especially skeptics!)

  necessary (not sufficient) indicator of conceptual understanding.

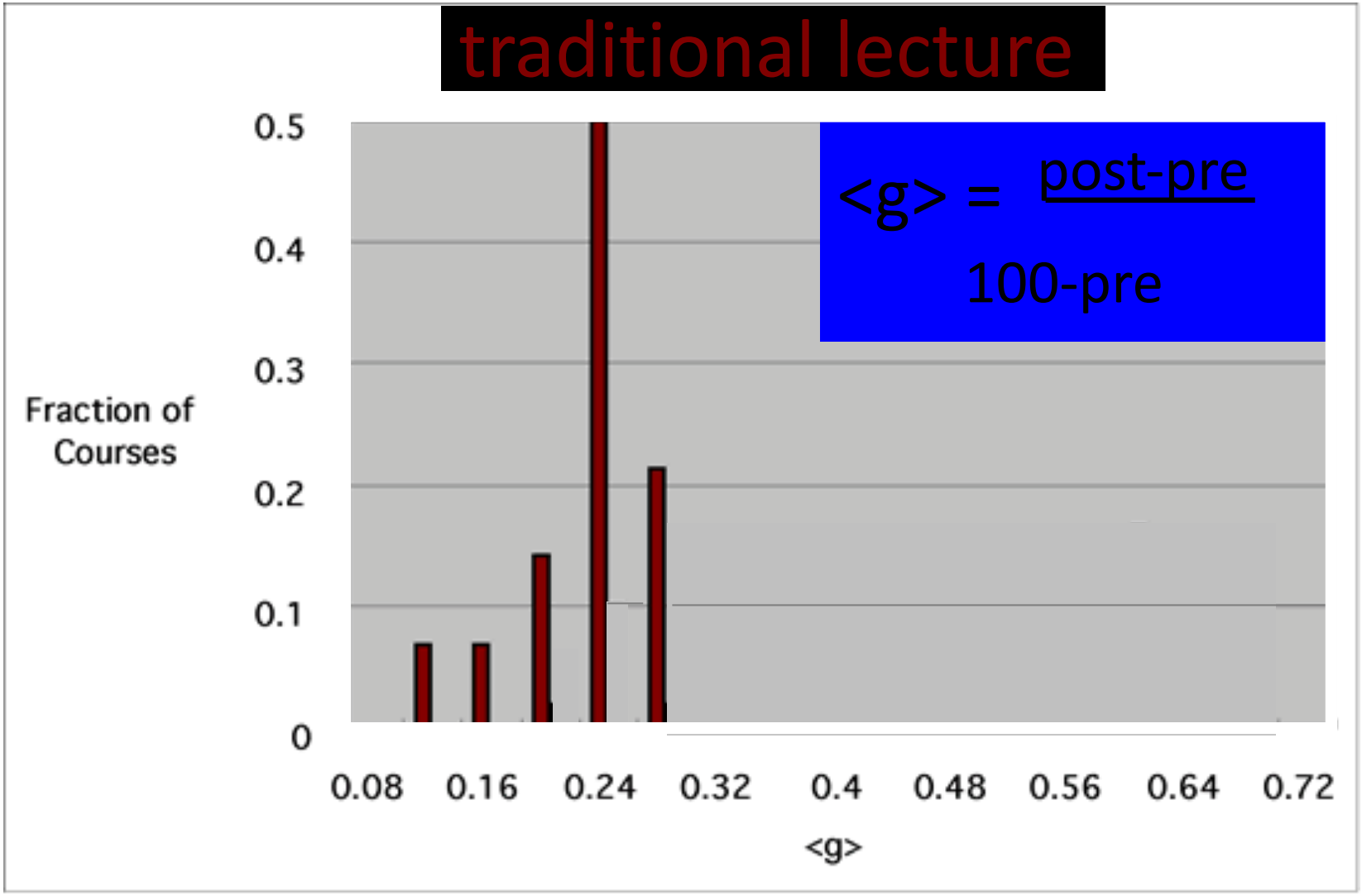
* Hestenes, Wells, Swackhamer, Physics Teacher 20, (92) 141

# Sample question



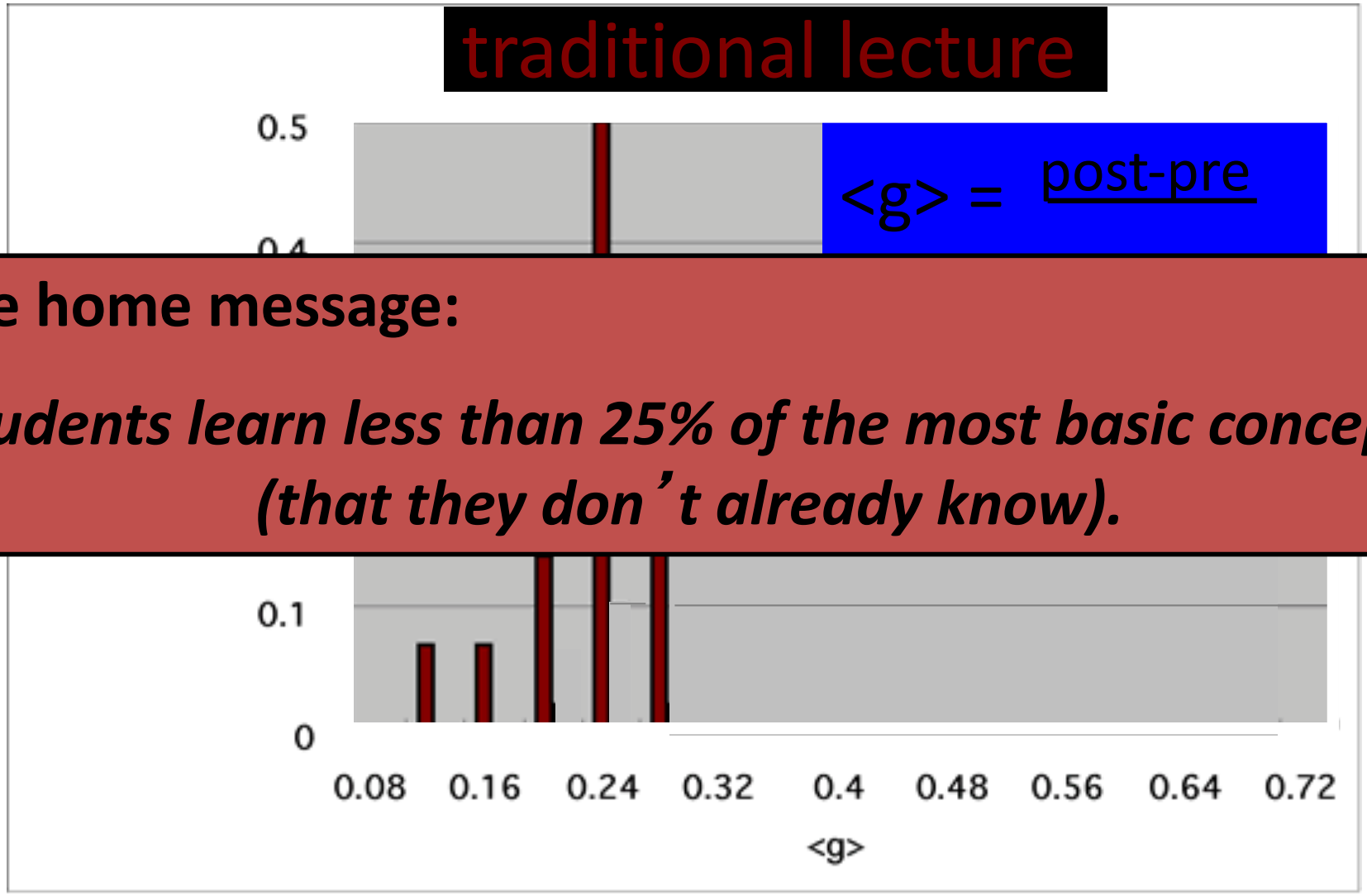

Looking down at a track (flat on table), a ball enters at point 1 and exits at point 2. Which path does it follow as it exits (neglect all friction)?

