

# Peer Instruction Workshop



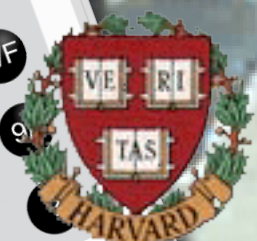
# Peer

# INSTRUCTION

Includes  
Class-Tested,  
Ready-to-Use  
Resources

A User's Manual

# ERIC MAZUR



Seminario Internacional:  
Metodologías Activas y Evaluación de Aprendizaje  
Santiago, Chile, 18 de julio 2011

# Introduction

**Write down some of the skills that brought you where you are — something you are good at, something that you know you do well.**

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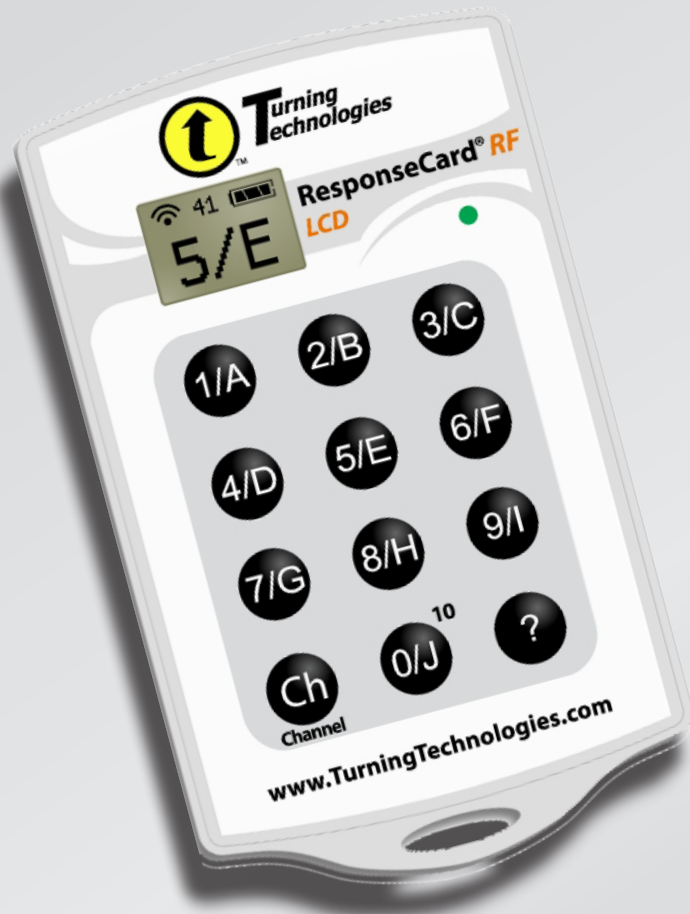
***How did you become good at this?***

# How do we learn?

**I learned it:**

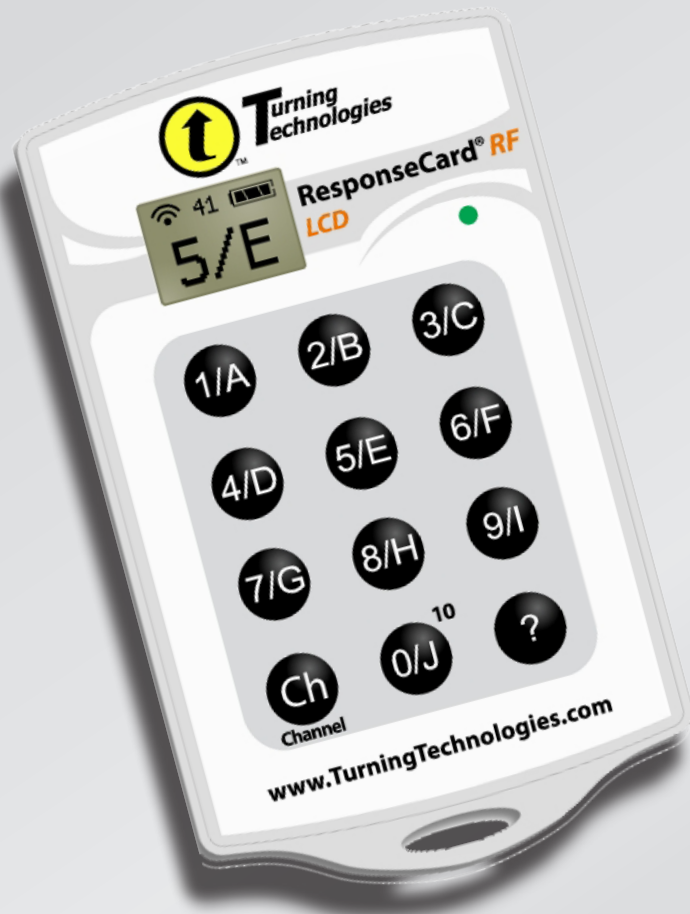
- A. by practicing**
- B. in lectures**
- C. by doing it (trial and error)**
- D. other**

# Get your clickers ready!



- no ON/OFF button
- only last "click" counts
- display shows recorded answer

# Get your clickers ready!



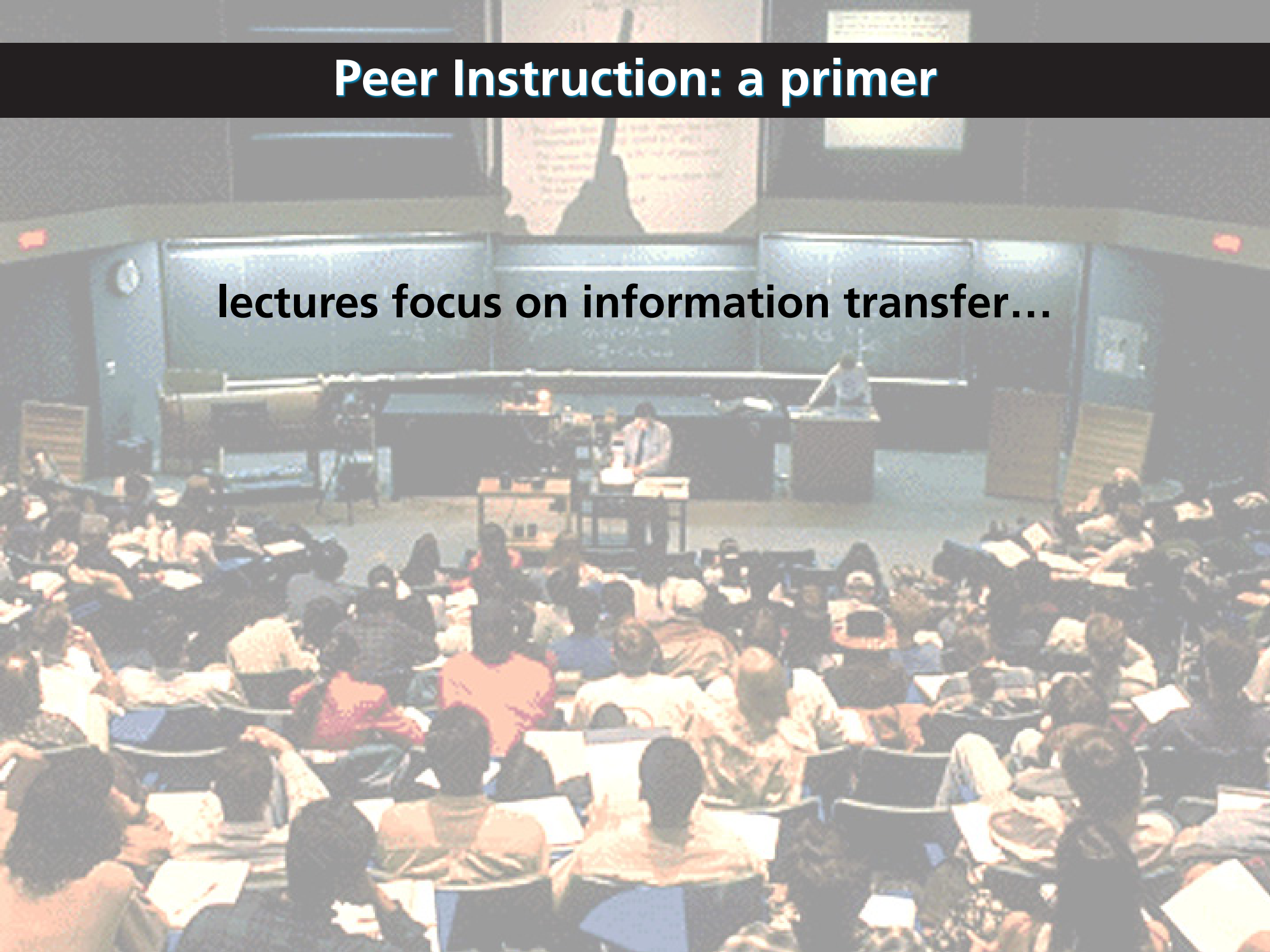
Can also use any web-enabled device!

- go to <http://rwpoll.com>
- enter session ID: **EMAZUR**

[rwpoll.com](http://rwpoll.com)

# Peer Instruction: a primer

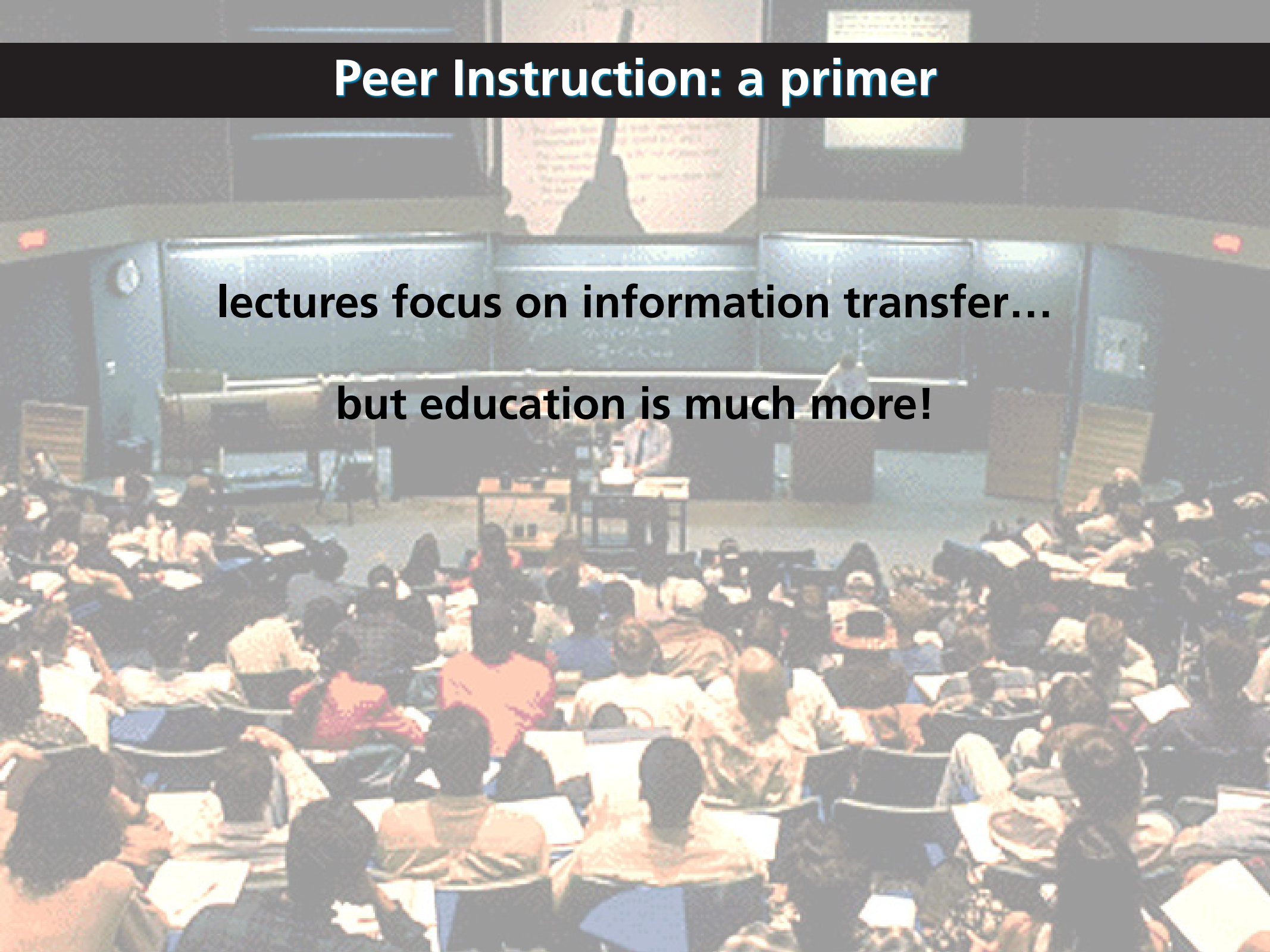
lectures focus on information transfer...



# Peer Instruction: a primer

lectures focus on information transfer...

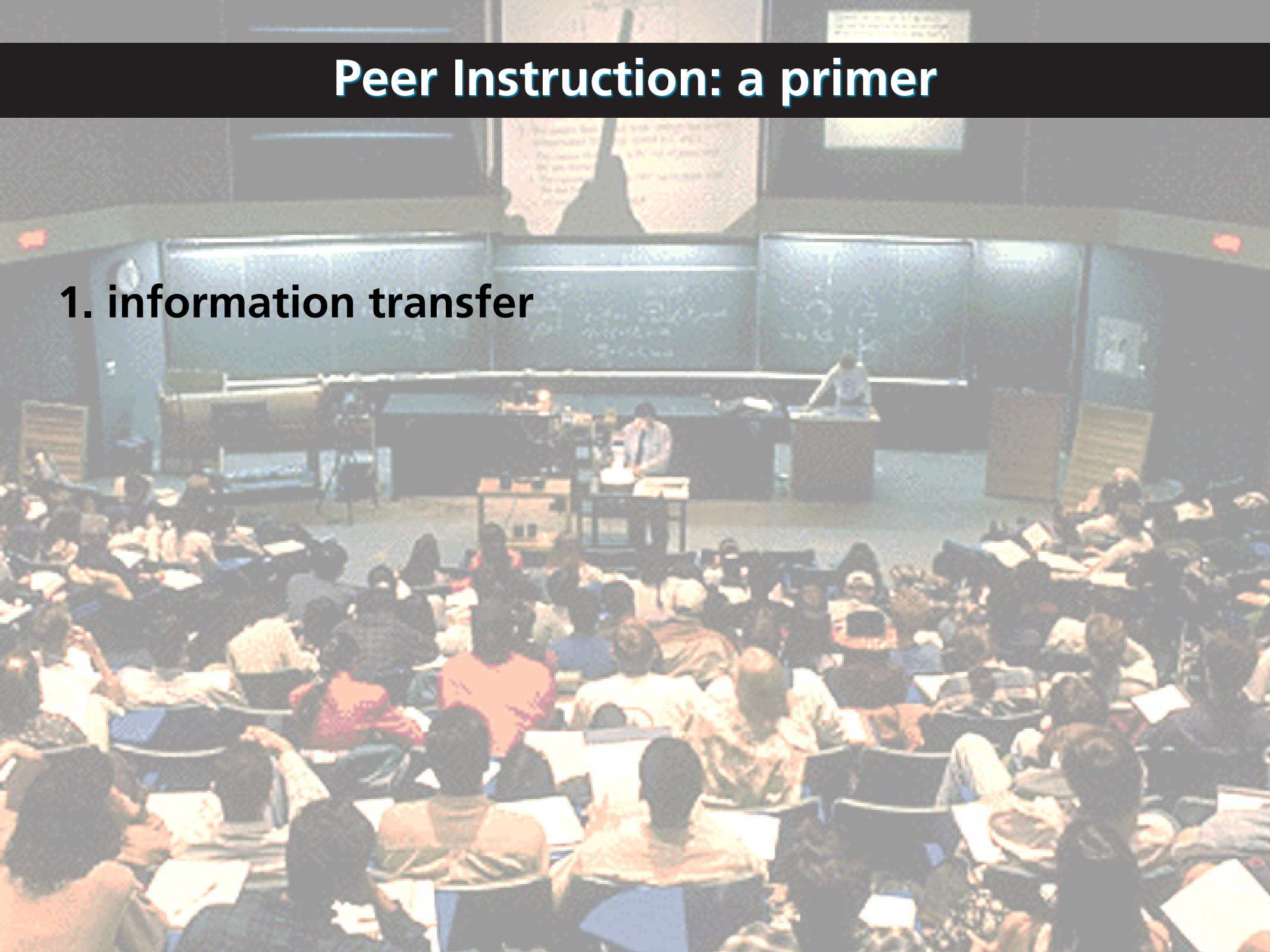
but education is much more!





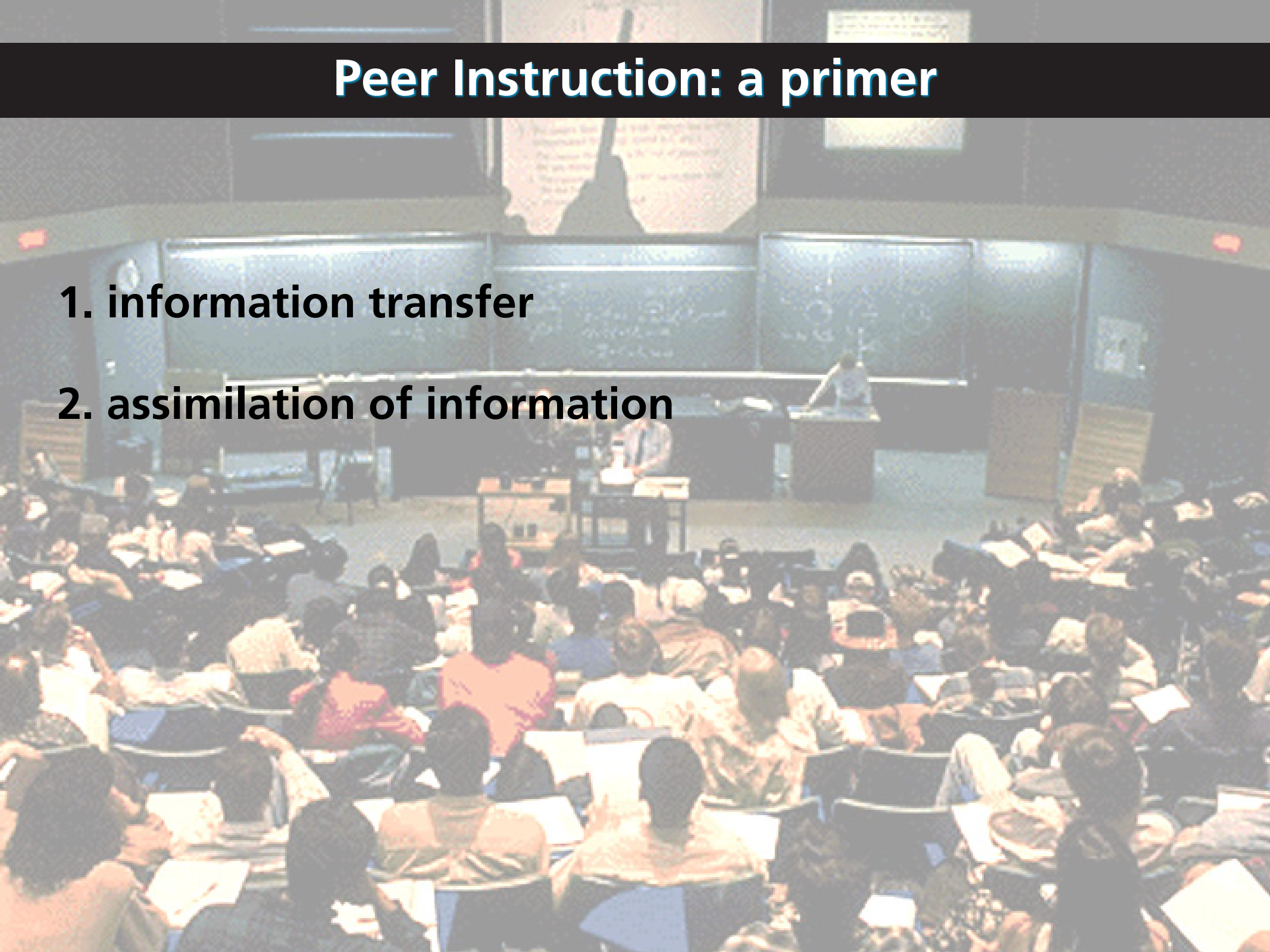
# Peer Instruction: a primer

## 1. information transfer



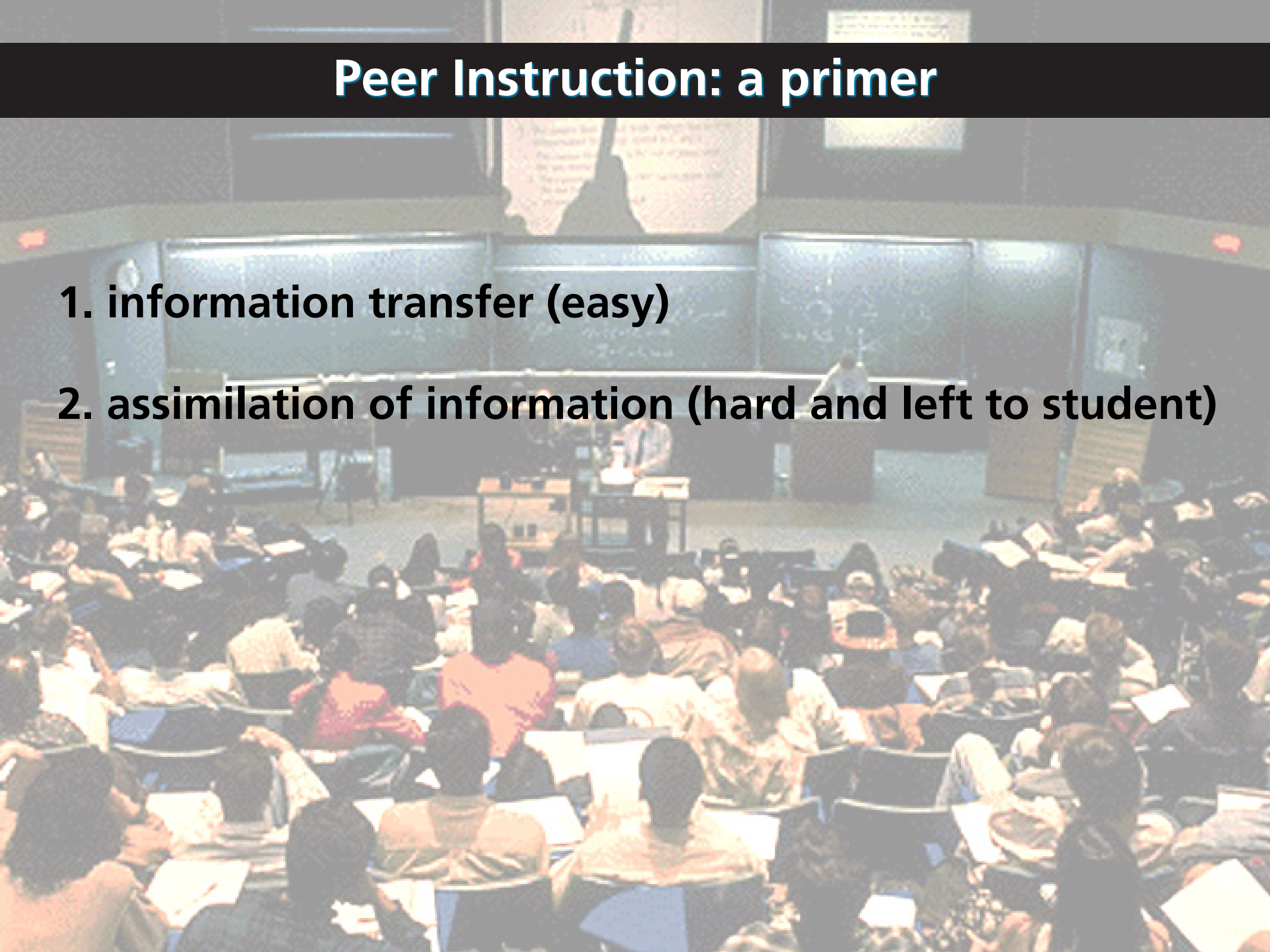
# Peer Instruction: a primer

1. information transfer
2. assimilation of information



# Peer Instruction: a primer

1. information transfer (easy)
2. assimilation of information (hard and left to student)



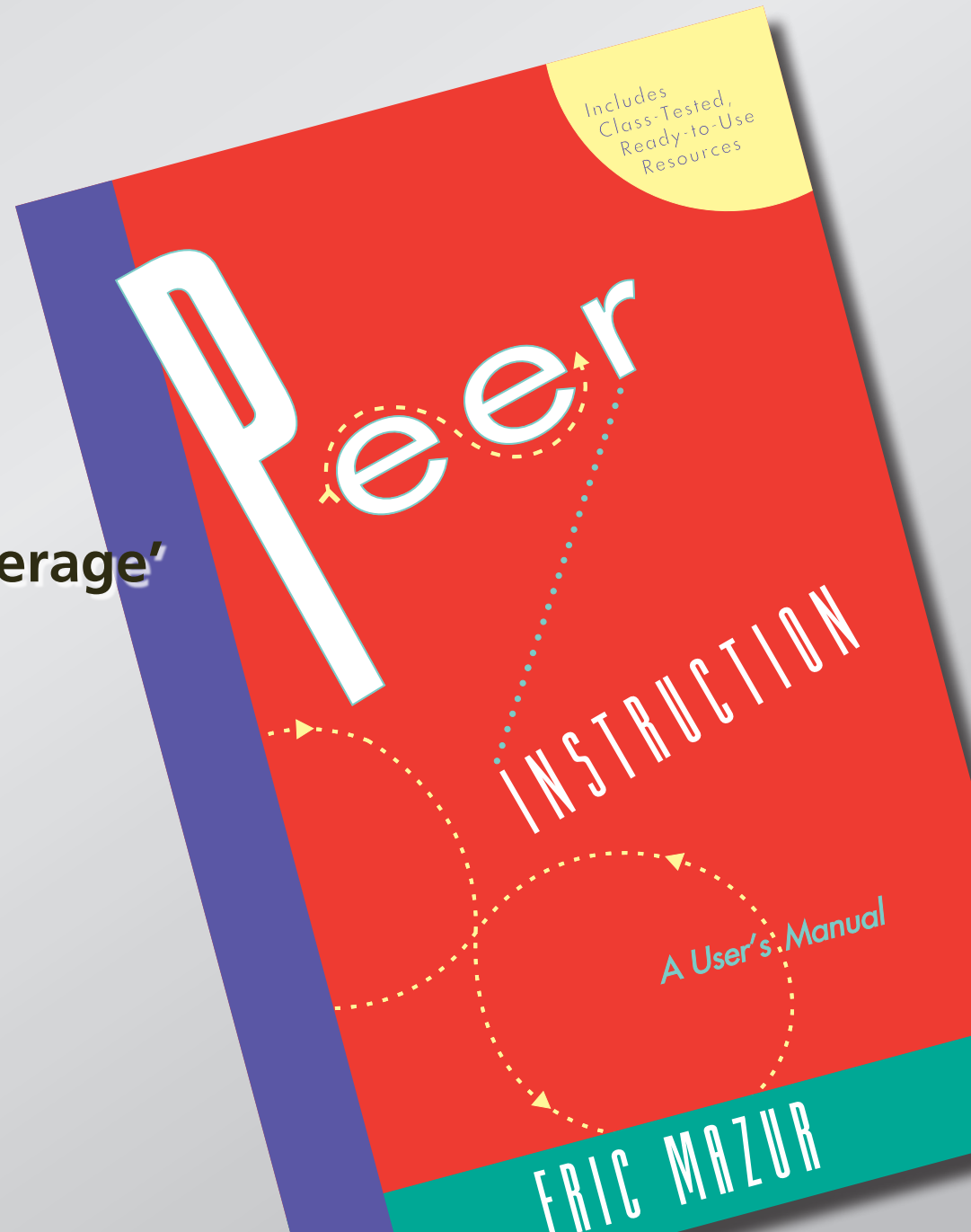
# Peer Instruction: a primer

**Solution: move information transfer out of classroom!**

# Peer Instruction: a primer

## Main features:

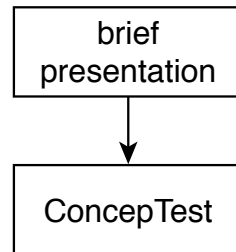
- pre-class reading
- in-class: depth, not 'coverage'
- ConcepTests



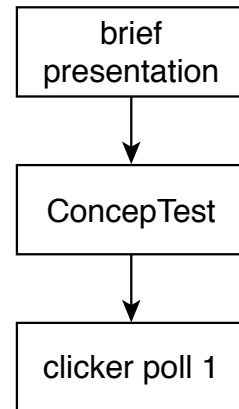
# Peer Instruction: a primer

brief  
presentation

# Peer Instruction: a primer

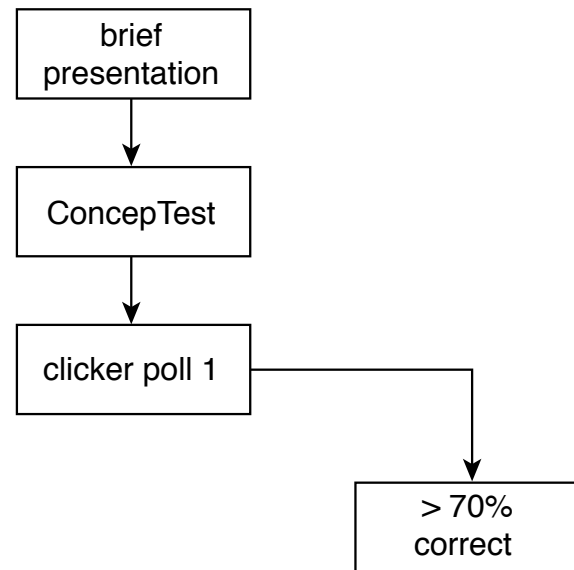


# Peer Instruction: a primer

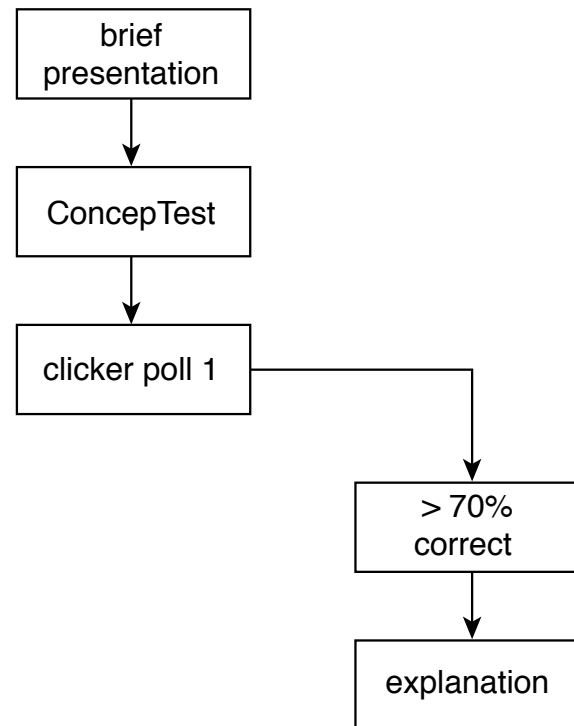




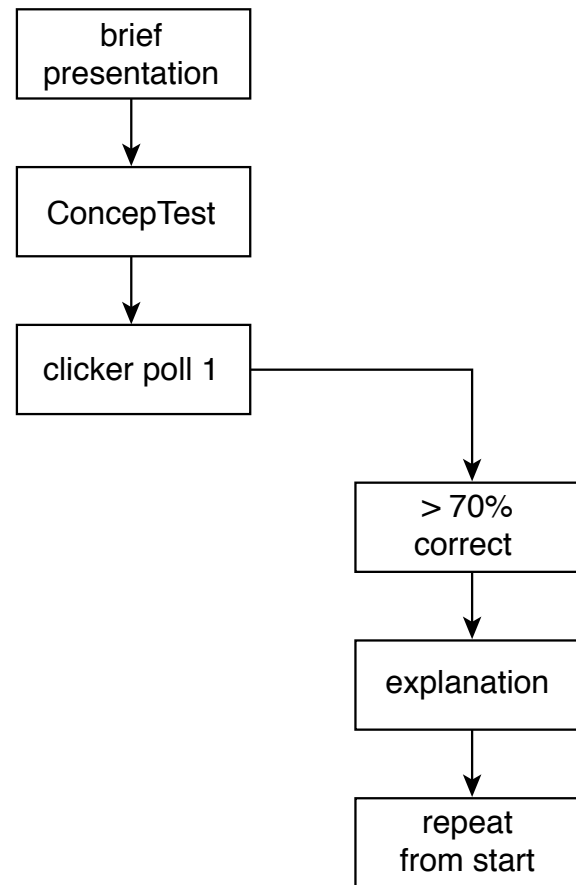
# Peer Instruction: a primer



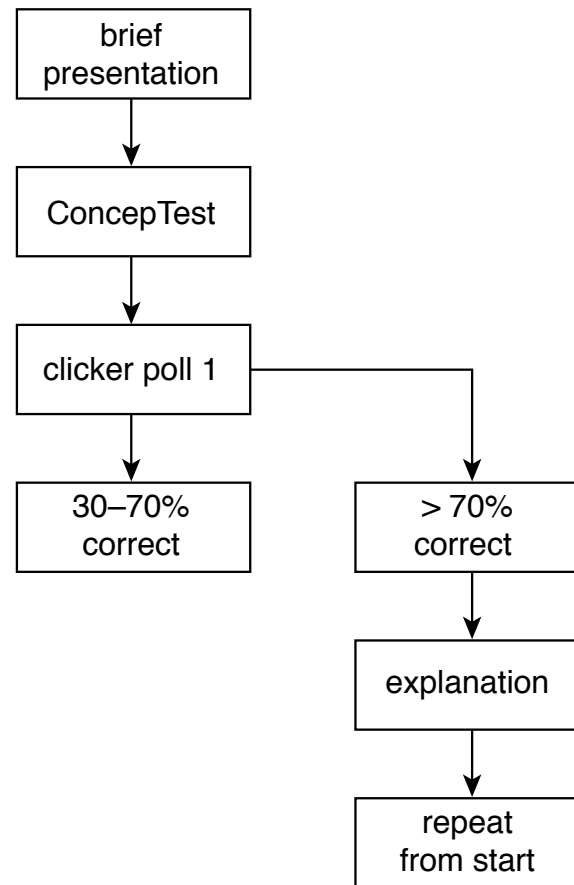
# Peer Instruction: a primer



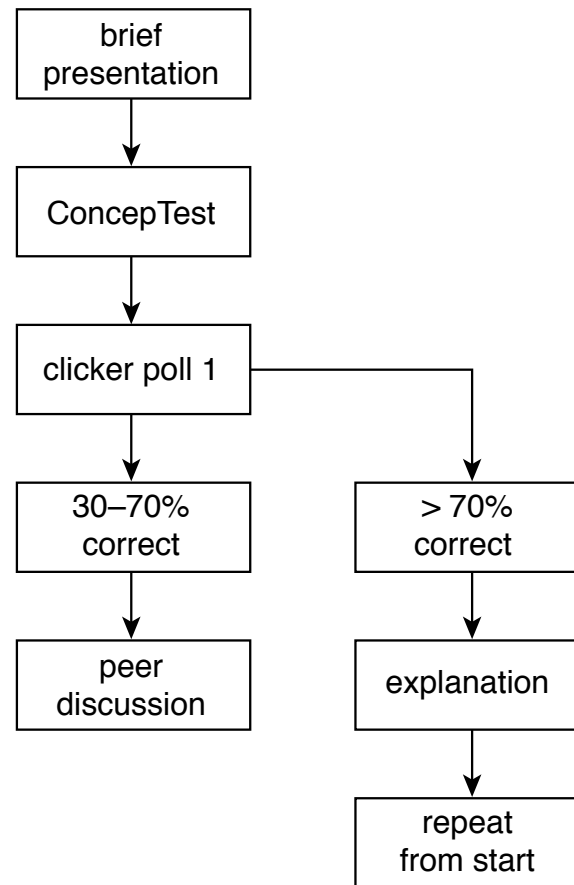
# Peer Instruction: a primer



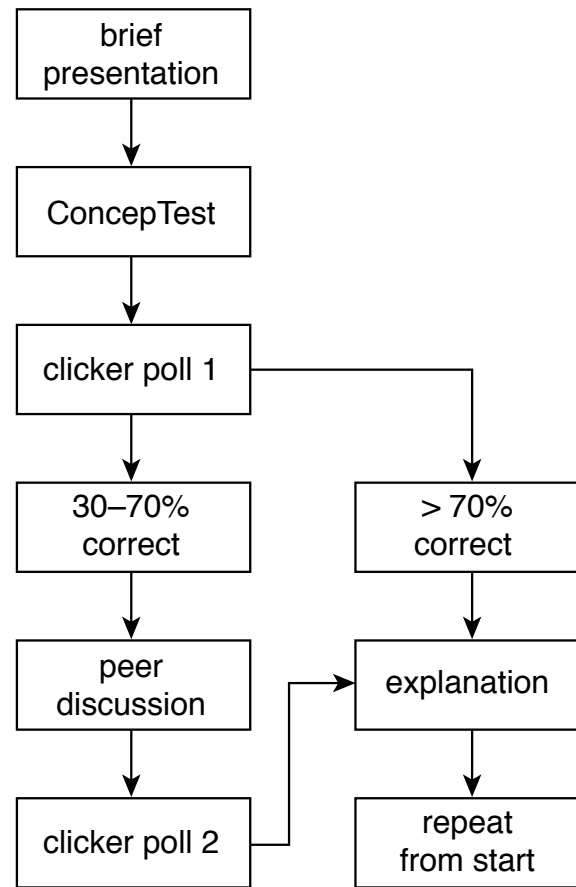
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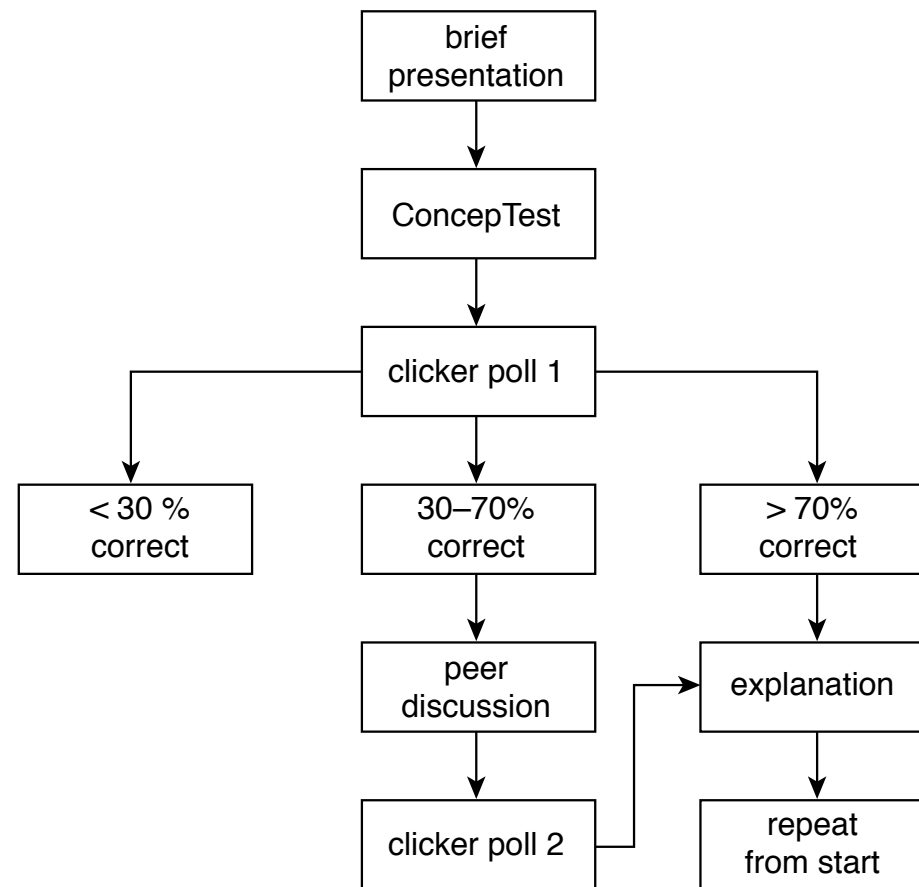
# Peer Instruction: a primer