# Force Concept Inventory




R. Hake, "…A six-thousand-student survey…" AJP **66**, 64-74 ( '98).

# Force Concept Inventory

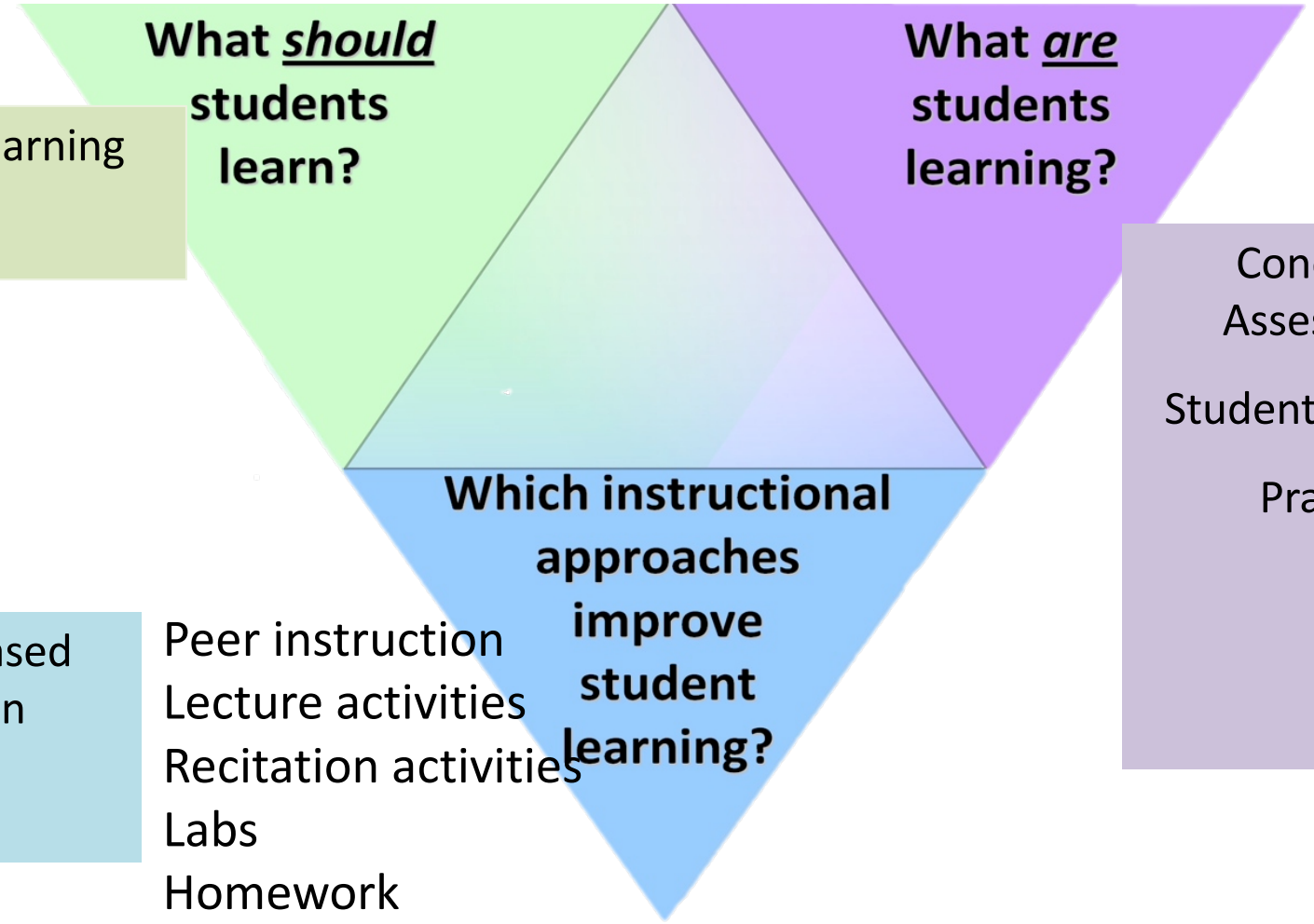



**Take home message:**

***Students learn less than 25% of the most basic concepts (that they don't already know).***

R. Hake, "…A six-thousand-student survey…" AJP **66**, 64-74 ('98).

# Course transformation using Backwards Design




Consensus learning

Conceptual Assessments

Student Reasoning

Practices

…

Evidence-based Instruction

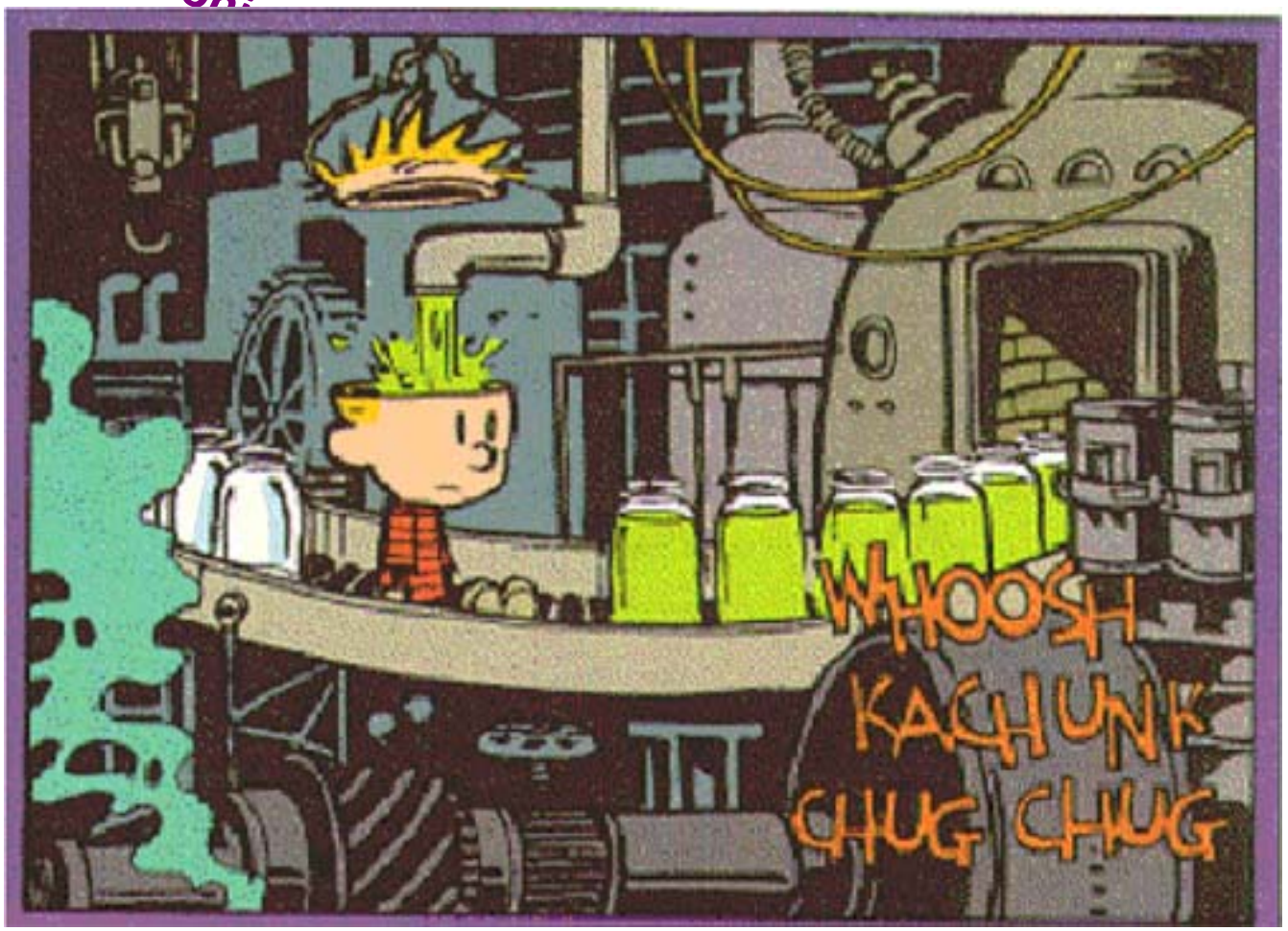
Peer instruction
Lecture activities
Recitation activities
Labs
Homework

SEI, C. Wieman et al, www.colorado.edu/sei

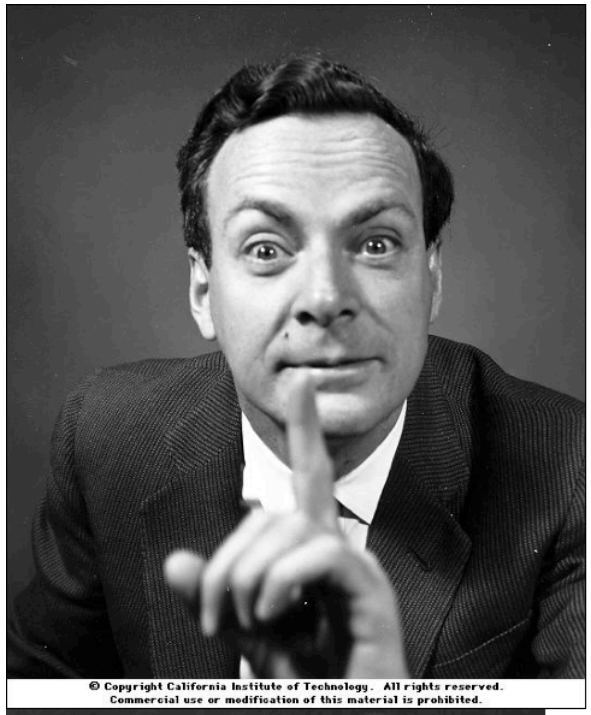
# Trad'l Model of Education

Individual ← Instruction via transmission — Content (e.g. circuits)

transmission:



# Where does this come from?




I don't think you can teach physics very well anyway to people in that manner, by giving lectures on a big scale. I think it's hopeless.

Richard Feynman, 1918-1988

# PER Theoretic Background

Individual ← Instruction via transmission — Content (E/M)

transmissionist

Individual ⟷ Active construction ⟷ Content

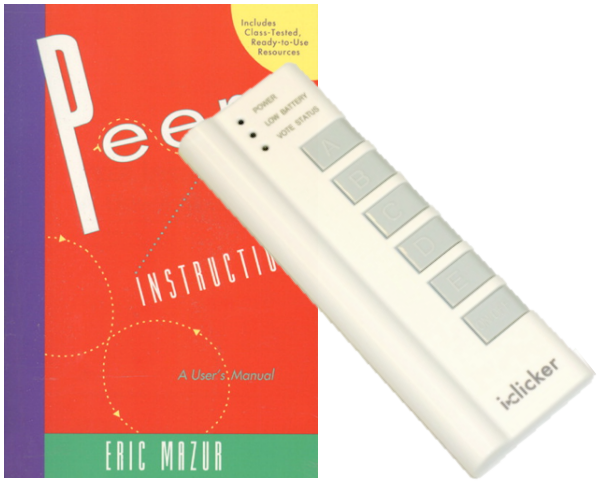
Prior knowledge

constructivist

*actively engaging students is important*

# Peer Instruction is the recommended pedagogy used with clickers

- 3-5 questions per class
- Students discuss & vote
- Improved learning (multiple studies)
- Used by ~30% of physics faculty*
- Used in 100% of large lecture STEM courses at CU





* Dancy & Henderson, AJP, 2010

# Have you (personally) used clickers in your classroom?

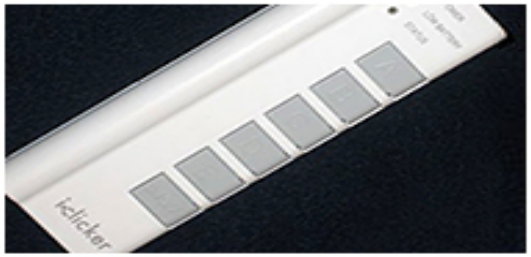
A) Yes I have, with some success

B) Yes I have, but with lots of problems

C) No, but I'm thinking about it

D) No, I really don't know enough about it

E) (None of the above really reflects what I want to say here!)



# disclaimer

- This is not a "lecture on teaching"
  focus on student learning

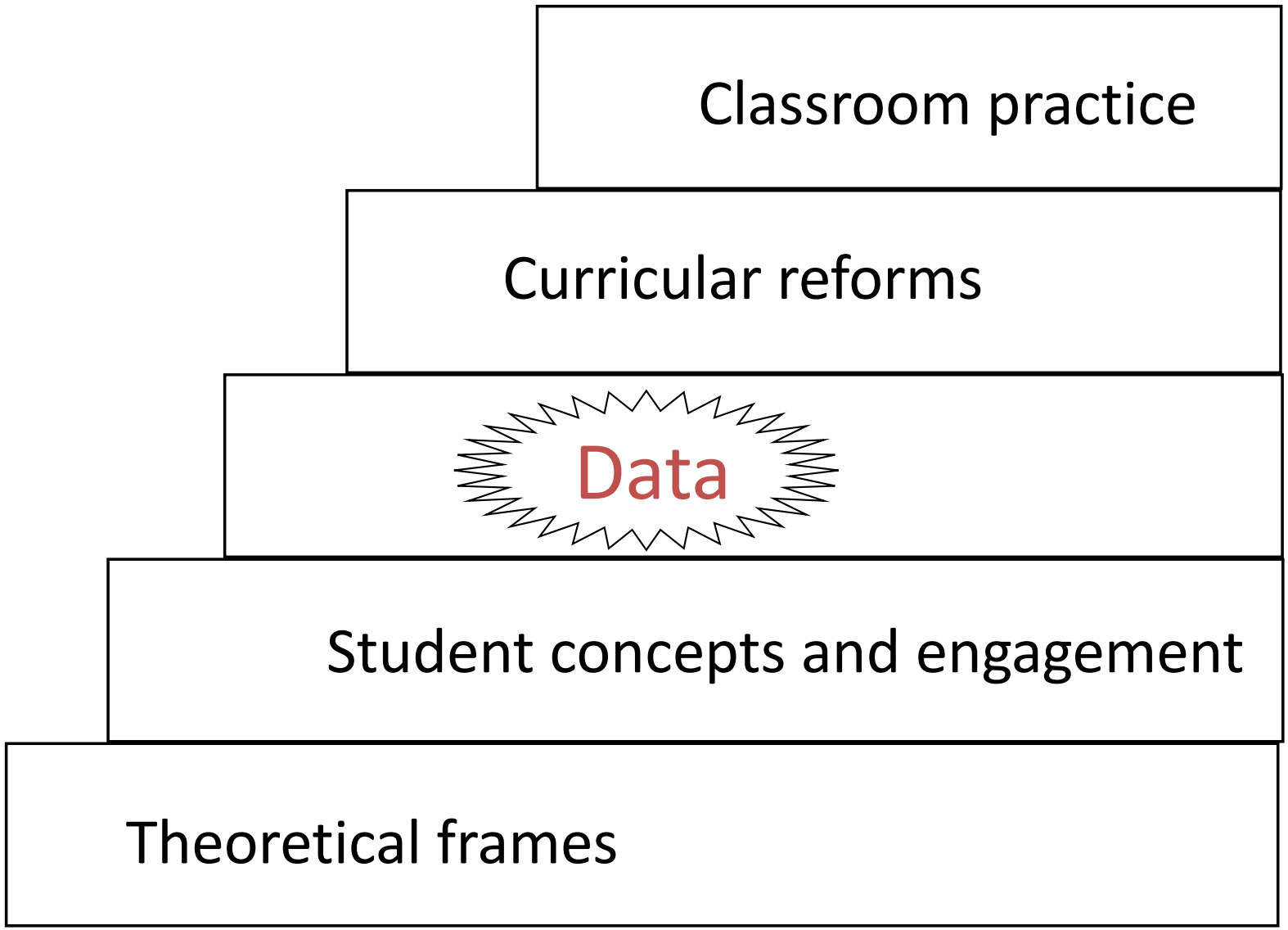
- Build on a base (Education Research)

- Why clickers?