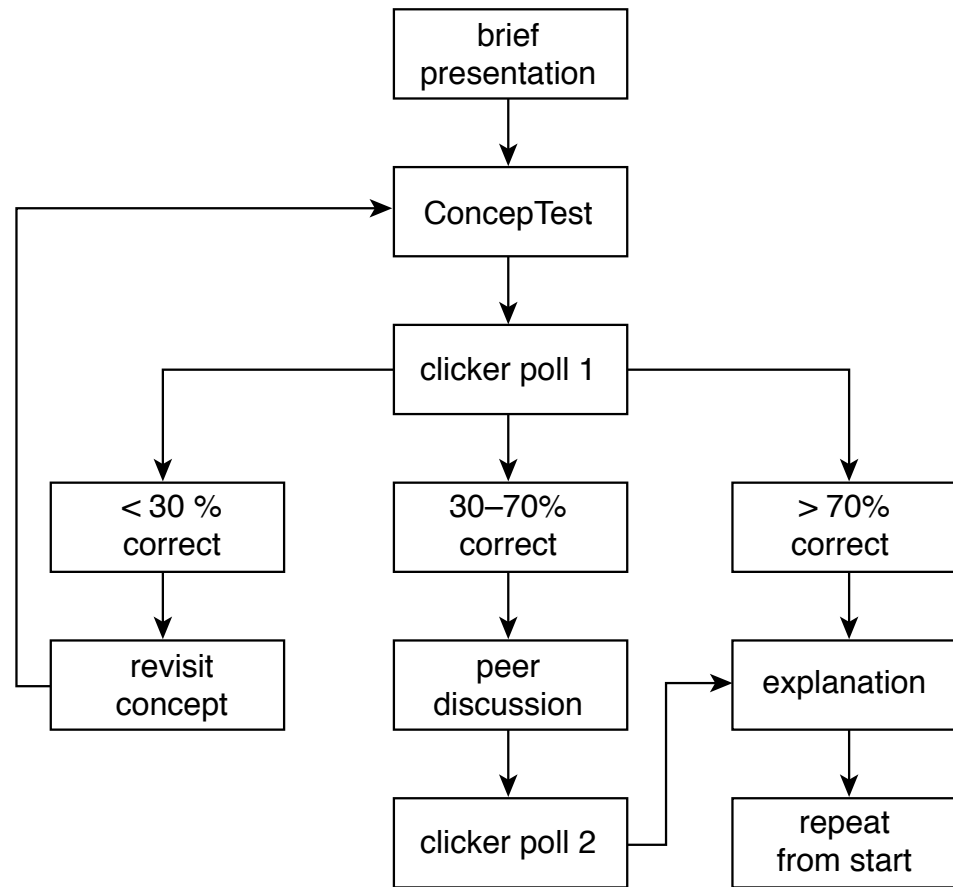
# Peer Instruction: a primer



# Peer Instruction: a primer



# Peer Instruction: a primer





# Introduction

**Questioning provides:**

- **a learning opportunity**
- **realization of gaps in knowledge**
- **reconsolidation opportunity**

# Introduction

## Retrieval Practice Produces More Learning than Elaborative Studying with Concept Mapping

Jeffrey D. Karpicke\* and Janell R. Blunt

Educators rely heavily on learning activities that encourage elaborative studying, whereas activities that require students to practice retrieving and reconstructing knowledge are used less frequently. Here, we show that practicing retrieval produces greater gains in meaningful learning than elaborative studying with concept mapping. The advantage of retrieval practice generalized across texts identical to those commonly found in science education. The advantage of retrieval practice was observed with test questions that assessed comprehension and required students to make inferences. The advantage of retrieval practice occurred even when the criterial test involved creating concept maps. Our findings support the theory that retrieval practice enhances learning by retrieval-specific mechanisms rather than by elaborative study processes. Retrieval practice is an effective tool to promote conceptual learning about science.

Most thought on human learning is guided by a few tacit assumptions. One assumption is that learning happens primarily when people encode knowledge and experiences. A related assumption is that retrieval—the active, cue-driven process of reconstructing knowledge—only measures the products of a previous learning experience but does not itself produce learning. Just as we assume that the act of measuring a physical object would not change the size, shape, or weight of the object, so too people often assume that the act of measuring memory does not change memory (1, 2). Thus, most educational research and practice has focused on enhancing the processing that occurs when students encode knowledge—that is, getting knowledge “in memory.” Far less attention has been paid to the potential importance of retrieval to the process of learning. Indeed, recent National Research Council books

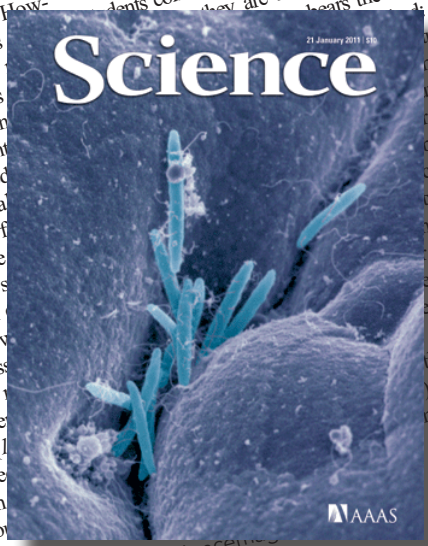
about how students learn in educational settings (3–5) contain no mention of retrieval processes. It is beyond question that activities that promote effective encoding, known as elaborative study tasks, are important for learning (6). However, research in cognitive science has challenged the assumption that retrieval is and uninfluential in the learning process. Not only does retrieval produce learning, a retrieval event may actually represent a powerful learning activity than an encoding event. This research suggests a conceptual model and learning that is different from which encoding places knowledge in memory and retrieval simply accesses that knowledge. Because each act of retrieval is considered essential to the processing of memory, the act of reconstructing knowledge is considered essential to the process.

Most previous research on retrieval has been conducted in the laboratory. The conditions of memory research that have been used have often not reflected the conditions in which students learn in educational settings (13). Most previous

used assessments thought to measure meaningful learning, which refers to students’ abilities to make inferences and exhibit deep understanding of concepts (14, 15). Perhaps the greatest impediment to broad application of retrieval practice, though, is that we do not know whether retrieval activities are more effective than other active, elaborative learning activities. Retrieval practice might produce levels of learning that are essentially the same as those produced by elaborative studying. Alternatively, if there are retrieval-specific mechanisms that promote learning, then retrieval practice may represent a way to promote student learning that goes beyond elaborative study activities used in science education.

The present experiments put retrieval practice to a test. Elaborative learning activities hold a central place in contemporary education. We examined the effectiveness of retrieval practice relative to elaborative studying with concept mapping (16–18). In concept mapping, students construct a diagram in which nodes are used to represent concepts, and links connecting the nodes represent relations among the concepts. Concept mapping is considered an active learning task, and it serves as an elaborative study activity when students construct concept maps in the presence of other students who are learning. Under these conditions, students construct concept maps that bears the defining characteristics of meaningful learning: It requires students to make inferences and exhibit deep understanding of concepts. The present experiments put retrieval practice to a test. Elaborative learning activities hold a central place in contemporary education. We examined the effectiveness of retrieval practice relative to elaborative studying with concept mapping (16–18). In concept mapping, students construct a diagram in which nodes are used to represent concepts, and links connecting the nodes represent relations among the concepts. Concept mapping is considered an active learning task, and it serves as an elaborative study activity when students construct concept maps in the presence of other students who are learning. Under these conditions, students construct concept maps that bears the defining characteristics of meaningful learning: It requires students to make inferences and exhibit deep understanding of concepts.

# Science



# Introduction

To Really Learn, Quit Studying and Take a Test  
(New York Times, Jan 21, 2011)



The New York Times

## Learning Through Testing

Researchers asked college students to study a short science text using one of four study methods, then tested them a week later. The most effective study method combined two study sessions with retrieval practice, tests that asked the students to recall what they had read.

STUDY METHOD

One study session  
Concept mapping  
Retrieval practice  
Repeated study

Direct questions  
answered correctly

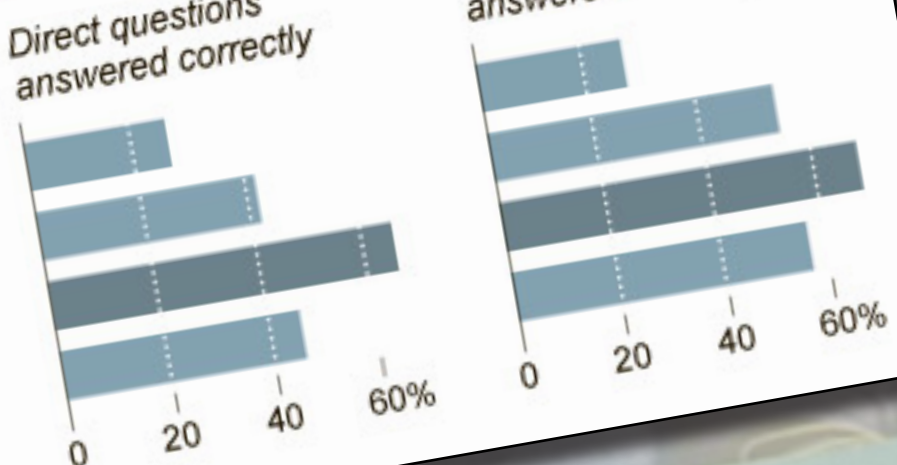
0 20 40 60%

Inference questions  
answered correctly

0 20 40 60%

Source: Science

January 21, 2011



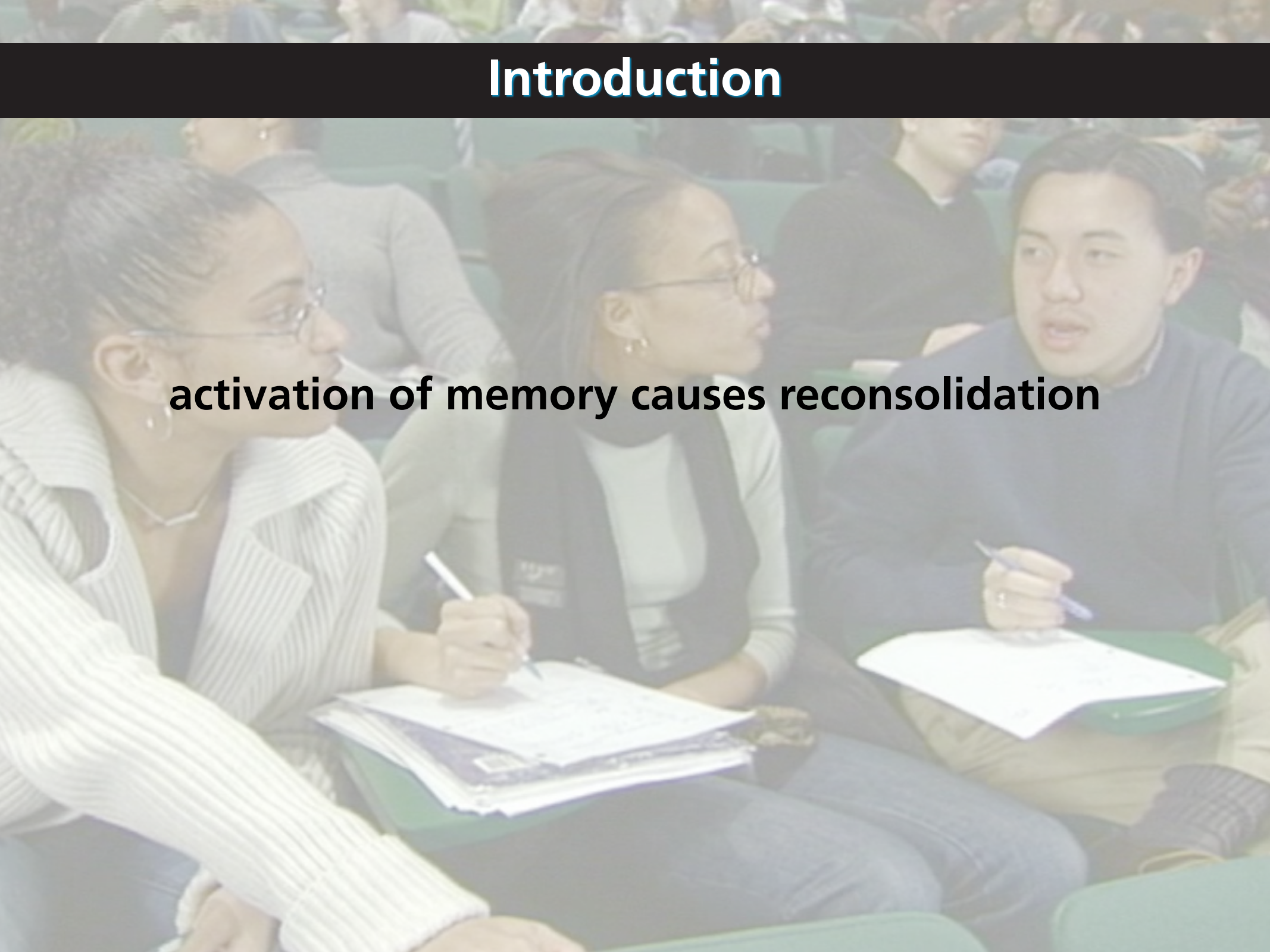
# Introduction

**“These other methods not only are popular, the researchers reported; they also seem to give students the illusion that they know material better than they do.**

**In the experiments, the students were asked to predict how much they would remember a week after using one of the methods to learn the material. Those who took the test after reading the passage predicted they would remember less than the other students predicted — but the results were just the opposite.”**

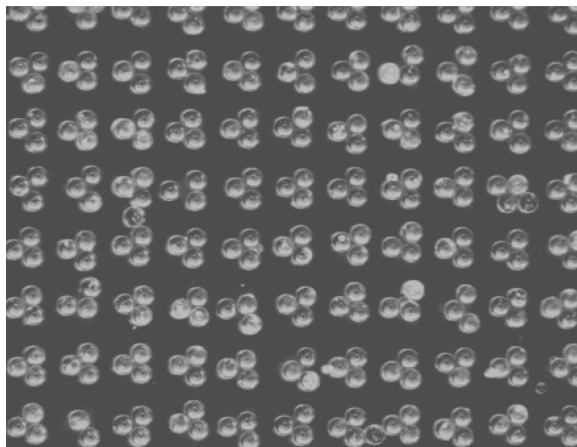
# Introduction

**activation of memory causes reconsolidation**

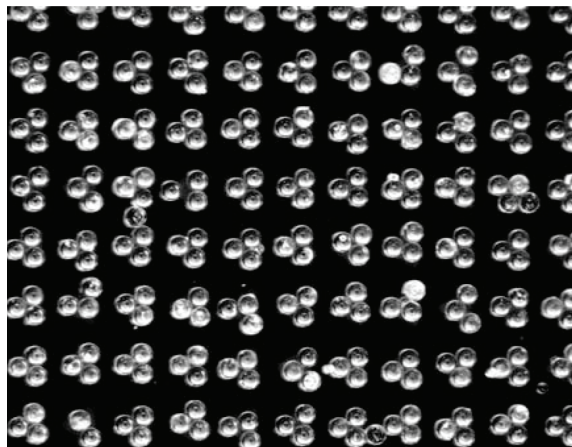


# Let's try it!

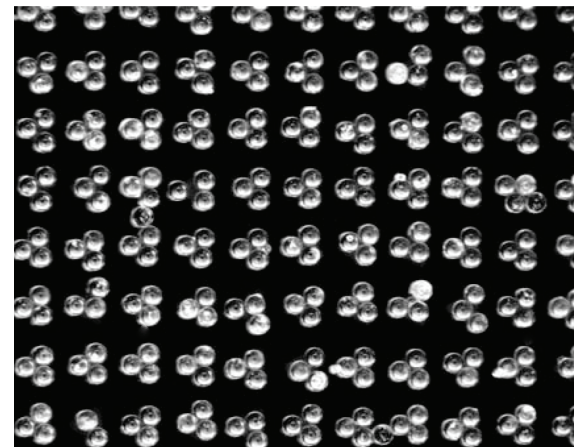
original



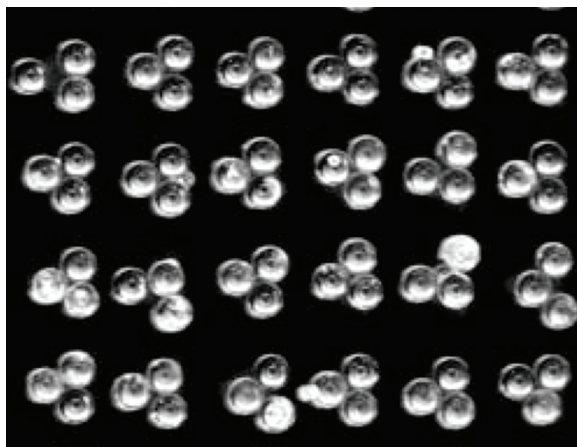
1. adjust contrast



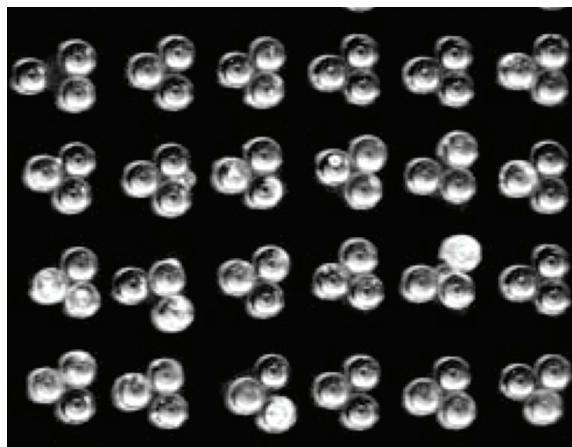
2. remove blemishes



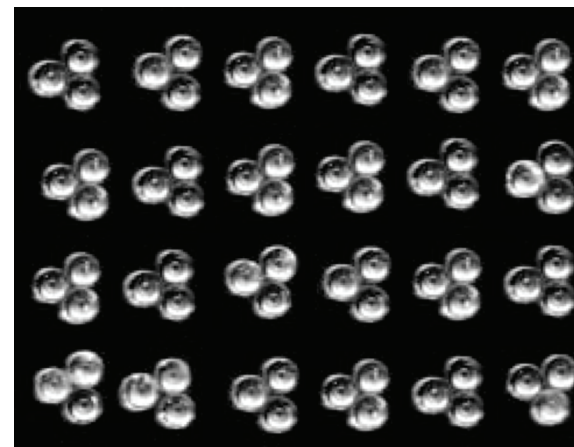
3. crop



4. remove outliers



5. reconstruct

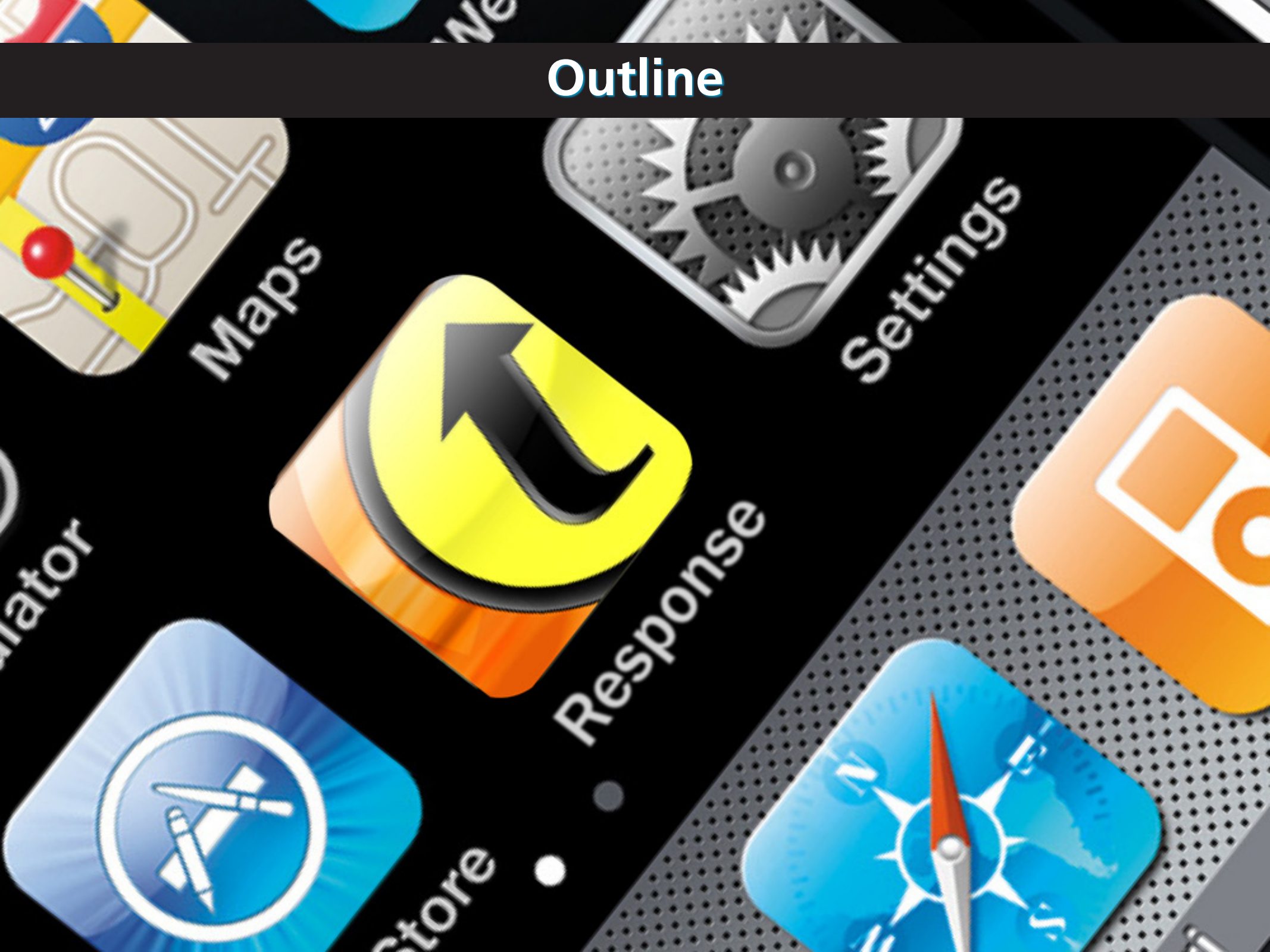


# Let's try it!

**At which step were acceptable standards of ethics violated?**

- 1. Optimize brightness/contrast**
- 2. Remove blemishes**
- 3. Crop on optimal area**
- 4. Remove outliers**
- 5. Reconstruct image with parts copied from other locations**

# Outline





# Outline

- **Setting the stage**
- **Making it happen**
- **Overcoming barriers**

# Setting the stage

**To set stage for successful implementation, I need to...**

# Setting the stage

**To set stage for successful implementation, I need to...**

**(actions to take *before* course begins)**

# Setting the stage

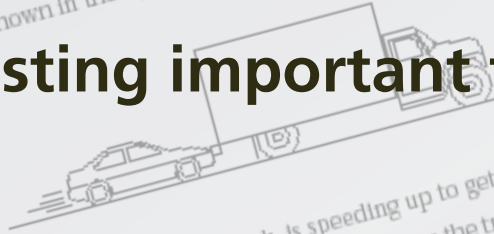
- **convince yourself (and your colleagues)**
- **set learning goals**
- **select approaches**
- **identify resources**

# Setting the stage

## Pre/post-testing important for:

- justifying approach
- improving implementation

Use the statement and figure below to answer the next two questions (15 and 16).  
A large truck breaks down on the road and receives a push back into town by a small compact car as shown in the figure below.



15. The car, still pushing the truck, is speeding up to get up to cruising speed.
- \_\_\_ 1. the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.
  - \_\_\_ 2. the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
  - \_\_\_ 3. the amount of force with which the car pushes on the truck is greater than that with which the truck pushes back on the car.
  - \_\_\_ 4. the car's engine is running so the car pushes against the truck, but the truck's engine is not running so the truck cannot push back against the car. The truck is pushed forward simply because it is in the way of the car.
  - \_\_\_ 5. neither the car nor the truck exerts any force on the other. The truck is pushed forward simply because it is in the way of the car.
16. After the car reaches the constant cruising speed at which its driver wishes to push the truck,
- \_\_\_ 1. the amount of force with which the car pushes on the truck is equal to that with which the truck pushes back on the car.
  - \_\_\_ 2. the amount of force with which the car pushes on the truck is smaller than that with which the truck pushes back on the car.
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  - \_\_\_ 5. neither the car nor the truck exerts any force on the other. The truck is pushed forward simply because it is in the way of the car.

# Setting the stage

**Evaluate assessment by comparing  
student performance on various kinds of problems**

# Setting the stage

**What constitutes a good problem?**

# Setting the stage

On a Saturday afternoon, you pull into a parking lot with unmeasured spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.



# Setting the stage

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How long do you have to wait before someone frees up a space?

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How long do you have to wait before someone frees up a space?

Requires:

Assumptions

Developing a model

Applying that model

# Setting the stage

On a Saturday afternoon, you pull into a parking lot with unmeasured spaces near a shopping area. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces. **On average people shop for 2 hours.**

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**Assuming people leave at regularly-spaced intervals,** how long do you have to wait before someone frees up a space?

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**Assuming people leave at regularly-spaced intervals,** how long do you have to wait before someone frees up a space?

Requires:

Applying a (new) model

# Setting the stage

On a Saturday afternoon, you pull into a parking lot with unmeasured spaces near a shopping area, where people are known to shop, on average, for 2 hours. You circle around, but there are no empty spots. You decide to wait at one end of the lot, where you can see (and command) about 20 spaces.

How long do you have to wait before someone frees up a space?

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How long do you have to wait before someone frees up a space?

$$t_{wait} = \frac{T_{shop}}{N_{spaces}}$$



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How long do you have to wait before someone frees up a space?

Requires:

Using a calculator

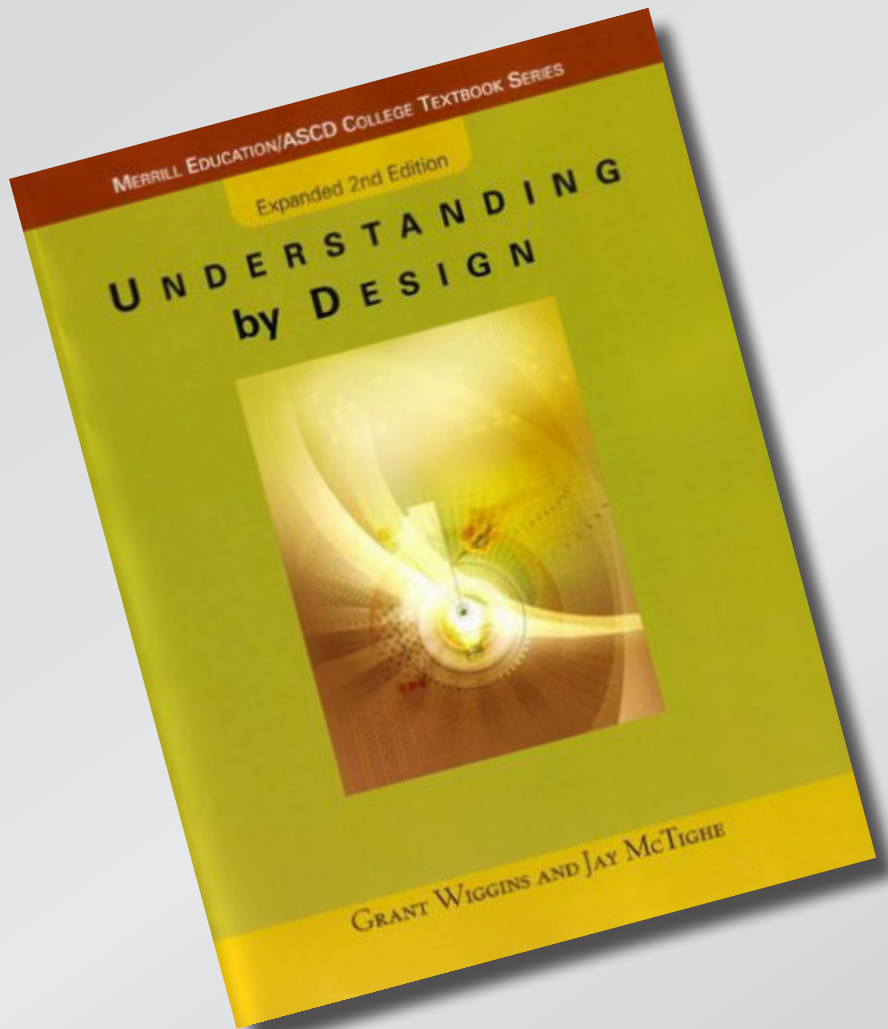
$$t_{wait} = \frac{T_{shop}}{N_{spaces}}$$

# Setting the stage

**Need to test meaningful skills!**

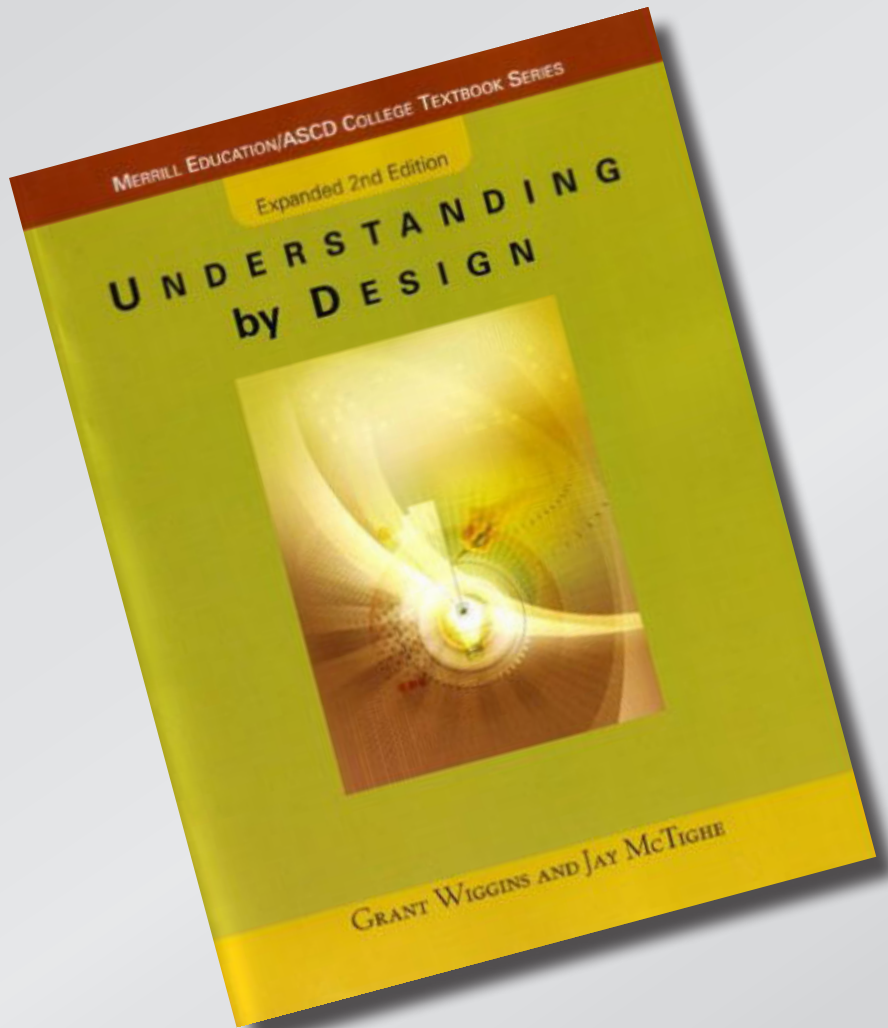
# Setting the stage

## Setting learning goals



# Setting the stage

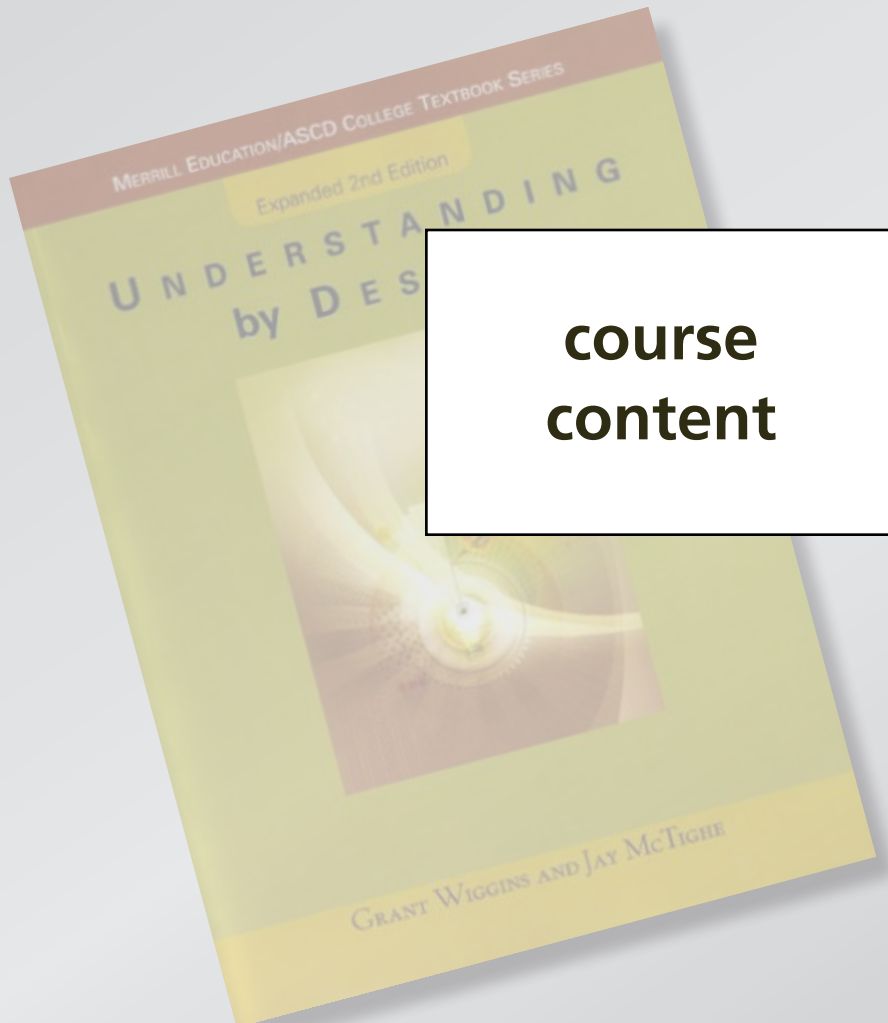
## Setting learning goals



- approach, not content
- focus on understanding
- backward design

# Setting the stage

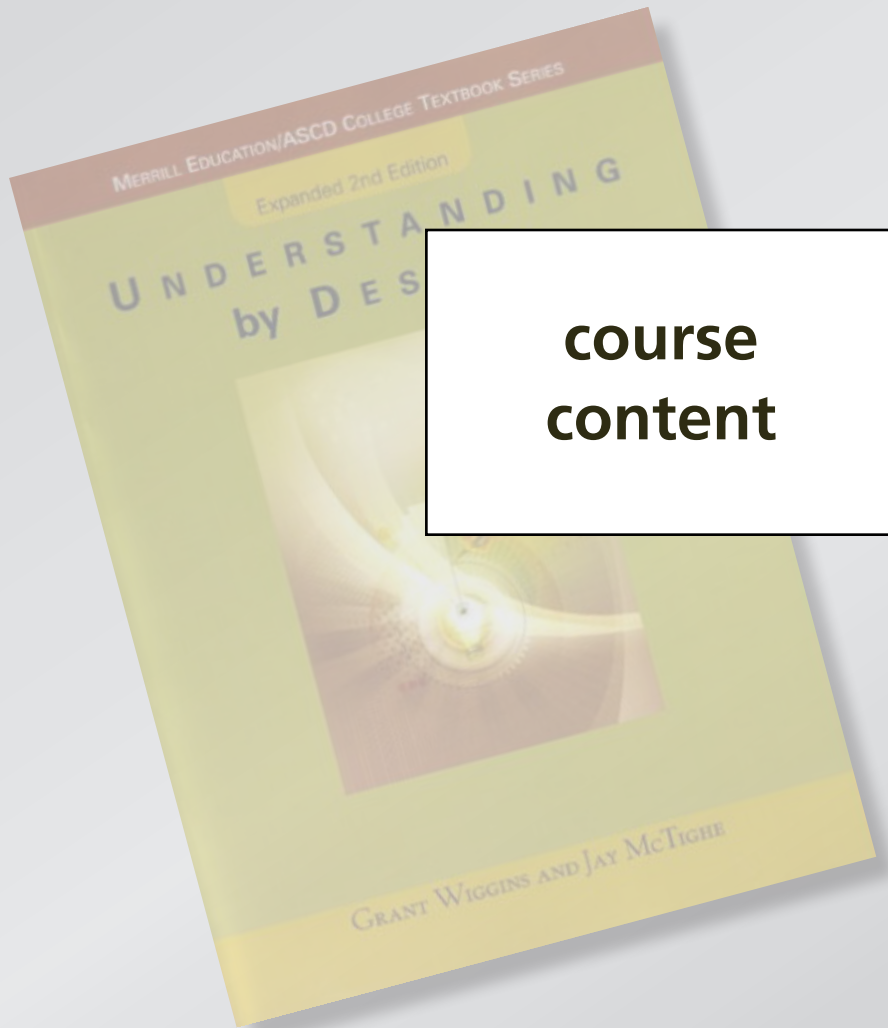
## Traditional approach to course planning