  Interactive Engagement

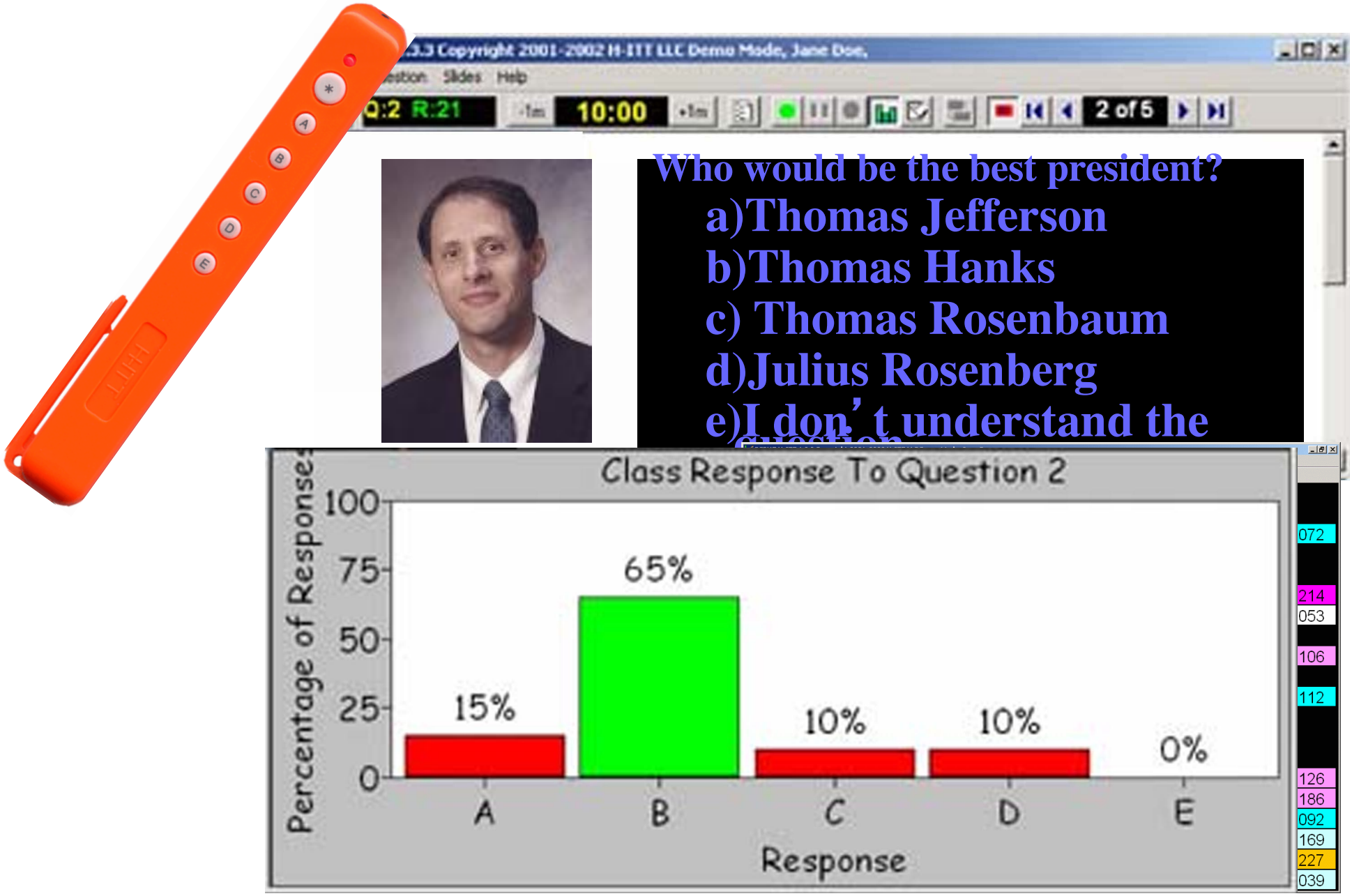
  (Just a bit on how/what/when clickers)

# Building on a base



# What are your classroom /course goal(s)?

# Personal Response System



Which of the following is the *best* reason for *you* to use clickers?

A) Keep attendance (automatically)

B) Quizzes/practice for exams

C) Encourage/support peer interation

D) Feedback to instructor

E) Feedback to students

F) Something Else?

Which of the following is the *best* reason for *you* to use clickers?

A) Keep attendance (automatically)

B) Quizzes/practice for exams

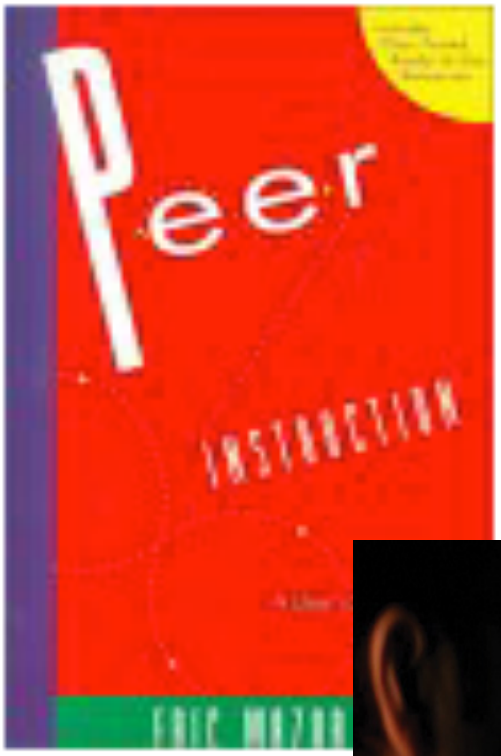
C) Encourage/support peer interaction

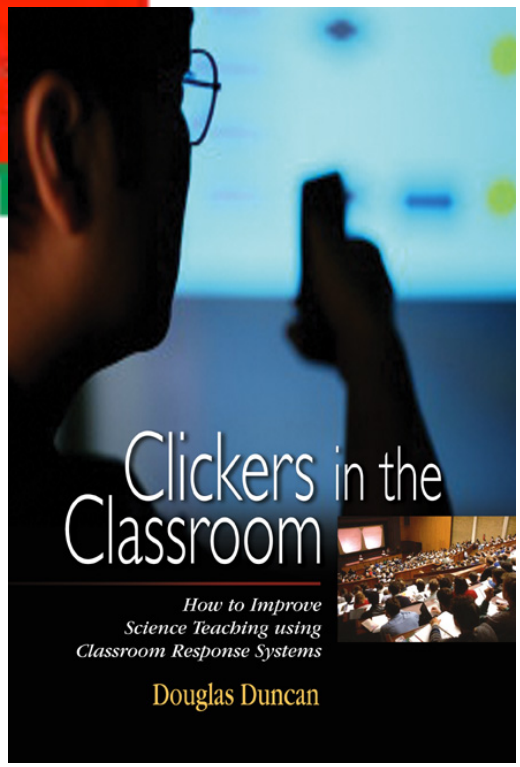
D) Feedback to instructor

*E) Feedback to students*

NF priorities .. Set your own

# Peer instruction* (used locally)




1. Question
2. Talk (2-3 min)
3. Vote
4. Discuss (Class)

Question to think about:
For each of these four steps, what is its role in the student's learning process?

* http://galileo.harvard.edu/

# Can clickers help students learn?

- Give students feedback about performance *before* the exam
- Create accountability and "benchmarks" for learning
- Students can better answer a similar question after talking to their peers (especially difficult questions!)
- Courses using peer instruction outperform traditional lecture courses on a common test
- Creates a more democratic, engaging classroom culture – lifting the "ban" on speaking

http://STEMclickers.colorado.edu for references

# Clickers are a tool for questioning

But not a magic bullet!


The perfect question doesn't solve all problems.
Implementation is also important.