**course  
content**

# Setting the stage

## Traditional approach to course planning



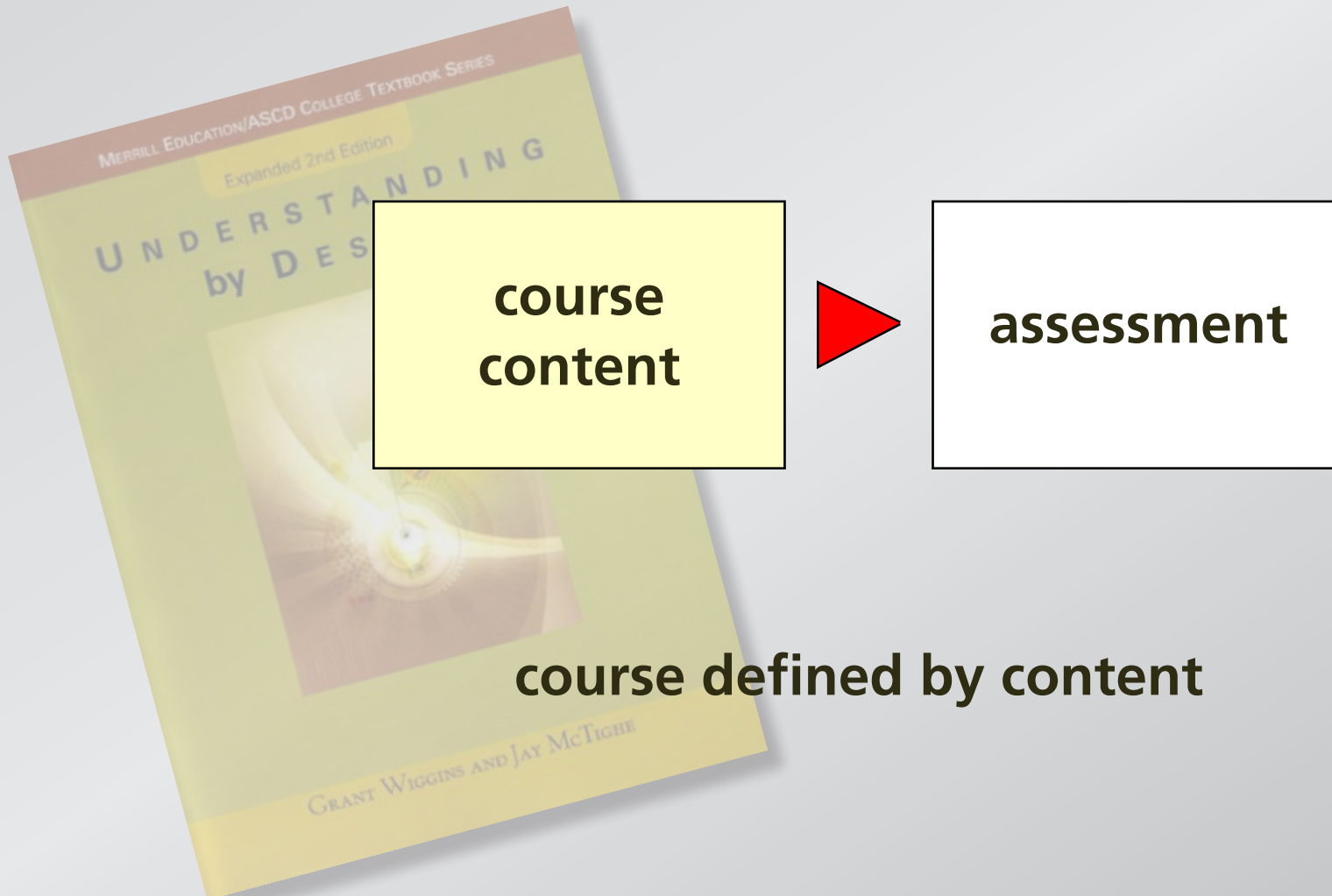
**course  
content**



**assessment**

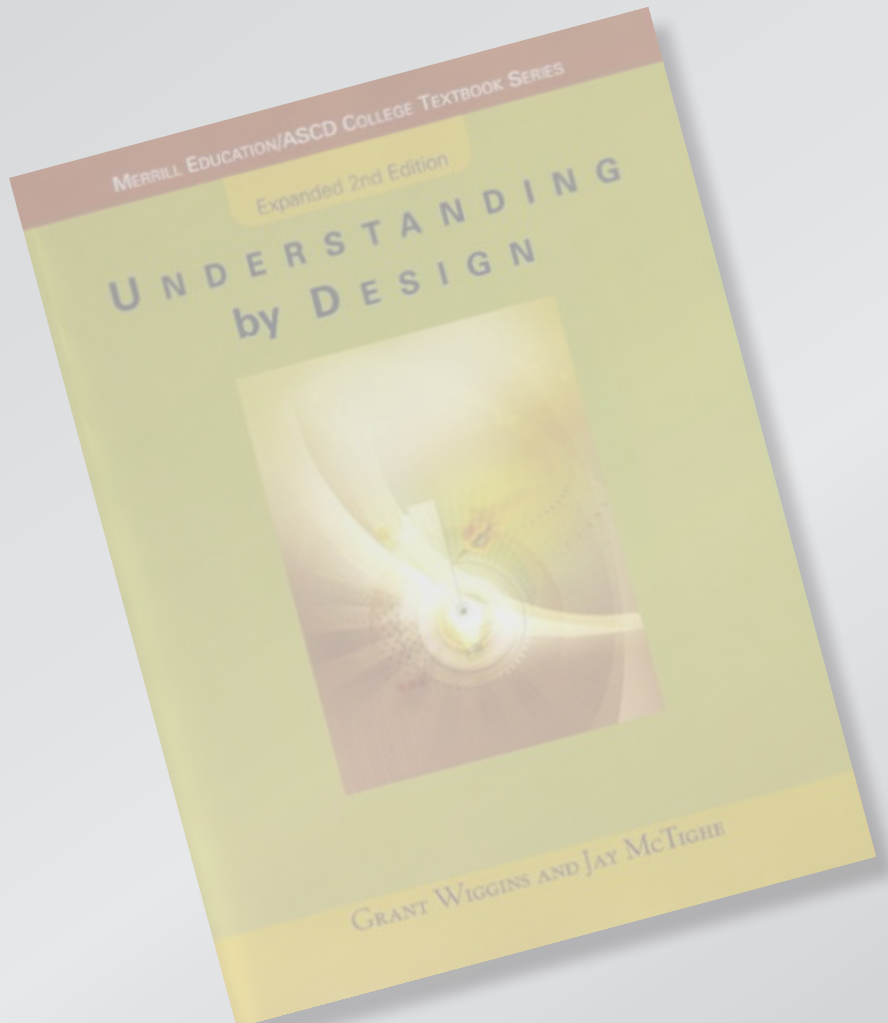
# Setting the stage

## Traditional approach to course planning



# Setting the stage

## Backward design

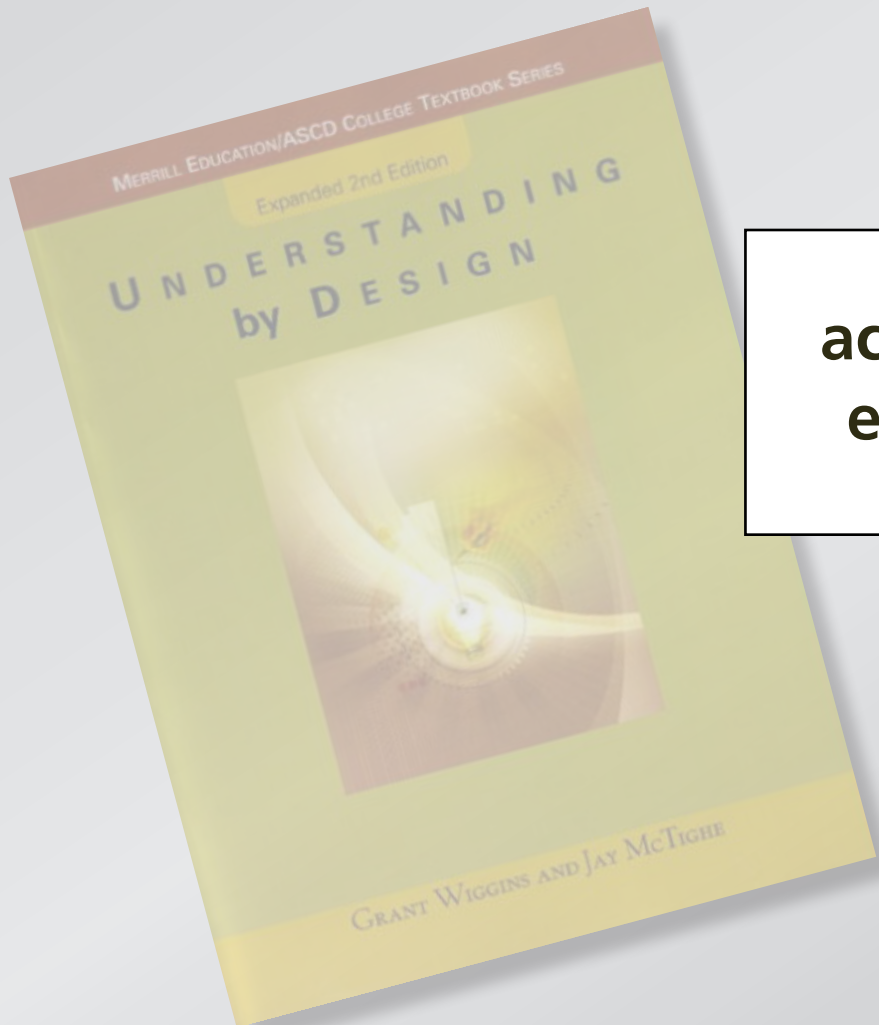


**desired  
outcomes**

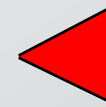


# Setting the stage

## Backward design



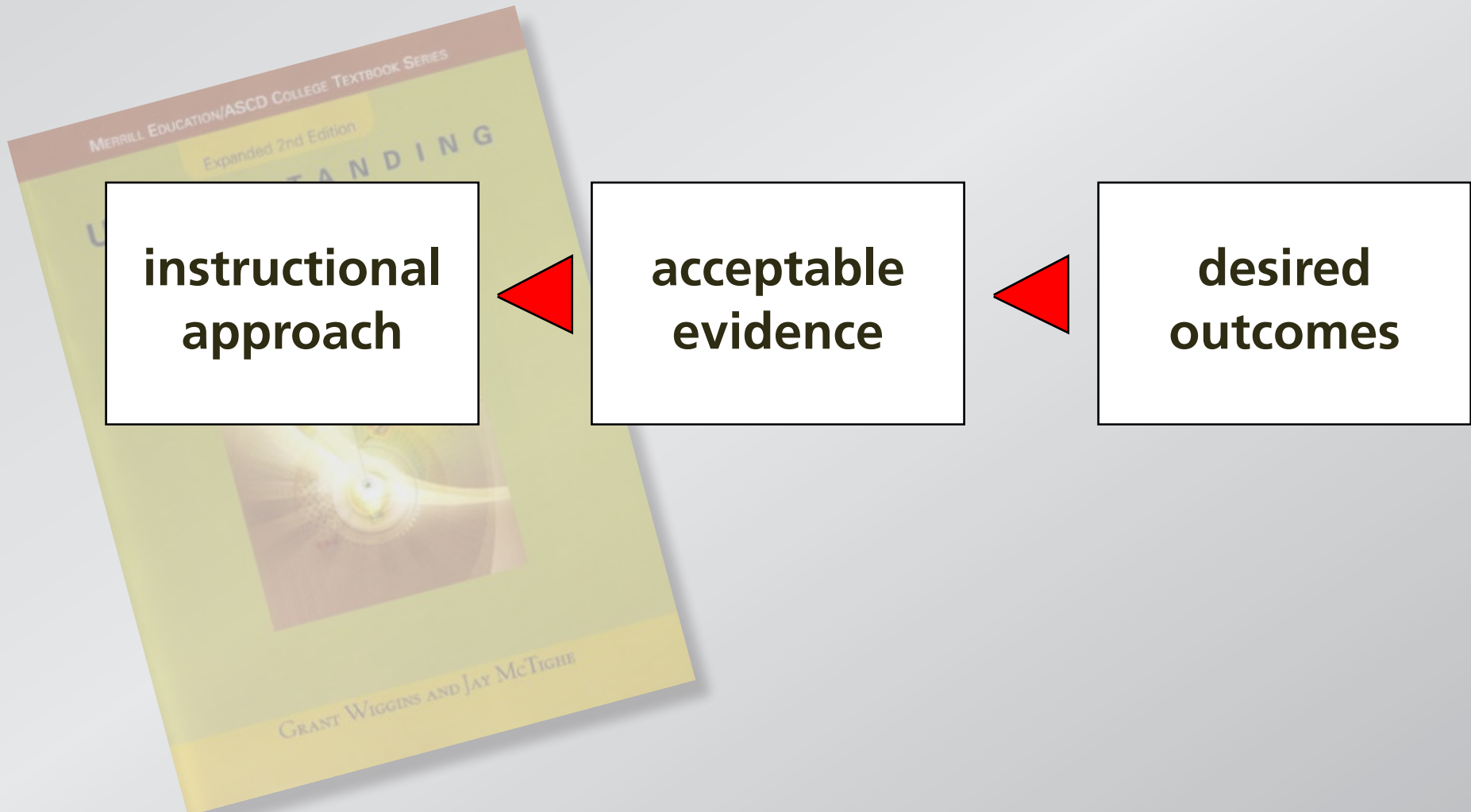
**acceptable  
evidence**



**desired  
outcomes**

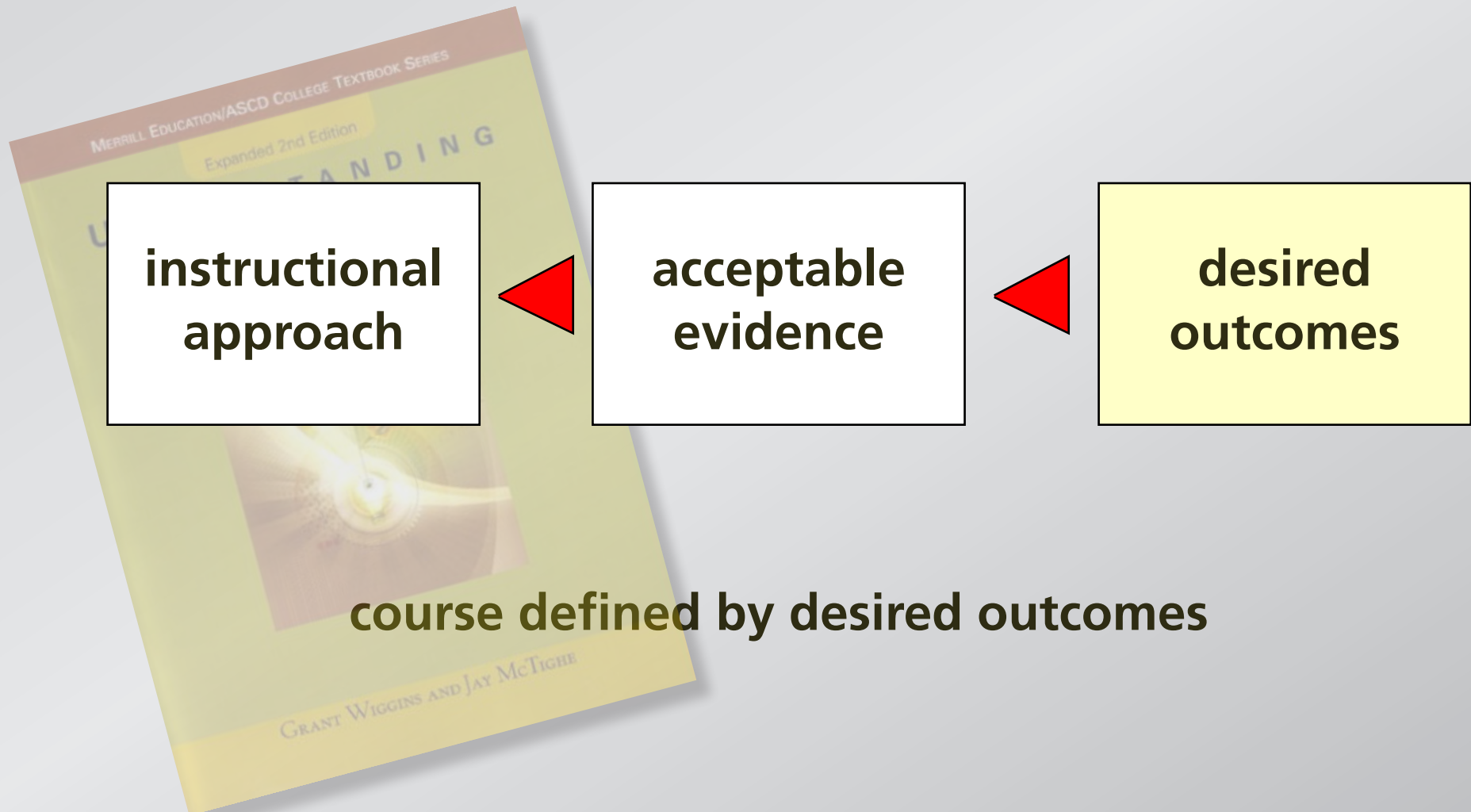
# Setting the stage

## Backward design



# Setting the stage

## Backward design



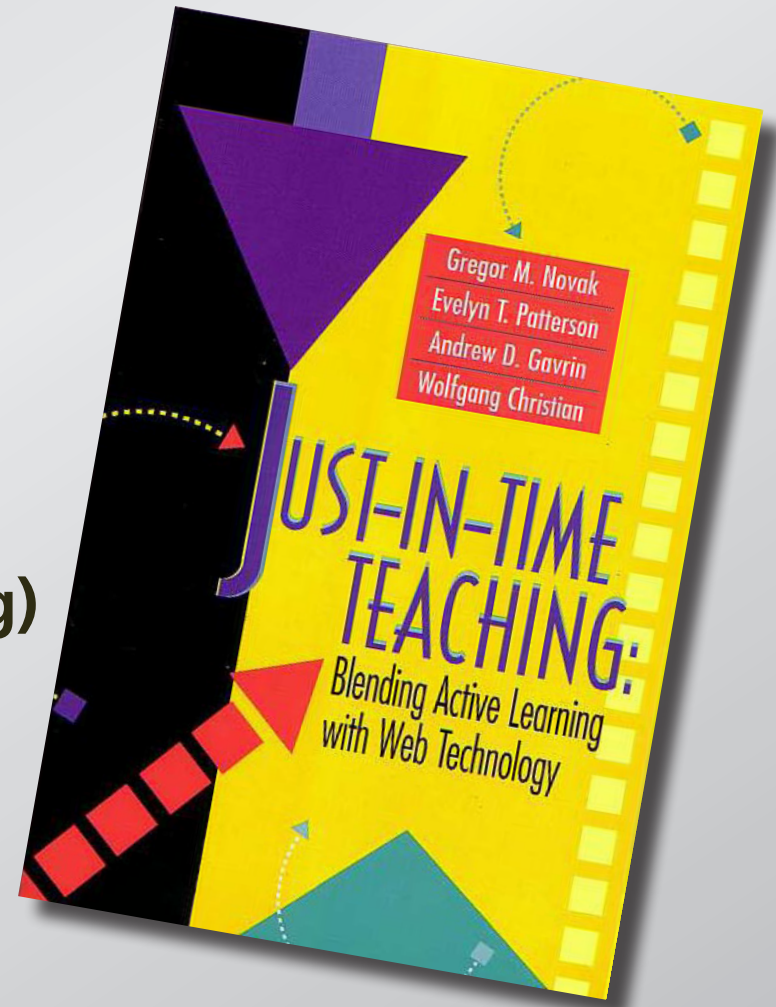
# Setting the stage

**How to move information transfer out of classroom?**

# Setting the stage

## Approaches for reading:

- Reading quizzes
- Summaries
- Just-in-time-Teaching ([www.jitt.org](http://www.jitt.org))



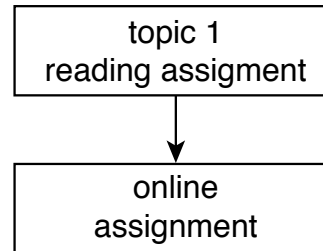
# Implementing PI & JiTT

## JiTT workflow

topic 1  
reading assignment

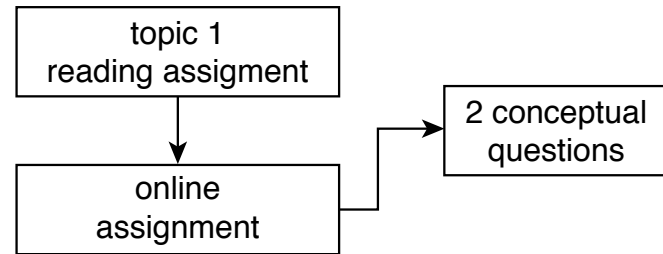
# Implementing PI & JiTT

## JiTT workflow



# Implementing PI & JiTT

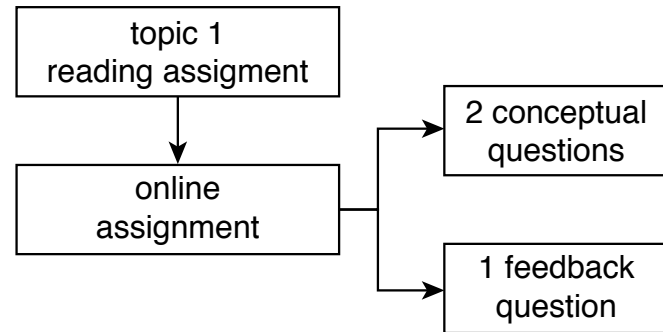
## JiTT workflow





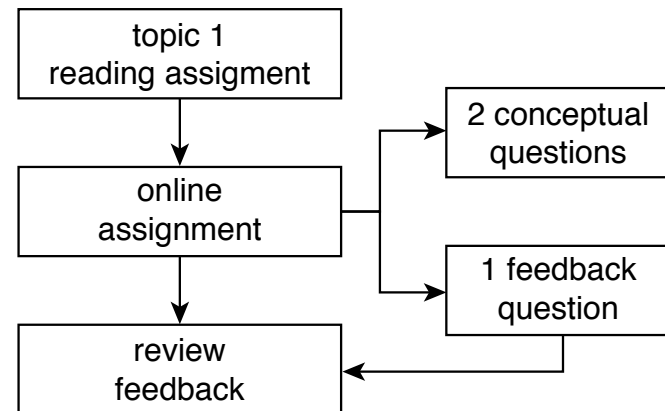
# Implementing PI & JiTT

## JiTT workflow



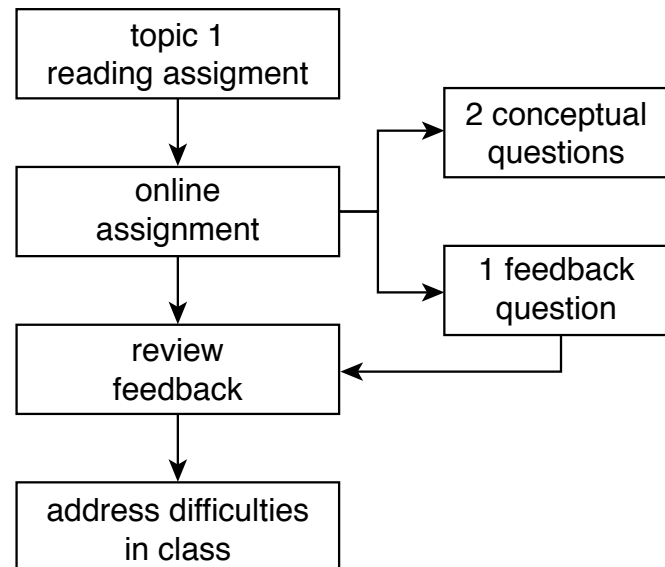
# Implementing PI & JiTT

## JiTT workflow



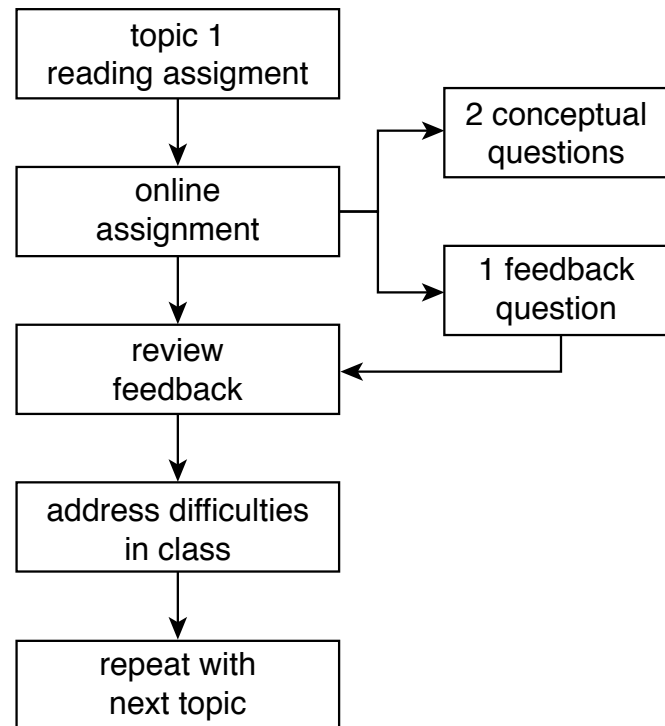
# Implementing PI & JiTT

## JiTT workflow



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## JiTT workflow



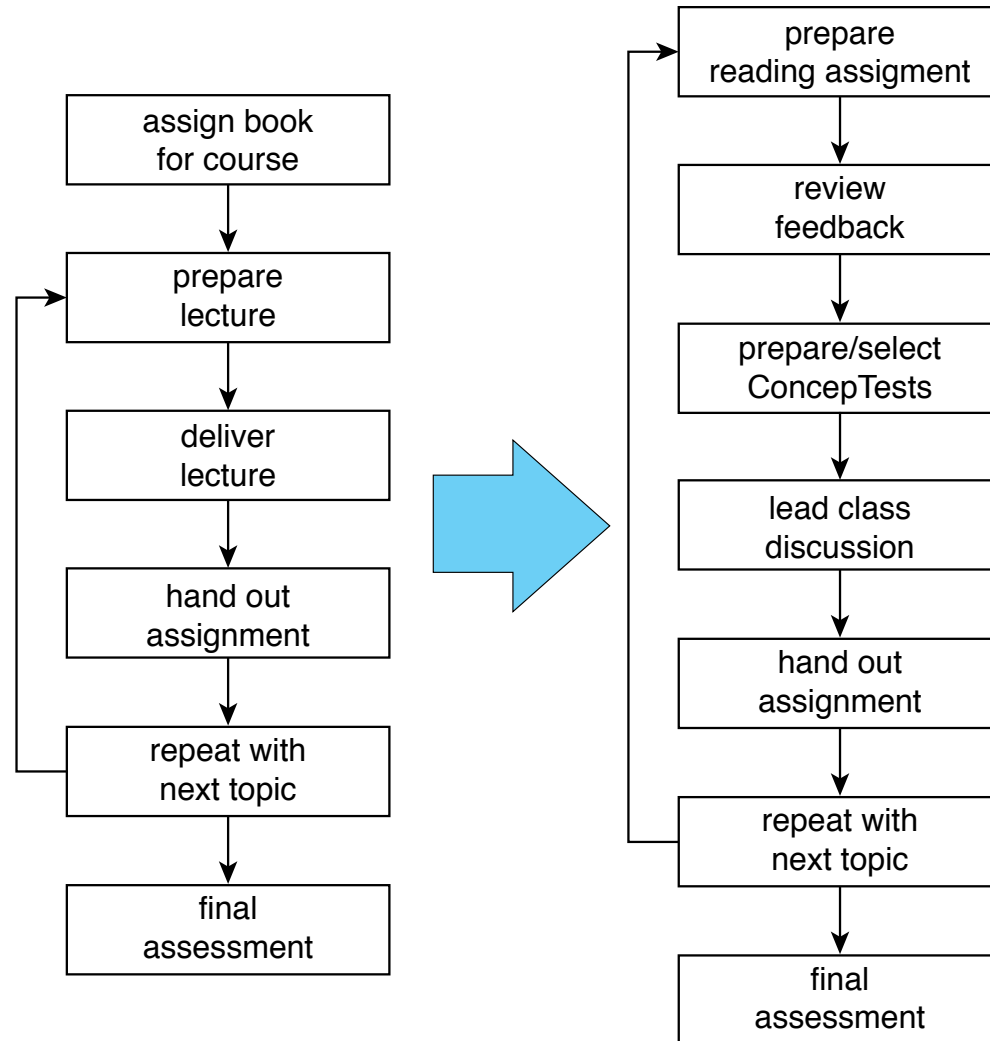
# Implementing PI & JiTT

## JiTT:

- prepares you for class
- prepares students for class
- helps you address student difficulties

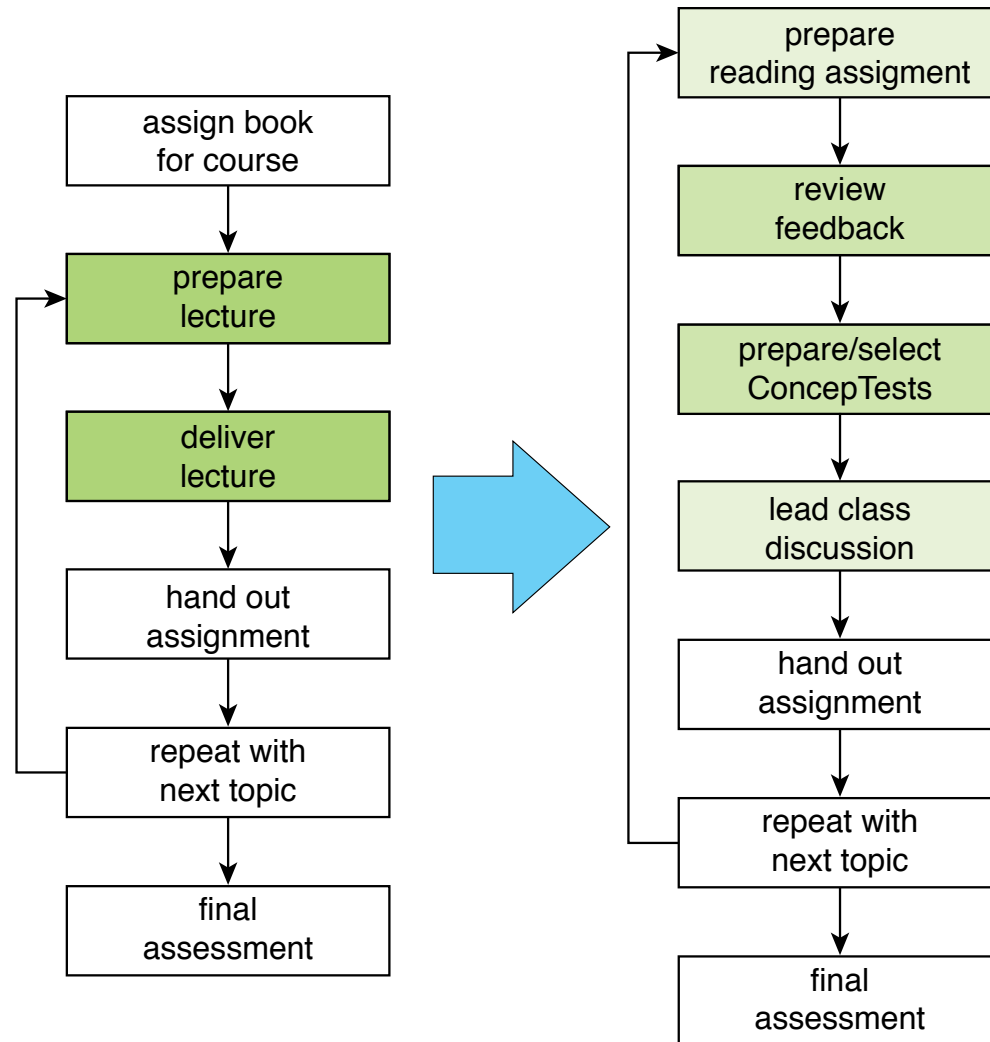
# Implementing PI & JiTT

transitioning: where does the effort go?



# Implementing PI & JiTT

transitioning: where does the effort go?



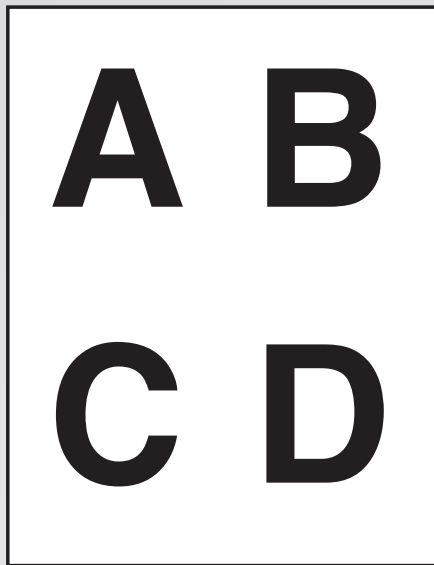
# Setting the stage

**Are clickers a required resource?**



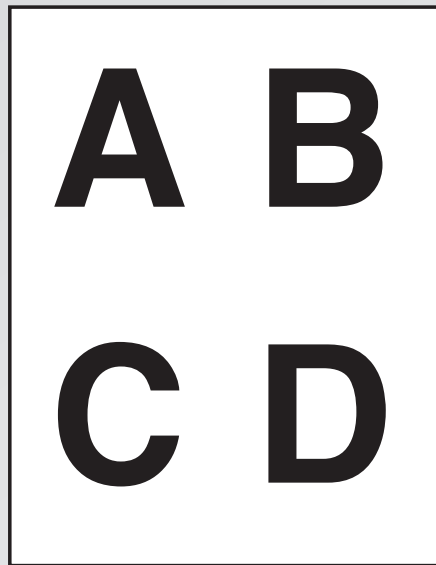
# Setting the stage

Flashcards: simple and effective



# Setting the stage

Flashcards: simple and effective



Meltzer and Mannivanan, South Eastern Louisiana University

# Setting the stage

Imagine a rope that fits snugly along the equator.



# Let's try it!

Imagine a rope that fits snugly along the equator.

Suppose the rope is cut and 1 m of rope is inserted between the cut ends. If the rope were to maintain a circular shape, how far off the surface of the Earth would it float?

1. the width of a few atoms
2. the width of a few hairs
3. the height of a curb
4. exactly 1 m
5. more than 1 m



# Setting the stage

*You all got fired up!*

# Setting the stage

*You all got fired up!*

**(WITHOUT CLICKERS!)**

# Setting the stage

**It's not the technology, but the pedagogy!**

# Setting the stage

**It's not the technology, but the pedagogy!**

**(but clickers do offer advantages)**



# Let's try it!

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Suppose the rope is cut and 1 m of rope is inserted between the cut ends. If the rope were to maintain a circular shape, how far off the surface of the Earth would it float?



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# Setting the stage

circumference at equator:

$$2\pi R_E$$

# Setting the stage

circumference at equator:

$$2\pi R_E$$

new circumference:

$$2\pi R_E + 1 \text{ m}$$

# Setting the stage

circumference at equator:

$$2\pi R_E$$

new circumference:

$$2\pi R_E + 1 \text{ m}$$

radius of circle with new circumference:

$$2\pi R = 2\pi R_E + 1 \text{ m}, \quad \text{and so} \quad R = R_E + \frac{1 \text{ m}}{2\pi}.$$

# Outline

- **Setting the stage**
- **Making it happen**
- **Overcoming barriers**

# Making it happen

**To make it happen, I need to...**

# **Making it happen**

**To make it happen, I need to...**

**(actions to take during course)**

# Making it happen

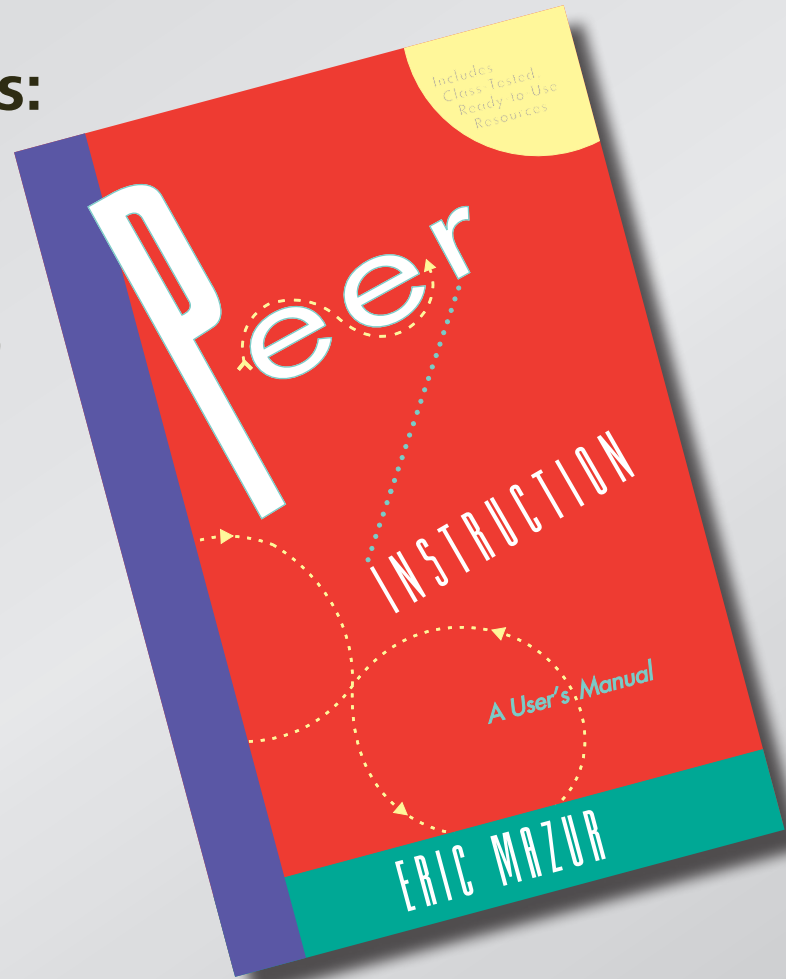
- **find or develop good questions**
- **know how to manage time**



# Making it happen

## Books with ConcepTests:

- Physics (Prentice Hall)



# Making it happen

## Books with ConcepTests:

- Physics (Prentice Hall)
- Chemistry (Prentice Hall)



# Making it happen

## Books with ConcepTests:

- Physics (Prentice Hall)
- Chemistry (Prentice Hall)
- Astronomy (Prentice Hall)



# Making it happen

## Books with ConcepTests:

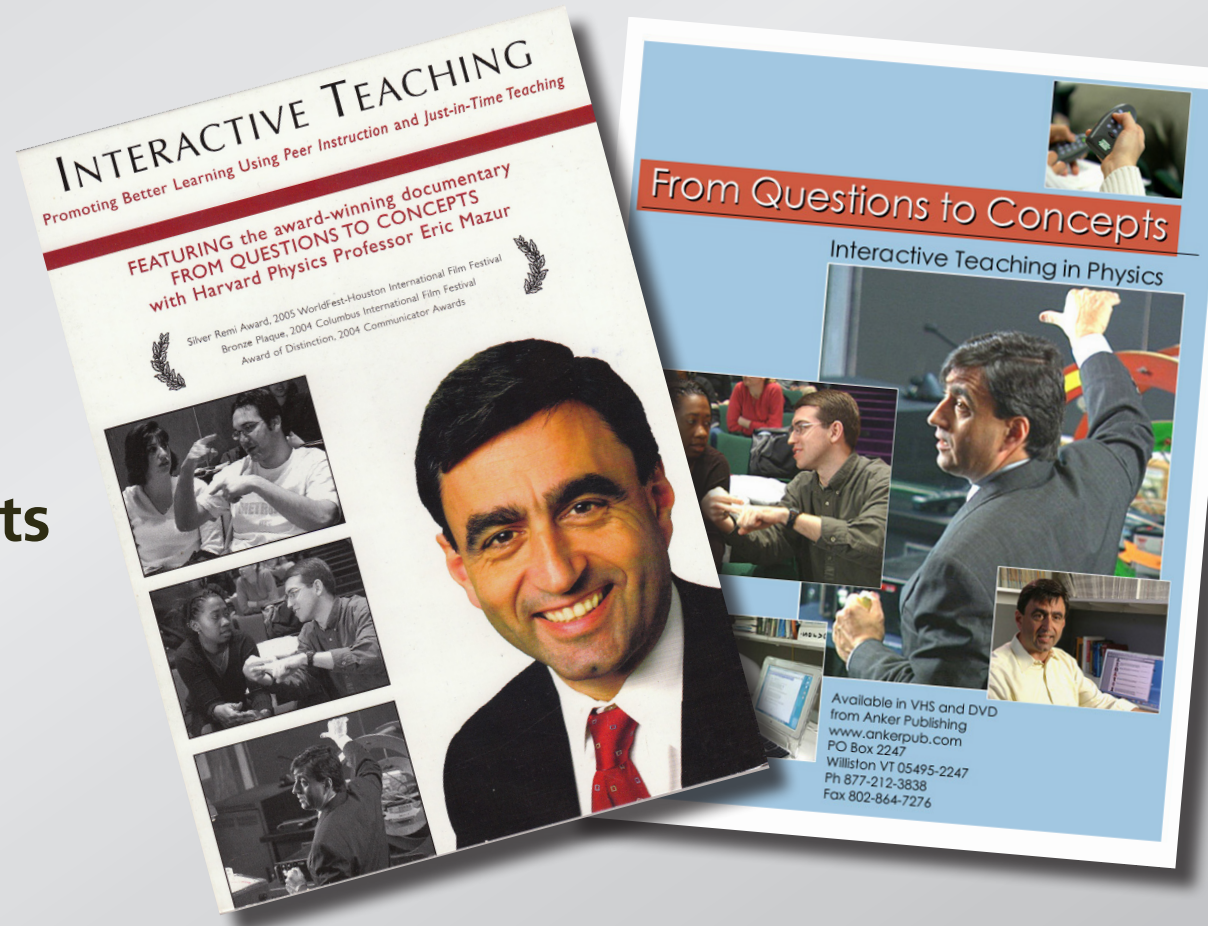
- Physics (Prentice Hall)
- Chemistry (Prentice Hall)
- Astronomy (Prentice Hall)
- Calculus (Wiley)



# Making it happen

## Videos:

- Interactive Teaching DVD
- From questions to concepts



# Making it happen

## Types of questions

- survey
- discussion
- model testing
- select from list

# Making it happen

Which of the following airlines tries to save fuel by suggesting that its passengers use the bathroom before boarding?