# Anatomy of Peer Instruction

Ask Question

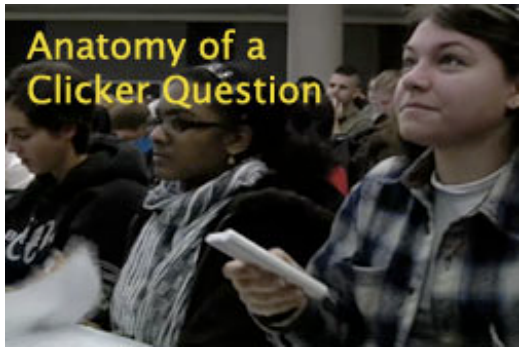
Individual vote

Peer Discussion

Vote

Whole-class debrief

…Lecture…



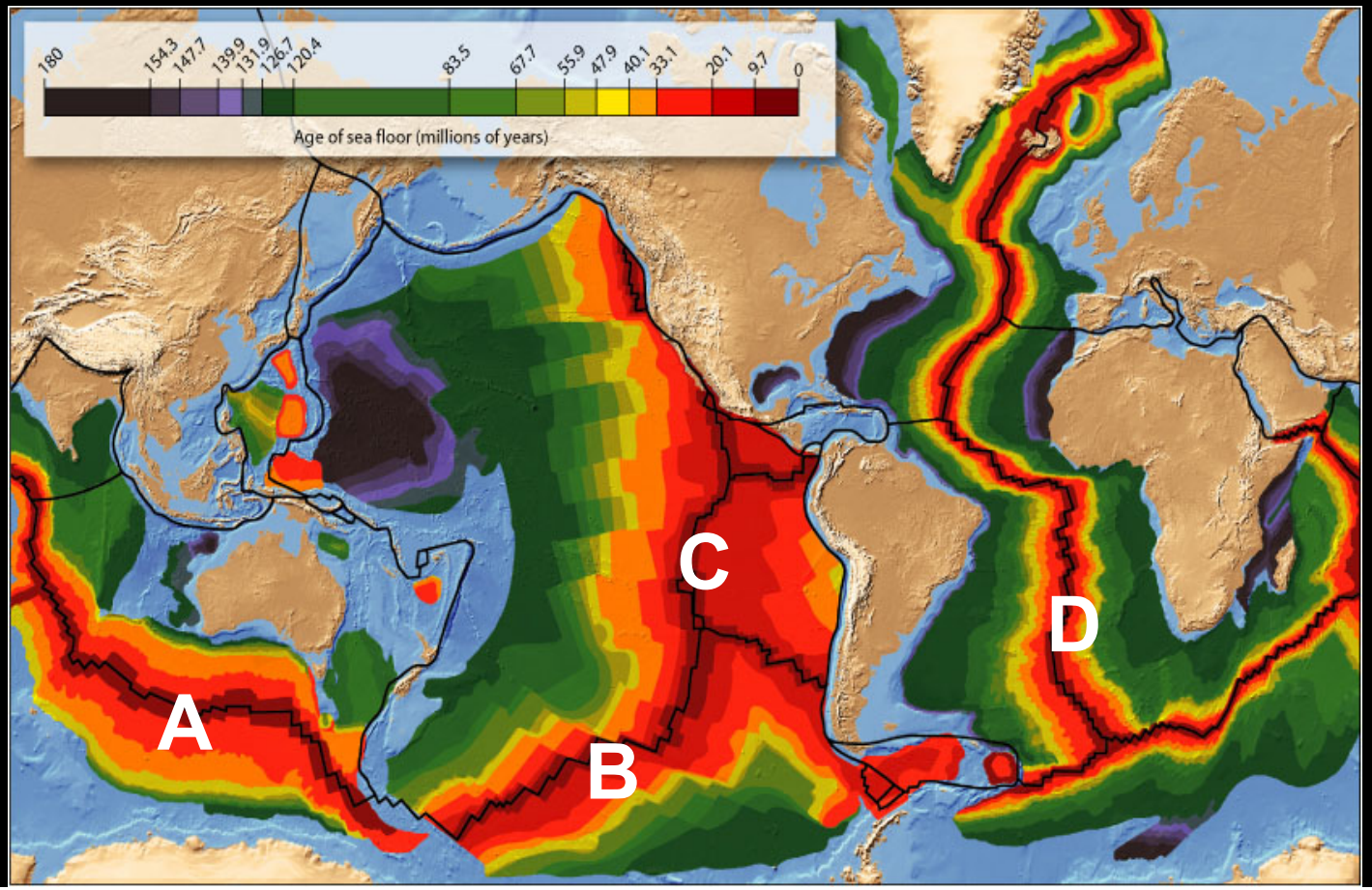

*** See also: Peer Instruction, A User's Manual. E. Mazur.**

# Let’s try it!

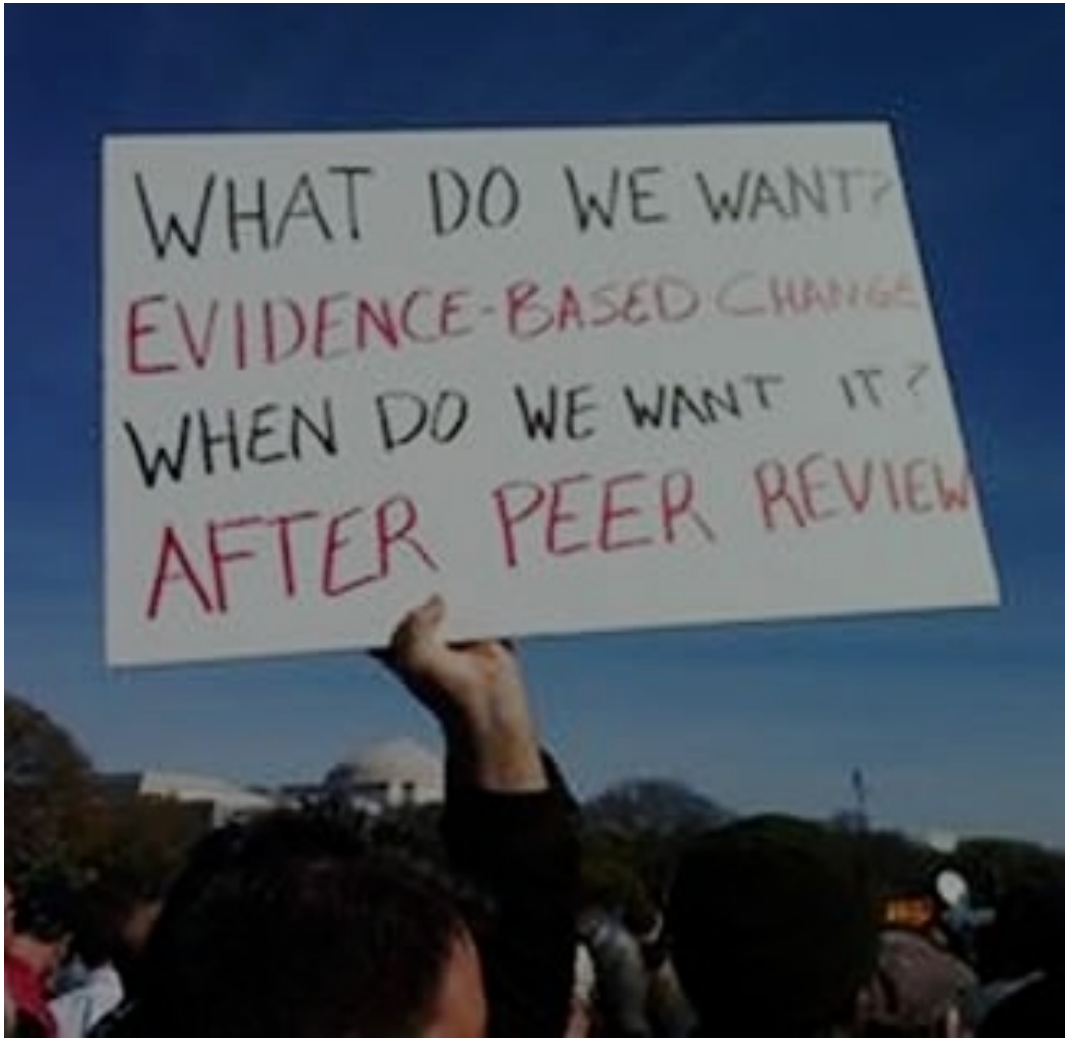
# Example from Geoscience

Rank the spreading centers (divergent plate boundaries) in order of FASTEST to SLOWEST average spreading rates:

A. A, B, C, D
B. C, A, B, D
C. D, B, A, C
D. Can't determine from this information
E. I have no idea



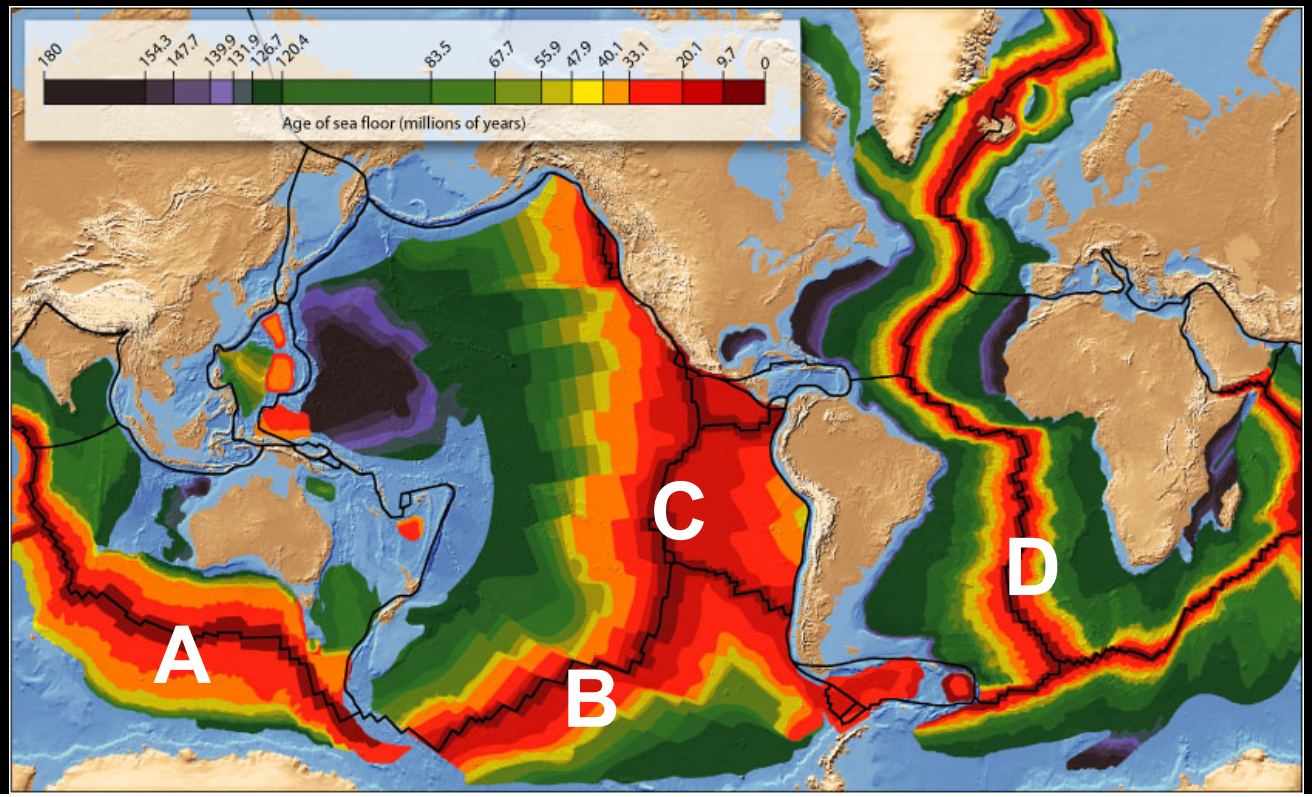
# Facilitation Matters



# Posing the question?

Rank the spreading centers (divergent plate boundaries) in order of FASTEST to SLOWEST average spreading rates:

A. A, B, C, D
B. C, A, B, D
C. D, B, A, C
D. Can't determine from this information
E. I have no idea



??

# Posing the question?

- Focuses students' attention on important idea
- Allows students to try applying ideas they just heard
- Allows students to build or make connections between ideas/representations

- Others for this question????

- Other questions can achieve other objectives.

# Student-student discussion?

- Actively engages students in thinking about the question
- Gives students an opportunity to explain and defend their reasoning, and evaluate others reasoning (to engage in scientific argument
- Gives the teacher a change to hear what students are thinking (ask students or listen to group discussion).

- Others????

# Voting?

- Gets students to commit to an answer and engaged in knowing the right answer. (They are vested in the outcome, but in a peer-anonymous way).
- Provides feedback to faculty
  - What are students thinking?
  - Can they apply these ideas?
- Provides feedback to students
  - Am I understanding this?
  - How does my understanding compare to the rest of the class?

# Follow-up Discussion?

**Whole-class discussion:**

- Teacher hears students reasoning for various answers.
- Students hear and respond to each others ideas
- Opportunity to emphasize and support reasoning as important

  "Why might someone pick B?

  Why is that answer tempting?"
- Important to make sure correct answer and reasoning clear by the end.

**Teacher explanation:**

- Students hear reasoning/argument for correct answer and why other answers are not correct.

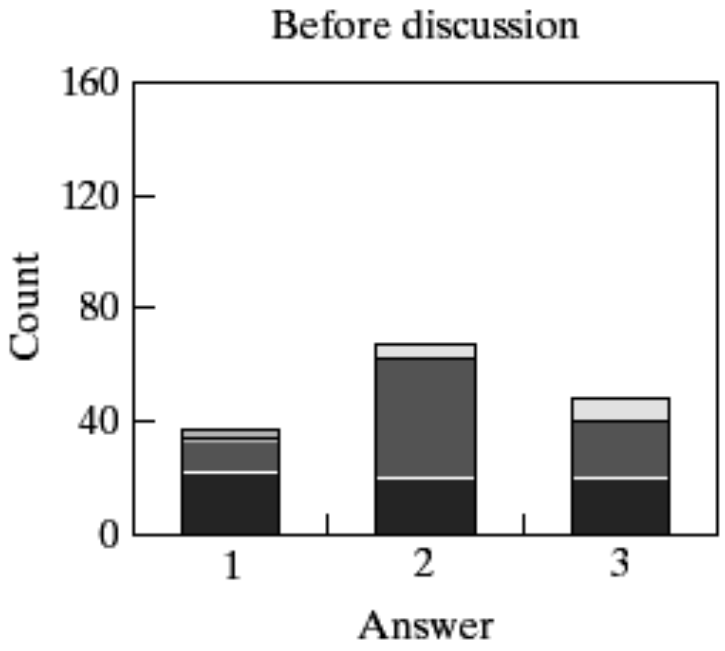
# Results

- Students learn more AND are more engaged
  - Higher learning gains
  - More and deeper questions (quite challenging!)

- Students take/accept more responsibility for their own learning

- Promotes (more) expert-like beliefs about what it means to learn and how one learns.

# Role of talk*





Mazur, *Peer Instruction*

# Modes of Use of Clickers

1 quiz on the reading

2 require recall of lecture point

3 elicit/reveal prior ideas

4 require prediction of demo, expt, sim.

5 test conceptual understanding

6 transfer/implication

7 relate different representations

8 draw on intuition from everyday life

9 do a calculation

10 survey students

# Pedagogy of Clickers

- Peer instruction/interaction
- role of social dynamics (talk, groups, consensus)
- lower threat of public presentation
- Reasoning
  - Thinking about thinking
- Elicit/confront/resolve

Formative Assessment

# Clicker question construction

CONTENT: concepts, relationships

PROCESS: analysis, habits of mind

METACOGNITION: attitudes and beliefs, how do I know if I know?

Beatty et al, AJP 74, Jan 2006 p. 31

# Treasure hunt

# (multidisciplinary questions)

See Handout

Which of these questions are gems and which ones are stinkers? With your buddy, rate each question on a scale of 1 (lousy) to 4 (fantastic). You might consider the question's content, difficulty, plausibility of distractors, clarity of writing, and whether it addresses an important idea. Assess as many as you have time for.

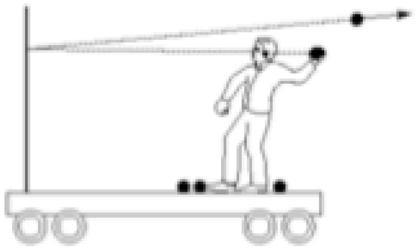
**1. ABUNDANT ELEMENT**
The most abundant element in the Earth is:
A. Hydrogen
B. Oxygen
C. Magnesium
D. Silicon
E. Iron

**2. BOILING**
Boiling occurs when the vapor pressure of a liquid equals the atmospheric pressure. In the high altitude city of Denver, is the boiling point of water
A) < 100C
B) 100 C
C) > 100C

**3. WEIGHT**
When you lose 10 pounds, where does most of the weight go?

A) Out of the body in secretions (urine, feces, and/or sweat)
B) Out of the body in air you exhale
C) The body uses it up as energy
D) Half out of the body in secretions and half used up as energy

**4. BALL BOUNCE**
Suppose you are on a cart, initially at rest on a track with no friction. You throw balls at a partition that is rigidly mounted on the front of the cart. If the balls bounce straight back, as shown in the figure, is the cart put in motion?



A. Yes, left
B. Yes, right
C. No
D. Don't know

# Bottom line goals for clickers:

- Facilitate interaction ("peer instruction")

  Increase learning!

  - Students' minds must be active.
  - Passive => learning is usually less than you think.
  - Even an exemplary lecture is limited

*actively engaging is important*

*what people know affects what & how they learn…*

*Is that it?*

*What else might be important?*

See Handtout

# Facilitation Tips for Success

## #1 Use a cue that encourages students to do what you feel is most important, and encourage any helpers in the classroom (LAs, TAs) to do the same

For example: “As you answer this question….

-”make sure to consider why each answer is correct or incorrect” OR

-”construct an argument with reasons and evidence for your choice” OR

-”be ready to share the reasons for your answers with your neighbors and the rest of the class”

# Facilitation Tips for Success

#2. Don't show the histogram to the class after the first vote, unless it is an equal split.


Popular choices may sway second vote.

- a student who picked an unpopular choice may be reluctant to participate in discussions
- Everyone will think the popular vote is correct

# Research tidbit

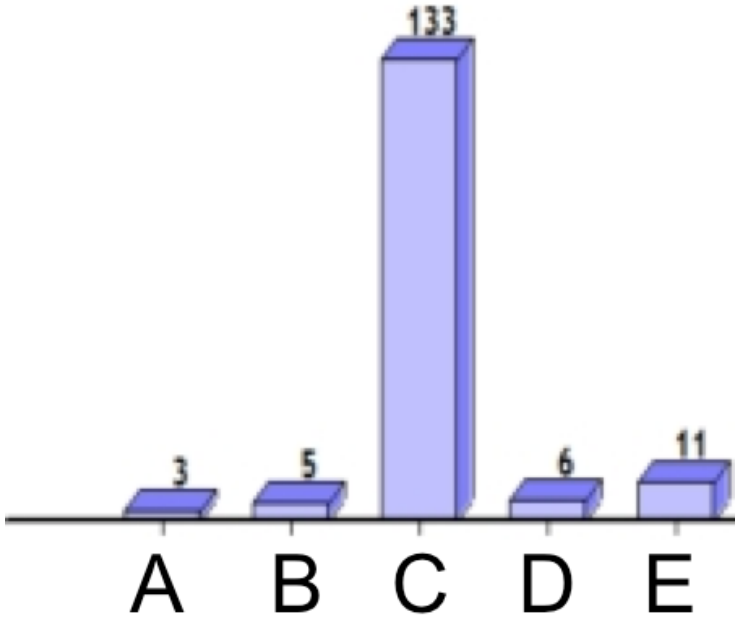
Does it matter if you show the histogram before discussion?

The research is mixed:

- One study showed that students tended to converge to the more common answer
- Another study didn't replicate those results.
- We think it's best to wait to show the histogram, to limit bias in discussions.

*Many of these results are from a recent review; Vickrey et al., CBE Life Sciences Education, 14(1) March 2015.*

What do you think you should do with this **first-vote** distribution?
(C is the correct answer)




A. "Turn to your neighbours and discuss the reasons for your answer"
B. Move on after a brief confirmation of correct answer
C. "Can someone share with us the reason for their answer?"
D. other

# Facilitation Tips for Success

#3: Don’t spend time going over things that students already know

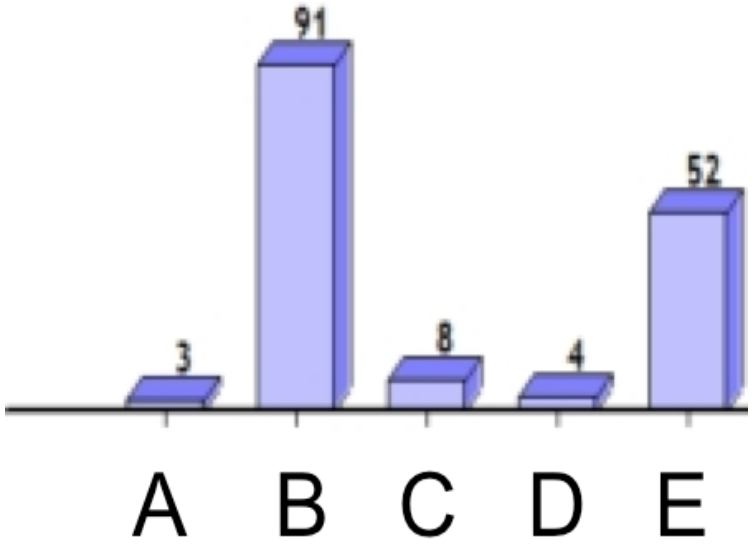
But do emphasize the reasoning behind the answers (why the wrong answer is wrong and why the right answer is right)

# Research tidbit

Should you have students discuss easy questions? No!

- Several studies confirm: students don't learn as much from talking to their neighbors on easy questions. Above 70% correct in initial vote – perhaps best to skip the peer discussion.

What do you think you should do with this **first-vote** distribution?




A. "You're split! Turn to your neighbors and discuss the reasons for your answer"
B. Move on after a brief confirmation of correct answer
C. "Can someone who answered either B or E explain the reasons for their answer?
D. other

# Facilitation Tips for Success

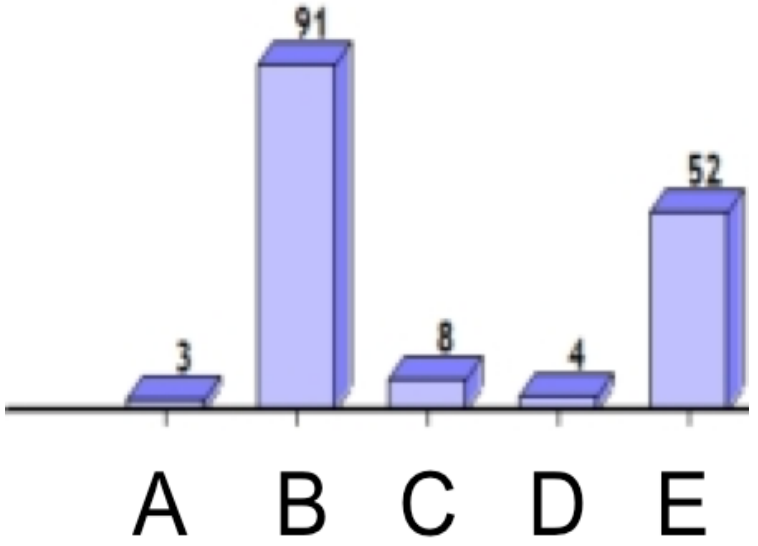
#4: Give students opportunity to discuss their reasons for answers whenever two or more votes, or an incorrect answer, are popular

# Research Tidbit

Should you have students discuss when most of them get the answer wrong? Yes!

- **Students learn from talking with each other,** even if none of them knew the answer before. Giving students more time to think about the question doesn't get the same results; learning gains are highest when students talk to one another.
- **Students learn the most when many students got the question initially wrong** (during the individual vote). Even when the majority of the class get the question wrong (e.g. less than 35%), students still get benefit from talking about each other about the question.

What do you think you should do when the **second vote** is the same as the first vote?




A. "You're still split! Why is B the right answer?"
B. "You're still split. The answer is B because…"
C. "Can someone who answered B tell us why they made that choice?"
D. "Can someone explain why somebody might vote for B or E?
E. other

# Facilitation Tips for Success

#5: Encourage them to rely on each other's ideas: let them explain their reasons to the rest of the class rather than YOU telling them more information

During the wrap-up discussion, focus on hearing students' ideas, rather than only giving your own explanation. But make sure that the correct answer is clear by the end of discussion.

Giving the answer stops student thinking!

# Student buy-in is key!

http://www.colorado.edu/sei/fac-resources/framing.html

https://www.physport.org/recommendations/Entry.cfm?ID=101163

# Facilitation Tips for Success

## #6: Encourage participation, likely with grading credit… but not too much credit!

Credit for participation is one way to communicate the value you place on the experience of peer instruction.

But too much credit, and students stress too much about getting the right answer. Consider the "whiff of credit."

# Research Tidbit

Should you give credit for correct answers?
Probably not…

- Several studies show that this changes the dynamics of the conversation, so that conversation is dominated by one student, and there is less rich peer discussion.

# Grading Methods

1. **Participation only** (no additional credit for correct answers):
    - Pro: likely to generate the most honest discussion and exchange of ideas
    - Con: students may not try as hard to achieve correct answer
2. **Participation with additional credit for correct answer**
    - Pro: students usually willing to work for a bonus
    - Con: students may just try to get “right” answer without really thinking about the reasons

# Ways of dealing with credit

- At the end of the semester, substitute the average clicker score for the worst homework score *if it is better.*
- Achieving 75% correct = full clicker credit (or some other scaling mechanism)

# Facilitation Tips for Success

## #7: Encourage participation in other ways

How might you motivate students, or communicate expectations?

# Other things we haven’t talked about?

- Things that you have seen and want to try?
- Things you have tried and it didn’t work?
- Other questions…?

# Will you modify this approach?

Honestly, I think that I'm most likely to modify this technique of peer instruction to suit me and my students. I probably *won't*….

A. Avoid factual recall questions
B. Ask 3-5 questions per lecture
C. Have students discuss with peers
D. Call on multiple students to share their reasoning
E. Other / more than one of the above

# Remember….

**Becoming a master clicker user is a process!**

- Talk to colleagues, watch other users, read research
- Start small and don’t aim for perfection yet
- Use Bloom’s Taxonomy to push questions higher
- Try questions in class and take notes on how it goes
- The perfect question doesn’t solve all problems!