1. Delta Airlines
2. Lufthansa
3. All Nippon Airways
4. British Midland Airways
5. Air France
6. JAL
7. Aboriginal Air Services
8. Aeroflot
9. Are you kidding me? None of the above.

# Making it happen

Which of the following airlines tries to save fuel by suggesting that its passengers use the bathroom before boarding?

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# Making it happen

hole in plate/circumference

model

microscopy image

discussion

airline

fact

# Making it happen

hole in plate/circumference

model

microscopy image

discussion

airline

fact

fact-recall not engaging

# Making it happen

**Good conceptual questions (ConceptTests):**

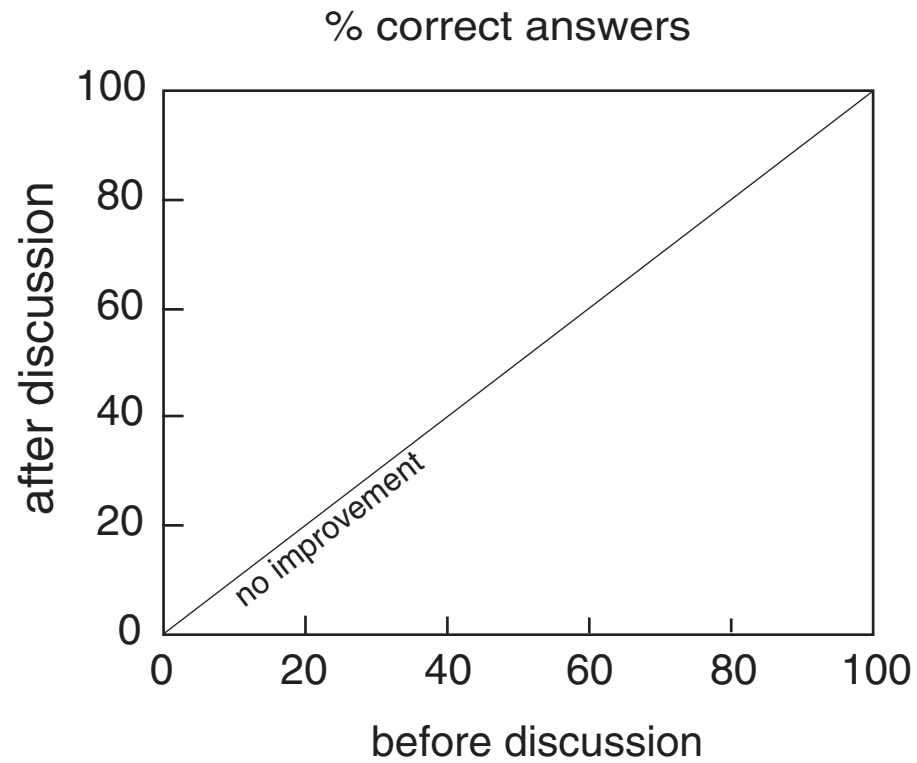
- are based on common student difficulties
- focus on single concept
- require more than “plug and chug”
- are clear and concise
- are of manageable difficulty