# CU Clicker resources…

**Videos of effective use of clickers**

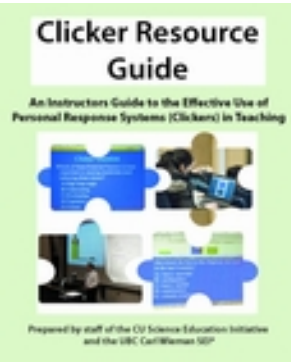
http://STEMvideos.colorado.edu

2-5 mins long

**Clicker resource page**

http://STEMclickers.colorado.edu

- Instructor's Guide
- Question banks
- Workshops
- Literature / Articles




**OIT clicker resource page**

http://www.colorado.edu/oit/services/teaching-learning-tools/cuclickers

**PhysPort Resources**

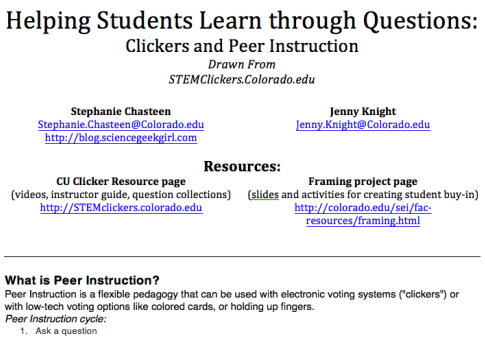
https://www.physport.org/methods/method.cfm?G=Peer_Instruction

# Variety of Handouts

Summary

Tips

Instructor Guide



Helping Students Learn through Questions:
Clickers and Peer Instruction
*Drawn From*
*STEMClickers.Colorado.edu*

**Stephanie Chasteen**
Stephanie.Chasteen@Colorado.edu
http://blog.sciencegeekgirl.com

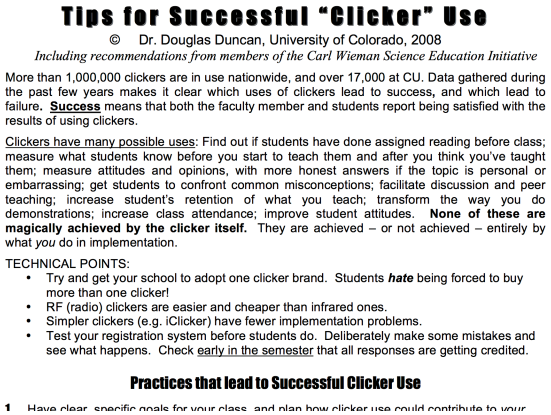
**Jenny Knight**
Jenny.Knight@Colorado.edu

**Resources:**

**CU Clicker Resource page**
(videos, instructor guide, question collections)
http://STEMclickers.colorado.edu

**Framing project page**
(slides and activities for creating student buy-in)
http://colorado.edu/sei/fac-resources/framing.html

**What is Peer Instruction?**
Peer Instruction is a flexible pedagogy that can be used with electronic voting systems ("clickers") or with low-tech voting options like colored cards, or holding up fingers.
*Peer Instruction cycle:*
1. Ask a question



**Tips for Successful "Clicker" Use**

© Dr. Douglas Duncan, University of Colorado, 2008
*Including recommendations from members of the Carl Wieman Science Education Initiative*

More than 1,000,000 clickers are in use nationwide, and over 17,000 at CU. Data gathered during the past few years makes it clear which uses of clickers lead to success, and which lead to failure. **Success** means that both the faculty member and students report being satisfied with the results of using clickers.

Clickers have many possible uses: Find out if students have done assigned reading before class; measure what students know before you start to teach them and after you think you've taught them; measure attitudes and opinions, with more honest answers if the topic is personal or embarrassing; get students to confront common misconceptions; facilitate discussion and peer teaching; increase student's retention of what you teach; transform the way you do demonstrations; increase class attendance; improve student attitudes. **None of these are magically achieved by the clicker itself.** They are achieved – or not achieved – entirely by what *you* do in implementation.

TECHNICAL POINTS:
- Try and get your school to adopt one clicker brand. Students ***hate*** being forced to buy more than one clicker!
- RF (radio) clickers are easier and cheaper than infrared ones.
- Simpler clickers (e.g. iClicker) have fewer implementation problems.
- Test your registration system before students do. Deliberately make some mistakes and see what happens. Check early in the semester that all responses are getting credited.

**Practices that lead to Successful Clicker Use**

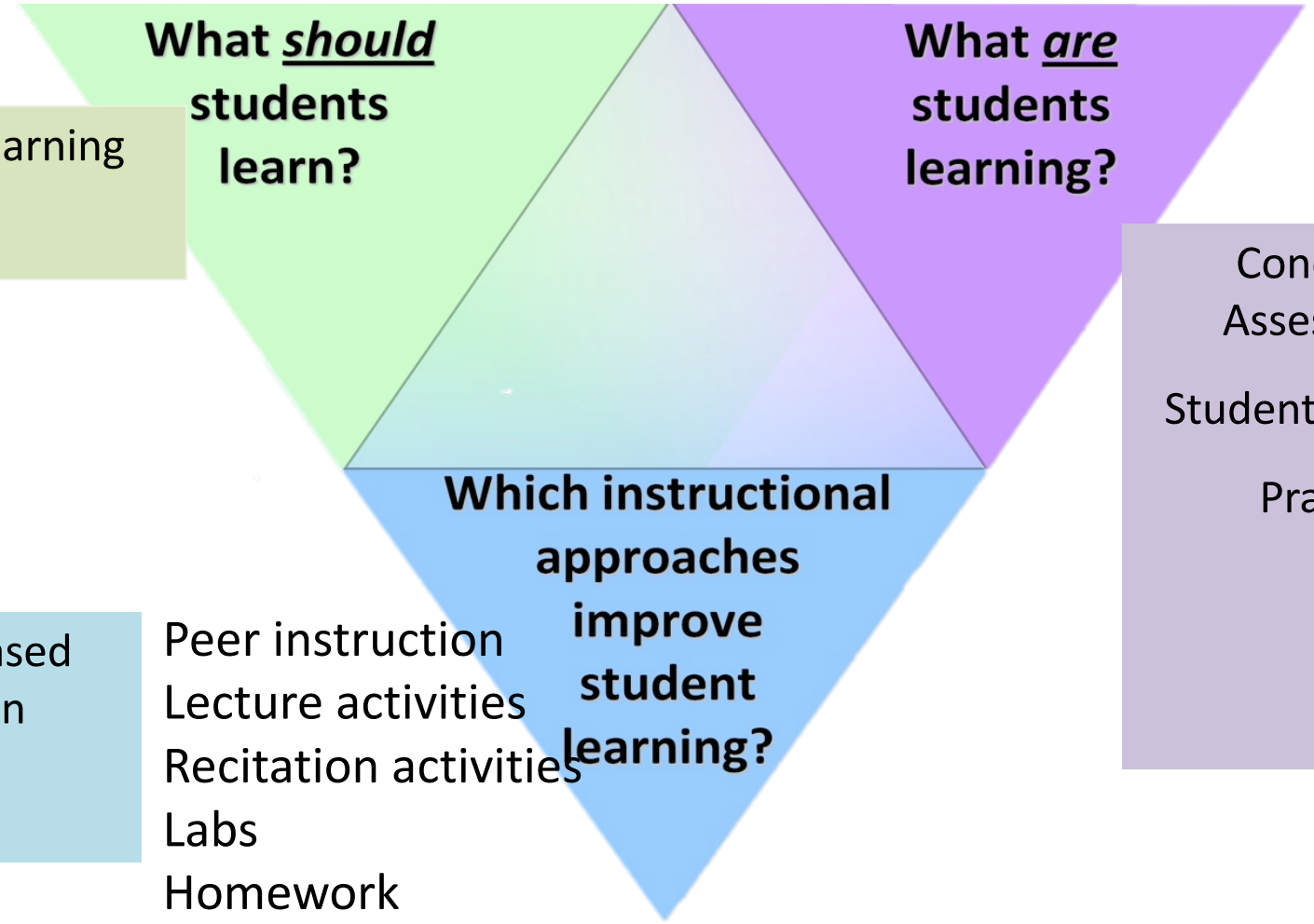
1 Have clear, specific goals for your class, and plan how clicker use could contribute to *your*

Clicker Resource Guide

An Instructors Guide to the Effective Use of Personal Response Systems (Clickers) in Teaching

Prepared by staff of the CU Science Education Initiative and the UBC Carl Wieman SEI

# Course transformation using Backwards Design




Consensus learning

Conceptual Assessments

Student Reasoning

Practices

…

Evidence-based Instruction

Peer instruction
Lecture activities
Recitation activities
Labs
Homework

SEI, C. Wieman et al, www.colorado.edu/sei

# What do you want them to learn today?

Learning goals and backwards course design

**Dr. Stephanie V. Chasteen**

*Physics Department & Science Education Initiative*
*Univ. of Colorado at Boulder*

**http://colorado.edu/sei**

# An issue…

We do not always design for what we value.

AND

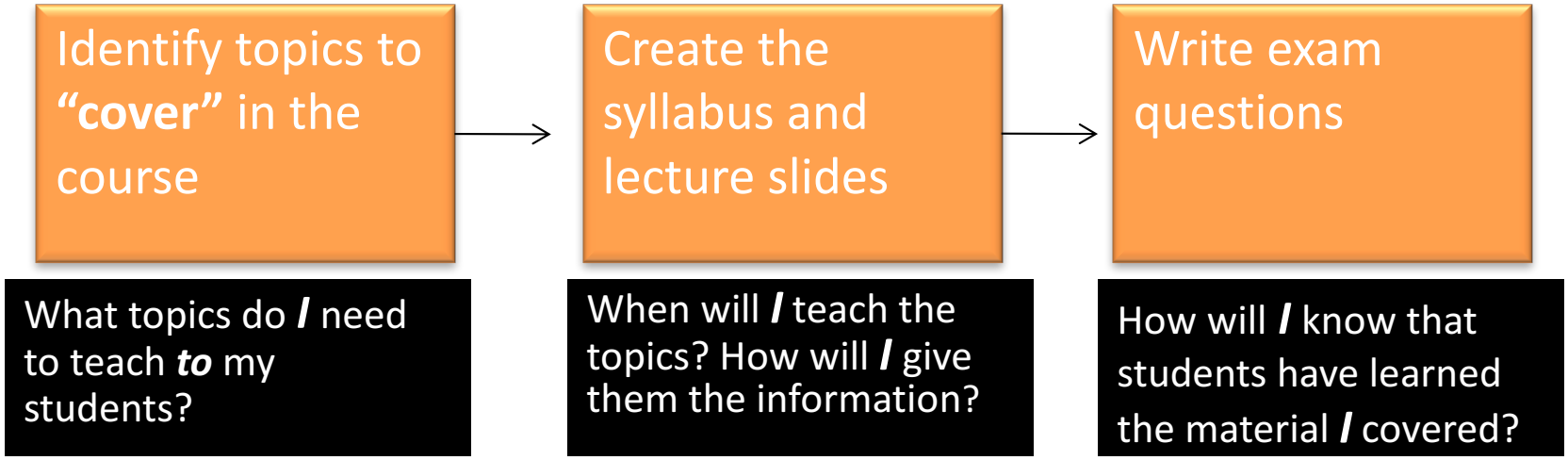
There is a huge disconnect between how students see the course and how we do. (They operate in a different reality!)

So… it's critical to be explicit about purpose and expectations.