# Making it happen

**must adjust level to audience**

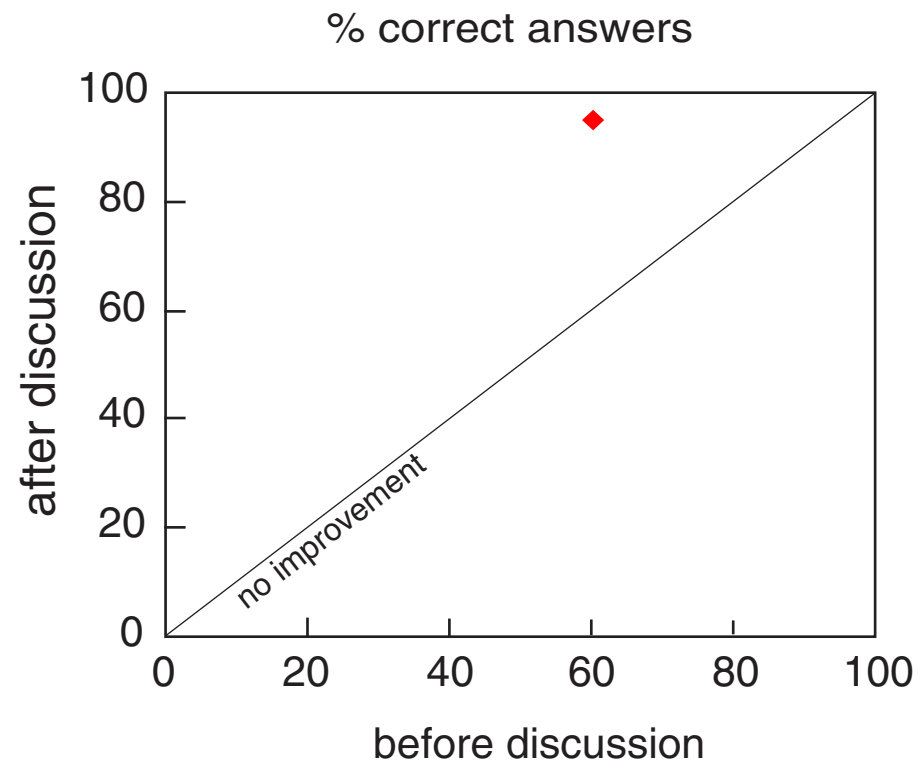
# Making it happen

## ConceptTest data



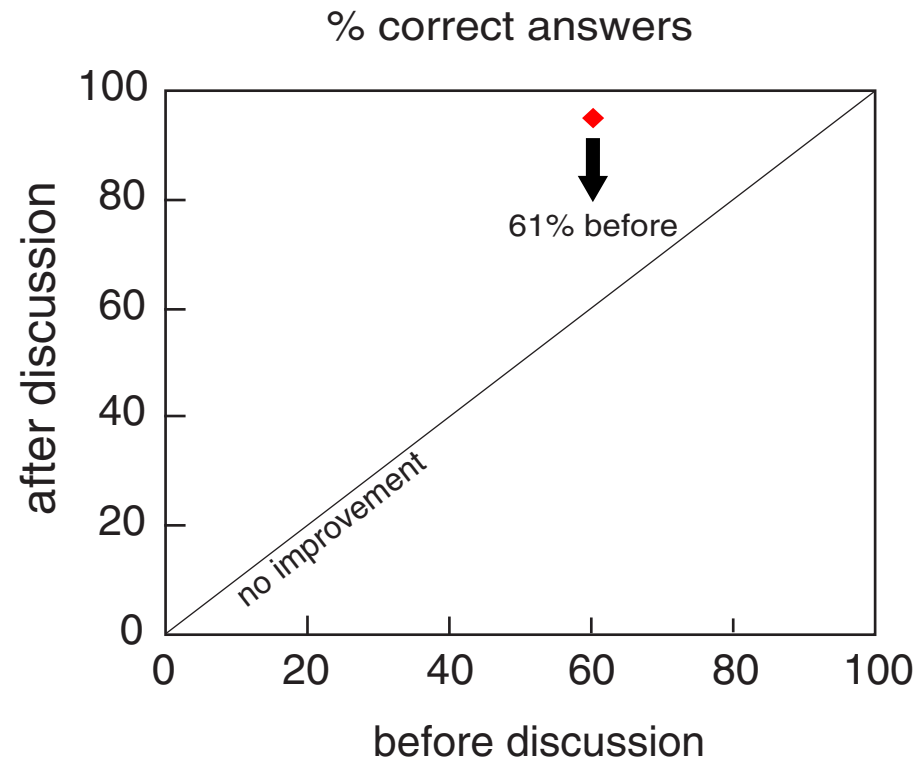
# Making it happen

## ConceptTest data



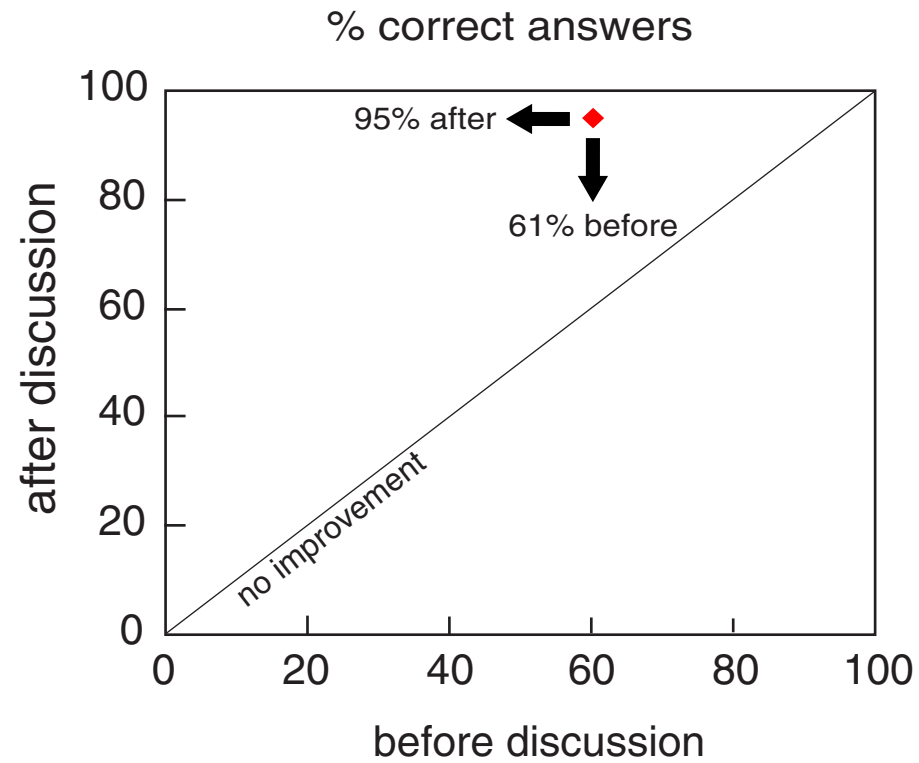
# Making it happen

## ConceptTest data



# Making it happen

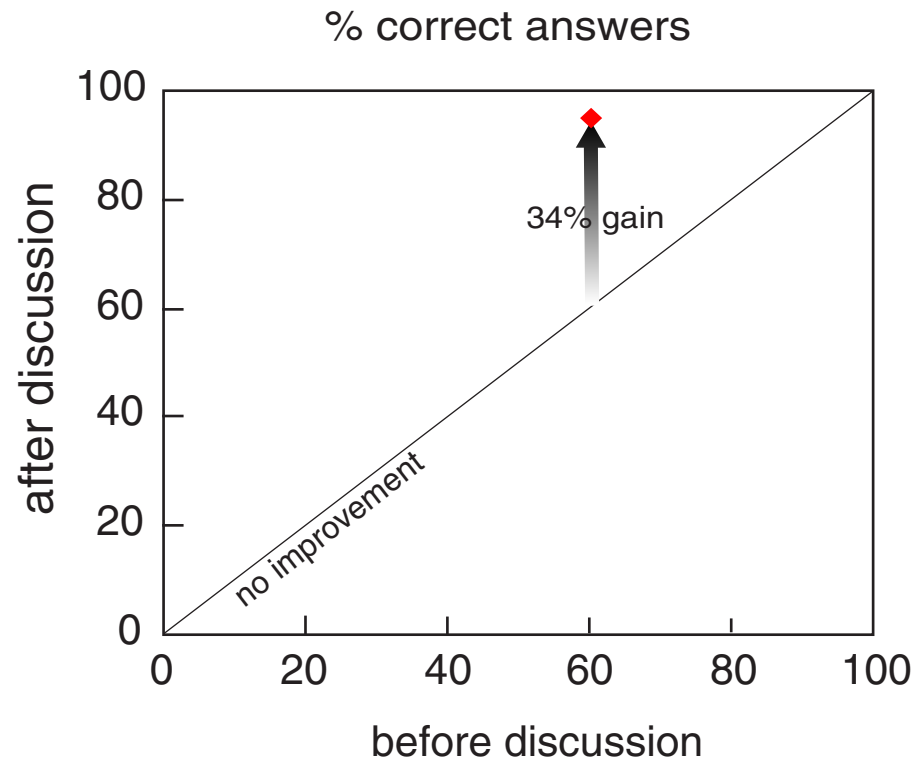
## ConceptTest data





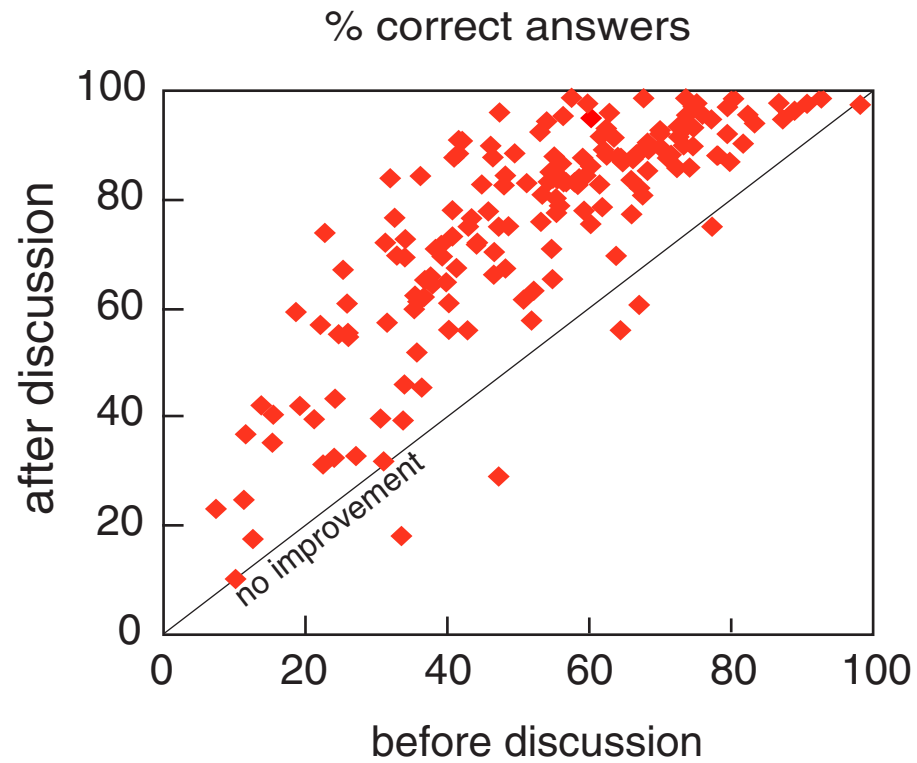
# Making it happen

## ConceptTest data



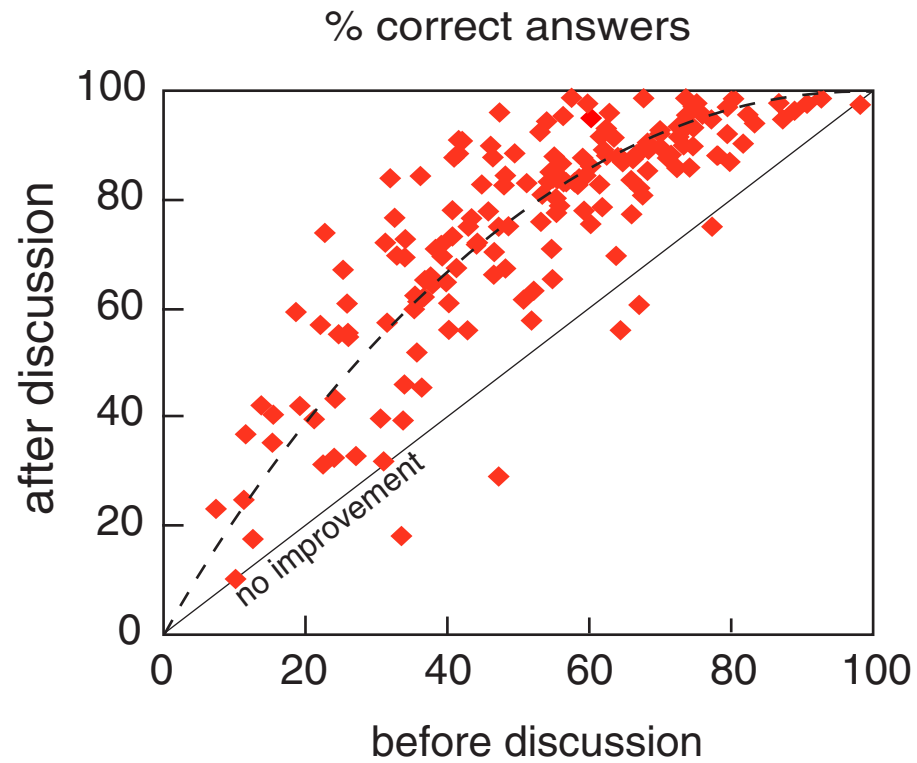
# Making it happen

## ConceptTest data



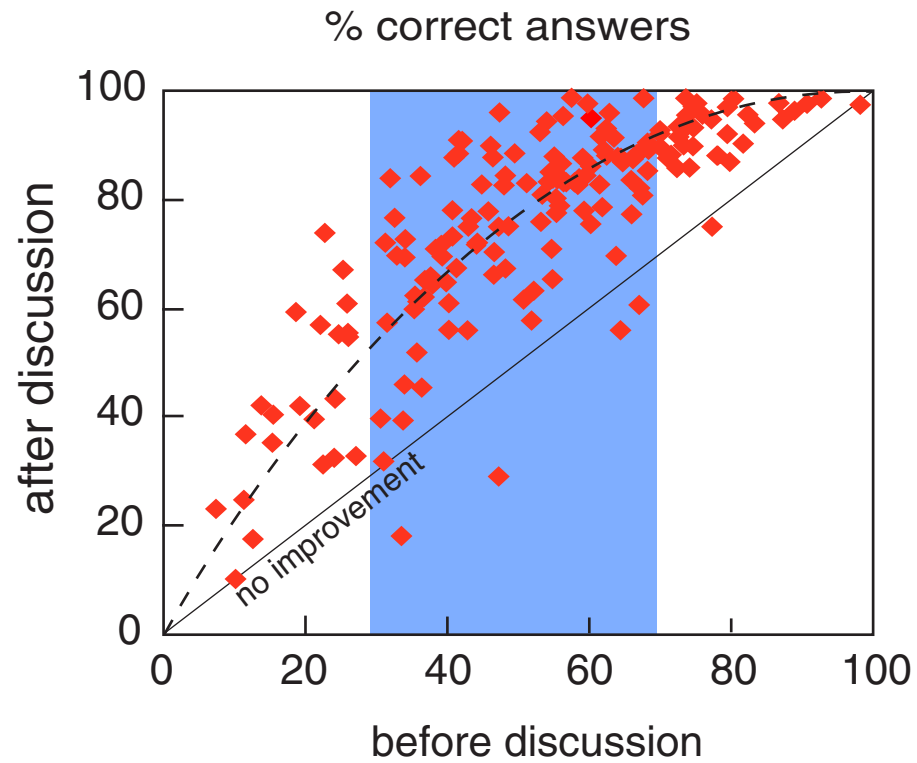
# Making it happen

## ConceptTest data

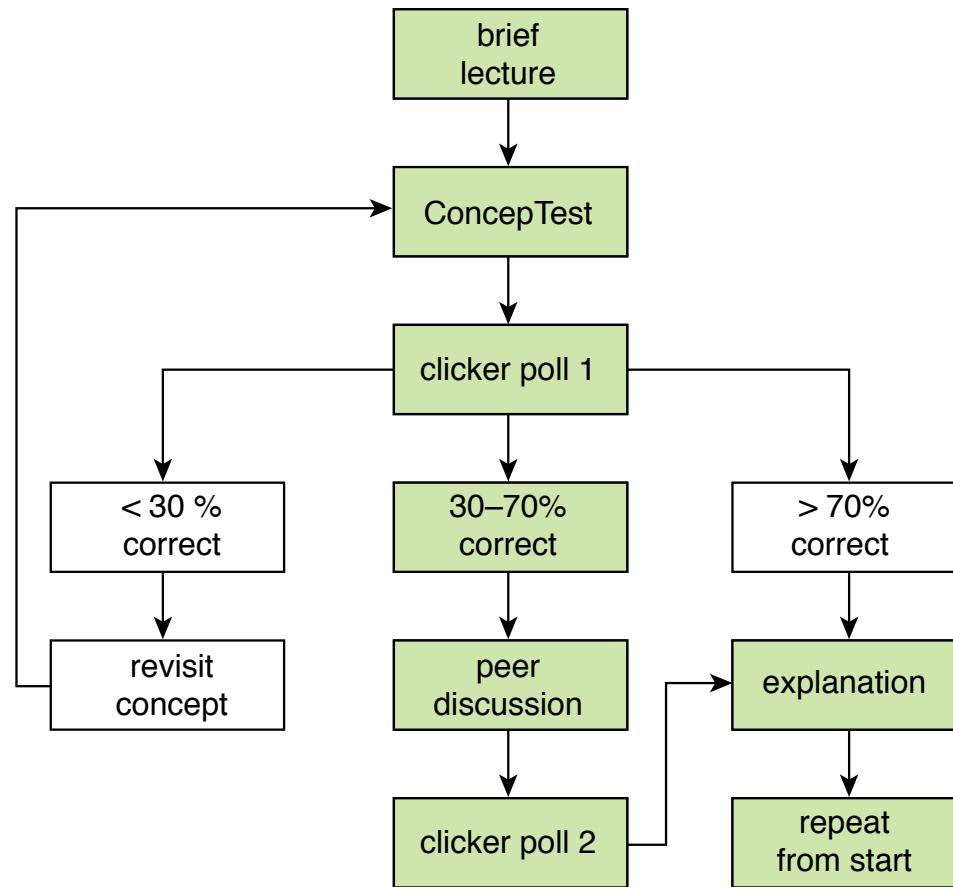


# Making it happen

## ConcepTest data



# Peer Instruction: a primer



# Outline

- **Setting the stage**
- **Making it happen**
- **Overcoming barriers**

# Overcoming barriers

**What are some potential barriers?**

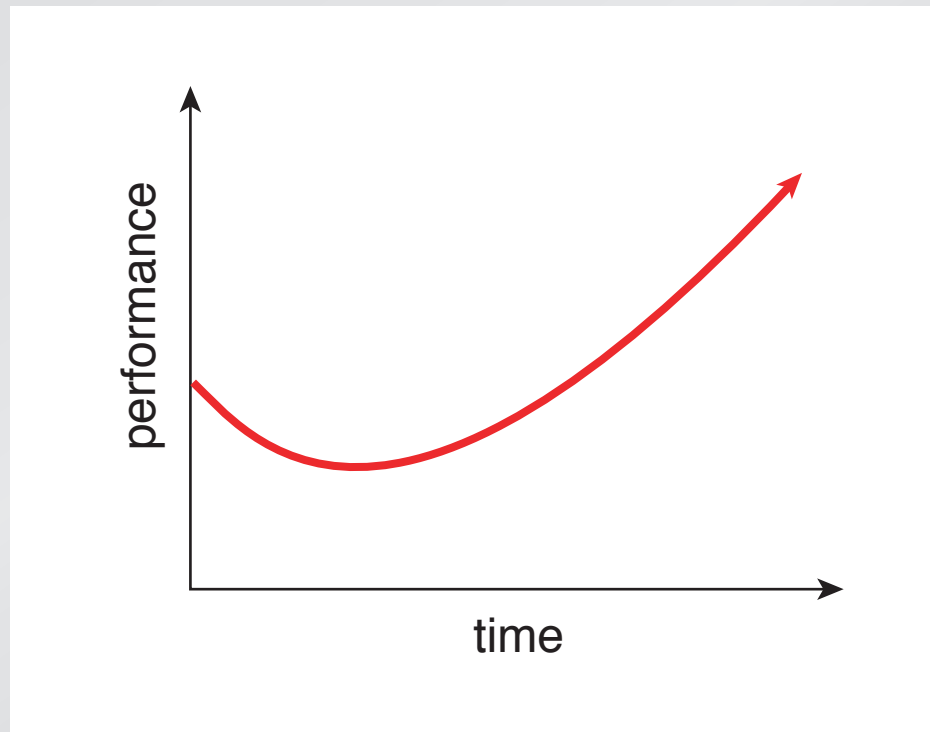
# Overcoming barriers

- **skepticism**
- **growing pains**
- **negative feedback**
- **limited circle of influence**



# Overcoming barriers

After changing, things might get *worse* before they get better!



# Overcoming barriers

**Better understanding leads to *more* — not fewer — questions!**

**(must recognize confusion as step towards understanding)**

# Overcoming barriers

**Things to do:**

- **take/analyze data**
- **motivate students**
- **be prepared for initial adjustments**

# Overcoming barriers

**Why is change so hard?**

# Overcoming barriers

---

	<b>"lectures"</b>	<b>PI</b>
<b>coverage</b>	<b>complete</b>	<b>partial</b>
<b>preclass reading</b>	<b>none</b>	<b>cover everything</b>
<b>confusion</b>	<b>little none</b>	<b>substantial</b>
<b>evaluations</b>	<b>known</b>	<b>unknown</b>

---

# Overcoming barriers

---

	<b>"lectures"</b>	<b>PI</b>	<b>considered</b>
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# Overcoming barriers

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# Overcoming barriers

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# Overcoming barriers

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---

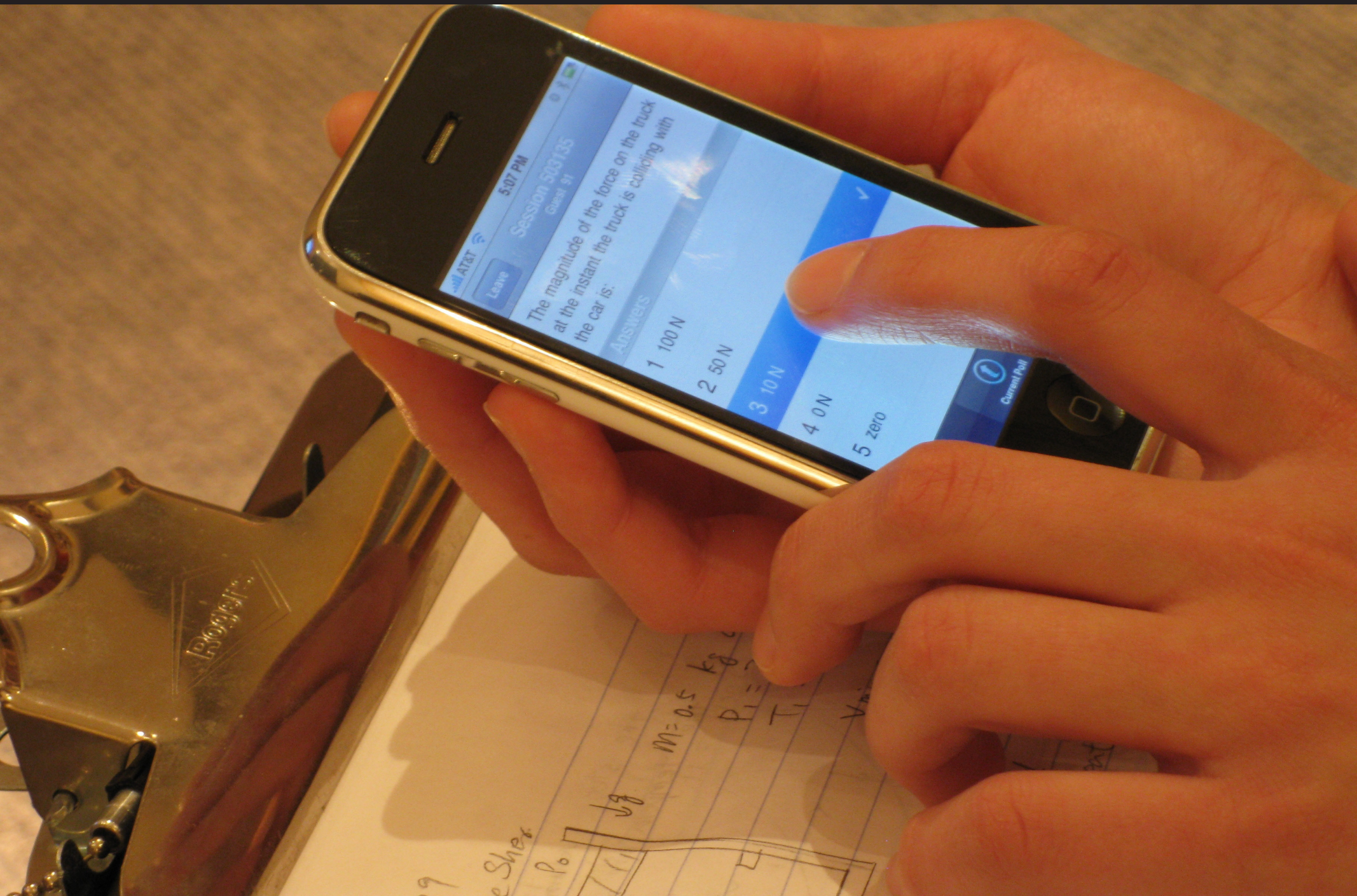
# Overcoming barriers

**But PI leads to better learning and retention**

# Overcoming barriers

**But PI leads to better learning and retention  
(neither of which is traditionally measured)**

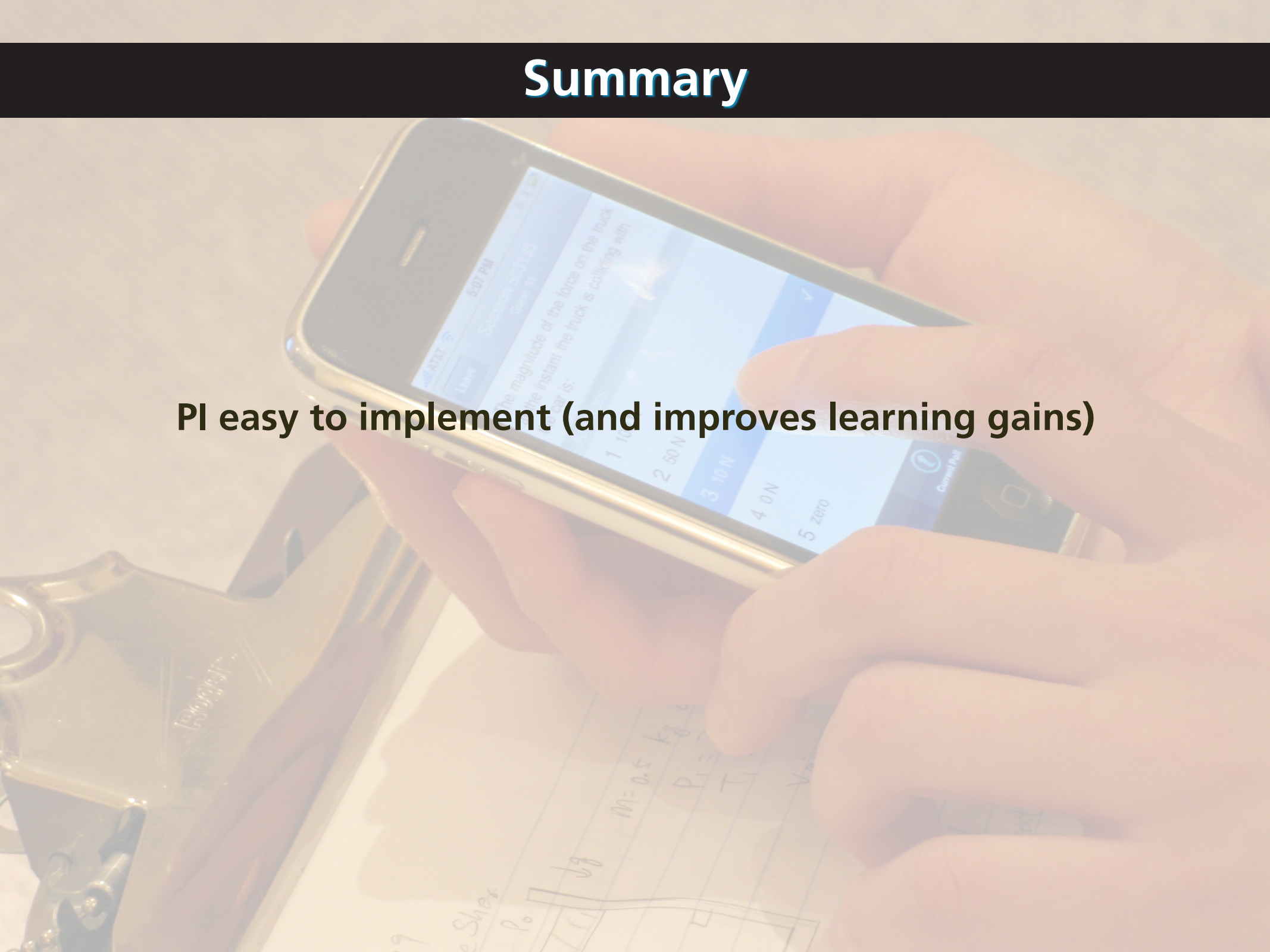
# Summary





# Summary

**PI easy to implement (and improves learning gains)**



# Conclusion

**PI easy to implement (and improves learning gains)**

**technology facilitates active engagement (but not required)**

# Conclusion

**not just a polling tool, but an engagement tool!**



## Research Funding:

**Pew Charitable Trust, Pearson/Prentice Hall, Davis Foundation, Engineering Information Foundation, Derek Bok Center for Teaching and Learning, National Science Foundation**

**for a copy of this presentation:**

**<http://mazur.harvard.edu>**

**response cards:**

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**Follow me!**



**eric\_mazur**

## **Dos preguntas para los participantes en taller Aprendizaje 360°**

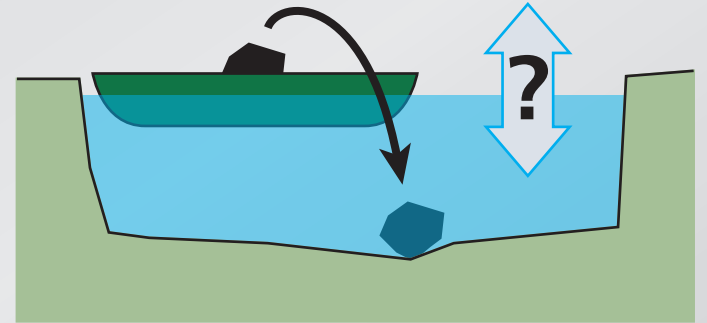
**Qué pregunta(s) tienen luego de la jornada de hoy, sobre:**

- 1. La posible implementación de Instrucción entre Pares en un curso que estará enseñando en el futuro próximo?**
- 2. ¿El diseño de evaluación en este curso?**

**Escriba la respuesta a estas preguntas en cada lado del papel**

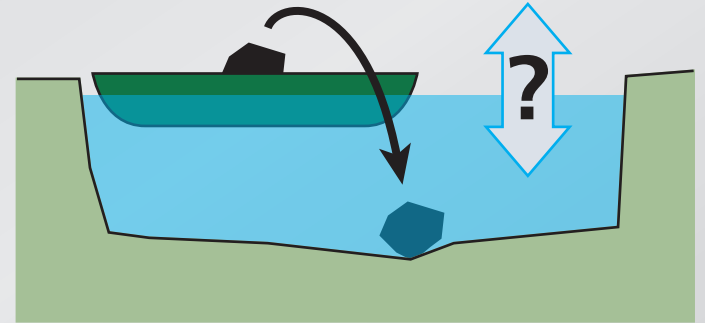
# Let's try it!

A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.



# Let's try it!

A boat carrying a large boulder is floating on a small pond. The boulder is thrown overboard and sinks to the bottom of the pond.



After the boulder sinks to the bottom of the pond, the level of the water in the pond is

1. higher than
2. the same as
3. lower than

it was when the boulder was in the boat.

**Let's try it!**

***We all make mistakes!***



# Let's try it!

When we hold a page of printed text in front of a mirror, the text on the image in the mirror runs from right to left:

**The New York Times**

# Let's try it!

When we hold a page of printed text in front of a mirror, the text on the image in the mirror runs from right to left:

**The New York Times**

Why is it that right and left are interchanged and not top and bottom? Because:

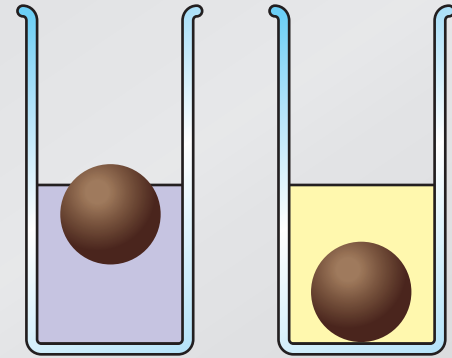
1. the mirror is oriented vertically.
2. we have two eyes in the horizontal plane.
3. the Earth's gravitation is directed downward.
4. a habit we have when looking at images in a mirror.
5. It only *appears* to run from left to right.

**Let's try it!**

*It's "simple" only if you know the answer*

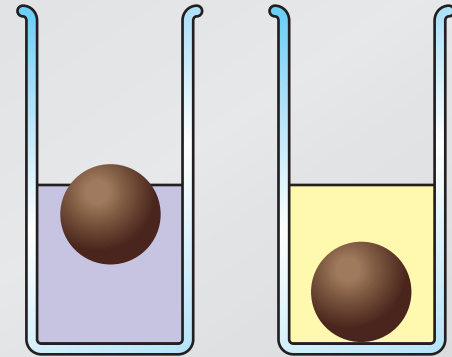
# Let's try it!

Consider an object that floats in water, but sinks in oil. When the object floats in water, most of it is submerged.



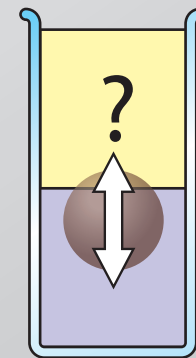
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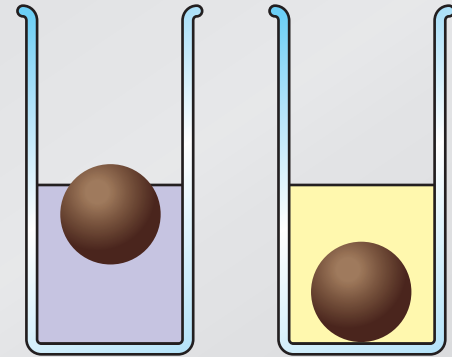
If we slowly pour the oil on top of the water so it completely covers the object, the object

1. moves up.
2. stays in the same place.
3. moves down.



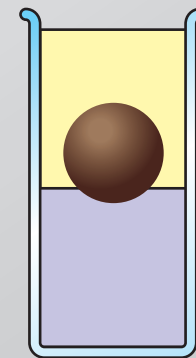
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**Let's try it!**

*It's easy to make simple demonstrations fascinating!*

## Let's try it!

The specific heat at constant volume for a monatomic crystal approaches zero at low temperature even though the specific heat for a monatomic gas remains  $\frac{3}{2}k$  per atom. Why is this so?



# Let's try it!

The specific heat at constant volume for a monatomic crystal approaches zero at low temperature even though the specific heat for a monatomic gas remains  $\frac{3}{2}k$  per atom. Why is this so?

1. Potential energy doesn't play a role for the monatomic gas, but it does for the crystal.
2. The particles are indistinguishable in the gas, but not in the crystal.
3. The energy difference between allowed states for the crystal is much larger than it is for the atoms.