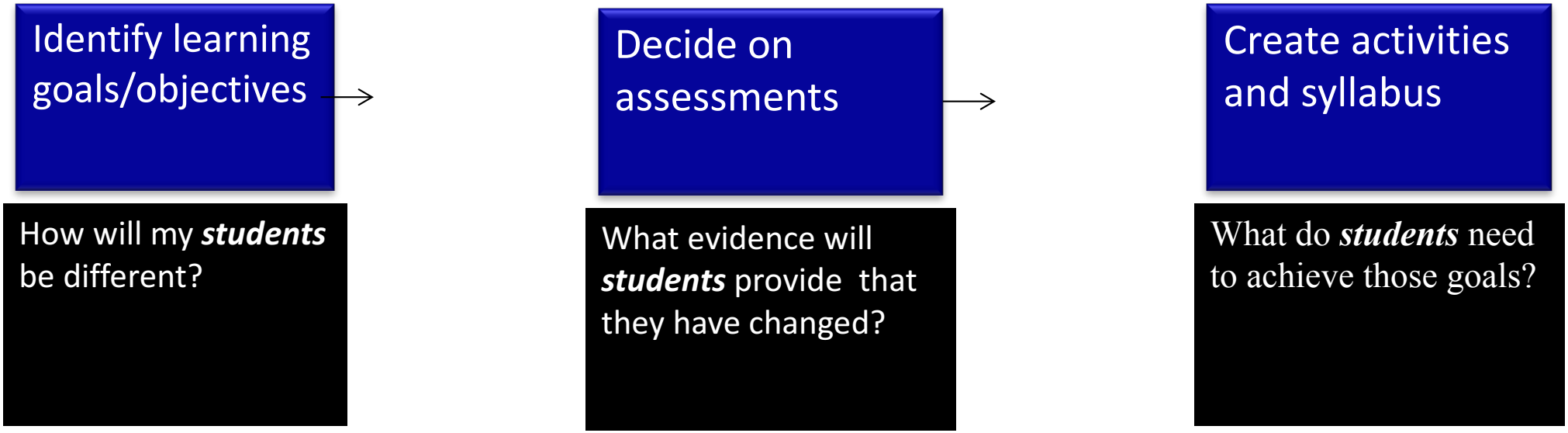
# What are learning goals?


- Work from the finish line, backward!
- What students should be able to DO
- Must be measurable!
- Reflects what you value in student learning

## Teacher Centered Approach

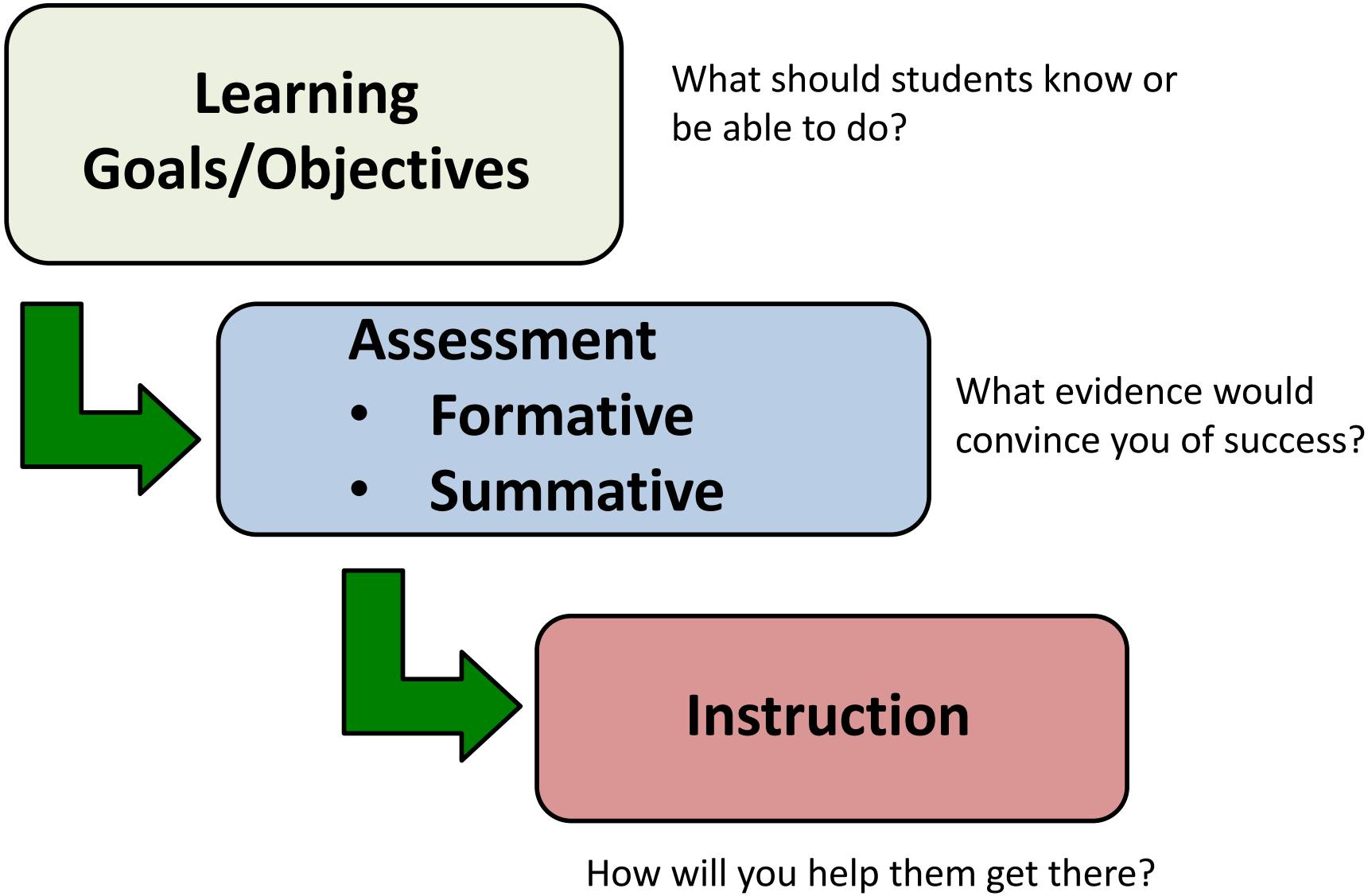



## Learner Centered Approach (Backward Course Design Model)



# The Backwards Design Process of course development

(When you teach, of course, you instruct and THEN assess)



# Terminology

**Learning Goal**: Broad description of what students will understand and learn : often COURSE LEVEL (usually 5-10 per course)

**Learning Objective**: specific, action-oriented description of what students will be able to do: often CLASS LEVEL (usually 2-5 per topic)

Must be MEASURABLE. This is not just a list of the syllabus topics, but statements of what students can do as a result of learning about the topic.

# Another example learning goal vs. objective

| Course learning goal | Topic level objectives |
| --- | --- |
| Students will apply problem solving techniques to simplify "real world" problems in terms of physics concepts | (Week 2: conservation laws)<br>Students will be able to:<br>• (week 2) recognize assumptions needed to apply conservation of mechanical energy<br>• (week 4) use a simple home heating model to calculate heat flow and associated heating bill |

Credit: UBC CWEI, www.cwsei.ubc.ca Phys100

# Course-scale goals for your class

**Write a few broad course-scale goals for your class that form the *driving goals* of your course: "Students should be able to…"**

**Talk to your disciplinary neighbor, if you have one.**

# Different kinds of learning goals/objectives

- **Content:**
  - Memorizing, explaining, analyzing, integrating
- **Skills:**
  - Demonstrating complex problem solving skills
- **Beliefs and affect:**
  - Thinking like a scientist, using scientific approaches
  - Appreciating/valuing/reflecting on science
- **Metacognition:**
  - Learning to learn, becoming an expert learner

Find these in the goals that were written. Are you missing any themes in your goals?

# Backwards Design & Alignment: An example

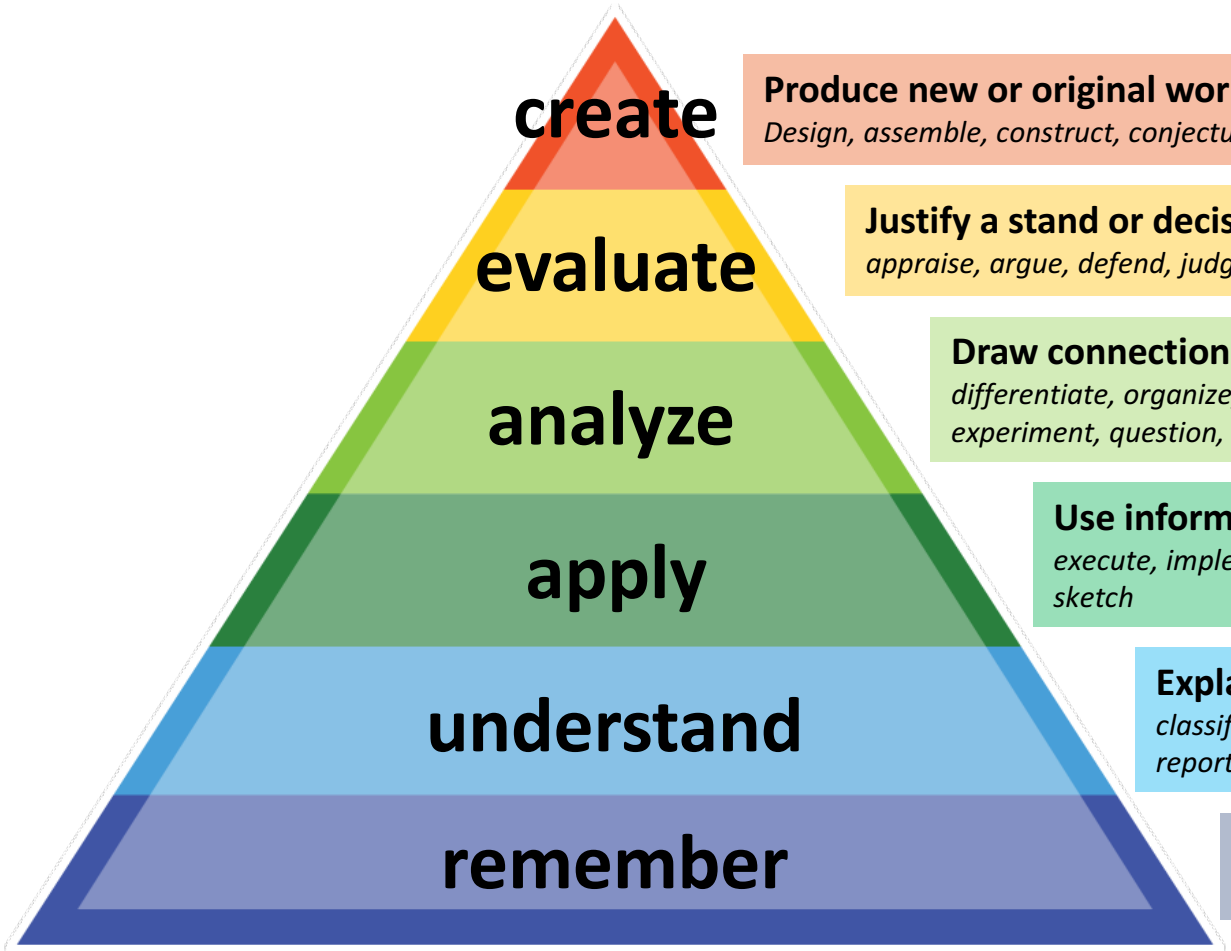
- Topic: Potential energy and equilibrium

| Learning goals | Assessment (Summative) | Instruction & formative assessment |
| --- | --- | --- |
| **Course goal: Interpret graphs, and use to predict behavior.** | **Exam: Interpret graphs of potential energy: Which of these points on the graph is stable? Why?** | **Group tutorial with topographic maps. HW problems give practice applying the analogy more broadly.** |

# Sketch out alignment for one of your goals!

| Learning goals | Assessment (Summative) | Instruction & formative assessment |
| --- | --- | --- |
| | | |

*Can the student…*




**Produce new or original work?**
*Design, assemble, construct, conjecture, develop, formulate, author, investigate*

**Justify a stand or decision?**
*appraise, argue, defend, judge, select, support, value, critique, weigh*

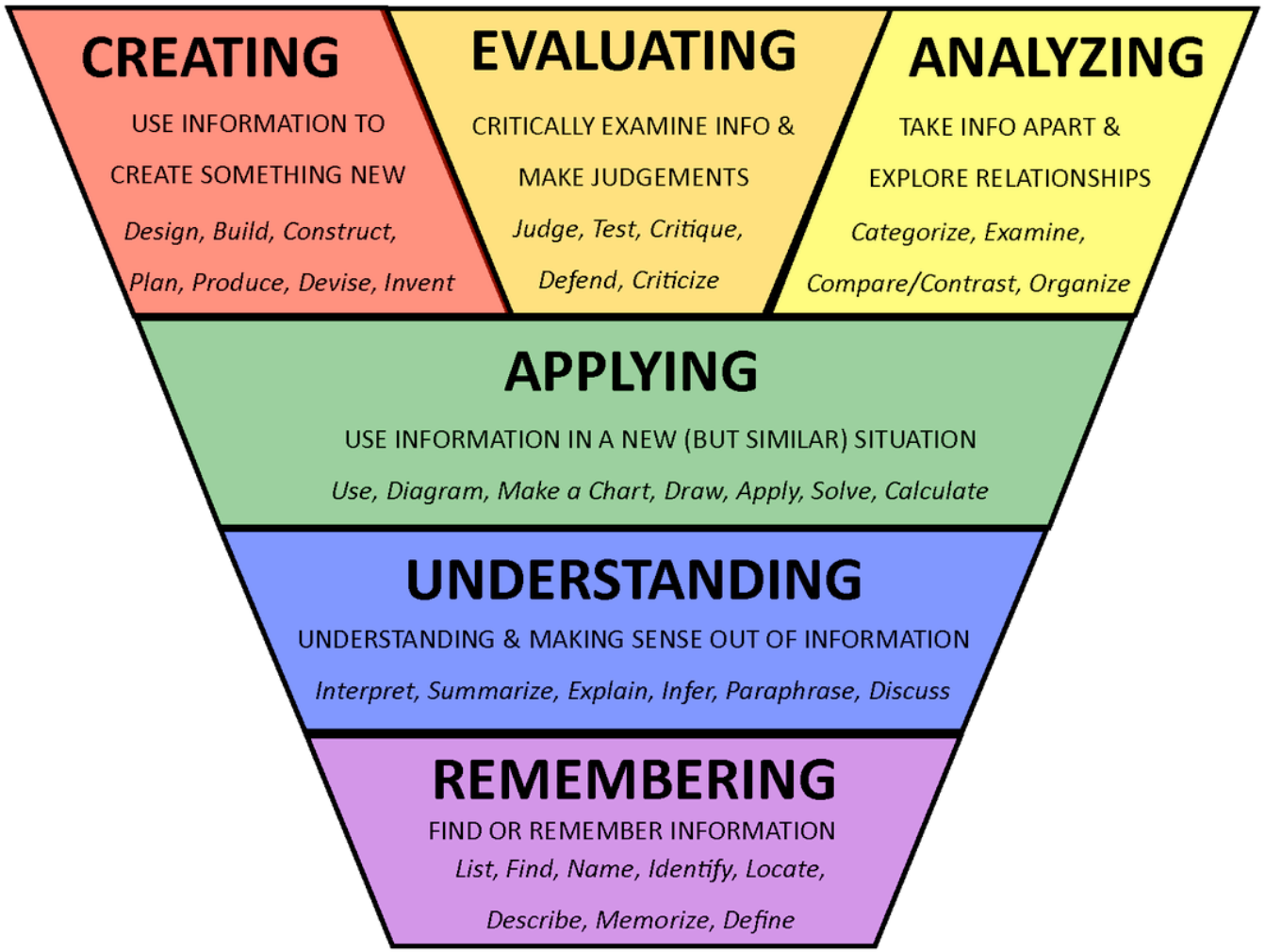
**Draw connections among ideas?**
*differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test*

**Use information in new situations?**
*execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch*

**Explain ideas or concepts?**
*classify, describe, discuss, explain, identify, locate, recognize, report, select, translate*

**Recall facts and basic concepts?**
*define, duplicate, list, memorize, repeat, state*

# Flip it?


CREATING
USE INFORMATION TO CREATE SOMETHING NEW
Design, Build, Construct, Plan, Produce, Devise, Invent
EVALUATING
CRITICALLY EXAMINE INFO & MAKE JUDGEMENTS
Judge, Test, Critique, Defend, Criticize
ANALYZING
TAKE INFO APART & EXPLORE RELATIONSHIPS
Categorize, Examine, Compare/Contrast, Organize
APPLYING
USE INFORMATION IN A NEW (BUT SIMILAR) SITUATION
Use, Diagram, Make a Chart, Draw, Apply, Solve, Calculate
UNDERSTANDING
UNDERSTANDING & MAKING SENSE OUT OF INFORMATION
Interpret, Summarize, Explain, Infer, Paraphrase, Discuss
REMEMBERING
FIND OR REMEMBER INFORMATION
List, Find, Name, Identify, Locate, Describe, Memorize, Define

# *Bloom's Revised Taxonomy*
# *Cognitive Process Definitions*

| Knowledge Category | Definition | Other example verbs |
|---|---|---|
| **Remember** | Retrieve relevant knowledge from long term memory | Retain, recall, recognize, memorize, recollect, think of, identify |
| **Understand** | Construct meaning from instructional messages, oral, written, or graphic | Interpret, exemplify, classify, summarize, infer, compare, explain, describe |
| **Apply** | Carry out procedures | Execute, implement |
| **Analyze** | Break material into parts and determine relationships | Differentiate, organize, attribute |
| **Evaluate** | Make judgments based upon criteria or standards | Check, critique, assess, judge, appraise |
| **Create** | Put elements together into a coherent or functional whole, reorganize into new patterns | Generate, plan, produce, invent |

# You can look at your goals through these two lenses: Level, and type of knowledge.

| | | Cognitive Process Dimension | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1. Remember | 2. Understand | 3. Apply | 4. Analyze | 5. Evaluate | 6. Create |
| Knowledge Dimension | A. Content | | | | | | |
| | B. Skills | | | | | | |
| | C. Belief/affect | | | | | | |
| | D. Meta-Cognitive | | | | | | |

Anderson, Lorin W., David R. Krathwohl, and Benjamin Samuel Bloom. *A Taxonomy for Learning, Teaching, and Assessing : A Revision of Bloom's Taxonomy of Educational Objectives*. Abridged ed. New York: Longman 2001.

# Check-list for refining **topic-scale** learning objectives:

- ✓ Is goal expressed in terms of **what the student will achieve** or be able to do?
- ✓ Is the goal **well-defined?** Is it clear how you would measure achievement?
- ✓ Do chosen verbs have a **clear** meaning?
- ✓ Is **terminology familiar**/common? If not, is the terminology itself a goal?
- ✓ Does the goal **align** with your course-scale goals?
- ✓ Is the **Bloom's level** of the goal appropriate? (Is it aligned with your actual expectations, and with student ability?) Do your goals cover a range of levels?
- ✓ Do your goals cover a **range of types of knowledge?**
- ✓ **Is it relevant and useful** to students?

# Lots of resources to help you

http://colorado.edu/sei/fac-resources/guide.html

Center for STEM Learning

UNIVERSITY OF COLORADO **BOULDER**

# Action Plan

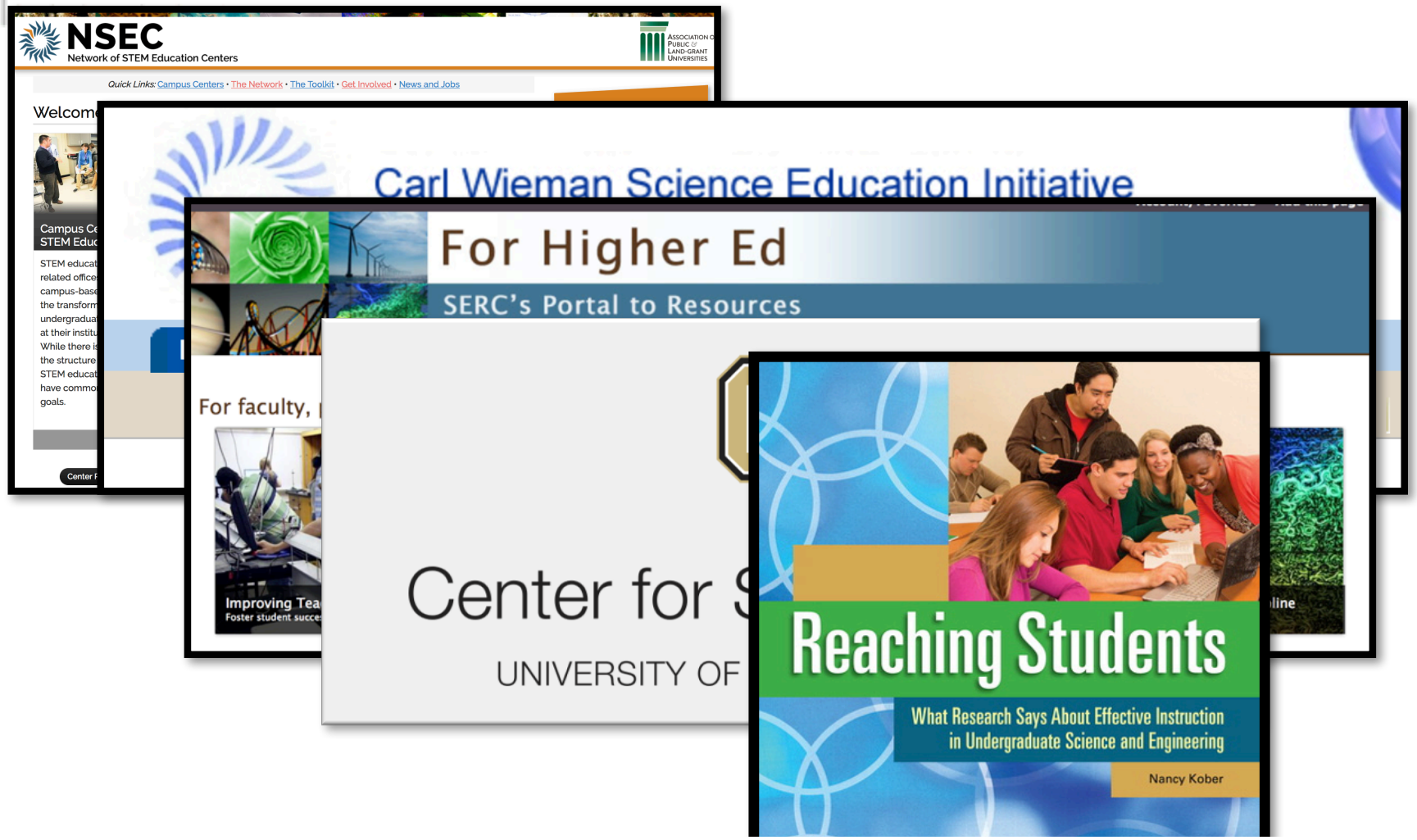
- Take a few minutes to write down your action plan to implement ideas you heard about in this part of the workshop.
- Email it to yourself!

***Thank you!***

# Many resources for change

Association of American Universities

## STEM Education Initiative



# Best resources are here…

Caltech Center for Teaching, Learning & Outreach

Resources Faculty TAs Students Outreach Technology Caltech Project for Effective Teaching Core

TeachWeek 2017 About CTLO Events Announcements

Planning & Teaching Courses | Teaching for Inclusion & Diversity | Books & Articles | Teaching Awards | Photographs

## LINKS TO CALTECH TEACHING AND LEARNING RESOURCES

**Please explore CTLO's on-demand resources on teaching in the following areas:**

- **Planning and Teaching Courses**
- **Teaching for Inclusion and Diversity**
- **Books and Articles**
- **Caltech Teaching Awards**

**The offices below also support teaching and learning through services and resources for students and faculty:**

- **Academic Media Technologies**: audio visual services and digital media solutions, strategies, and recommendations.
- **Center for Diversity**: leadership, outreach, policy and programming support for the campus-wide diversity initiatives associated with faculty, postdoctoral scholars, students and staff.
- **Counseling Center**: free for all students, regardless of insurance plan.
- **Dean's Office, Undergraduates**:

*Fin*

Much more at: *per.colorado.edu*

*noah.finkelstein@colorado.edu*