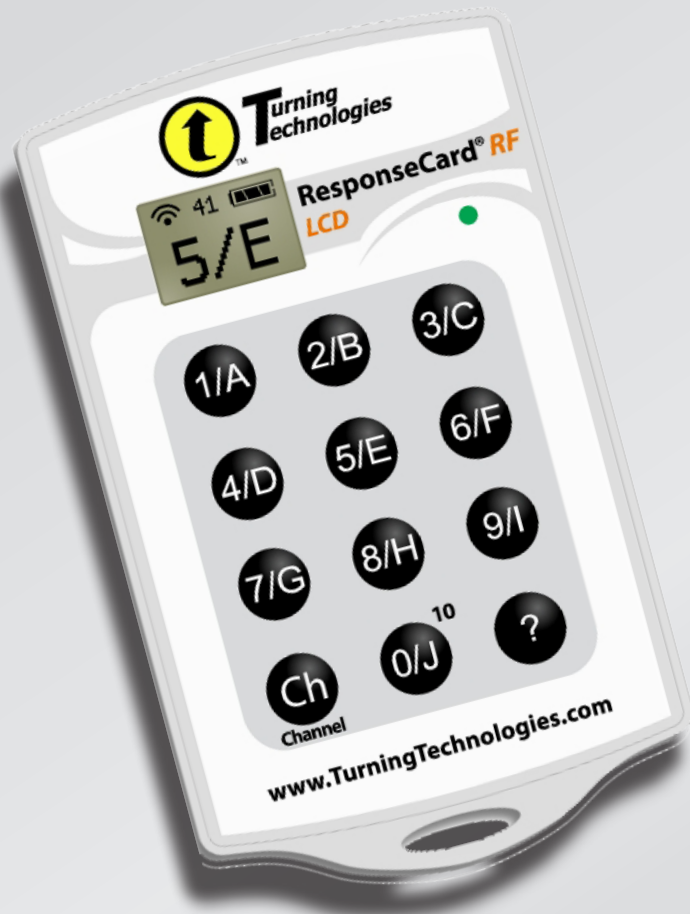


# Peer Instruction: A 'brains-on' workshop with clickers



All Faculty Meeting  
University of Tulsa  
Tulsa, OK, 6 January 2011

# Get your clickers ready!



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

# Quick survey...

## Peer Instruction...

1. Never heard of it.
2. Heard of it, but don't really know what it is.
3. Quite familiar with it.
4. I heard you speak about it so often, I could give your talk

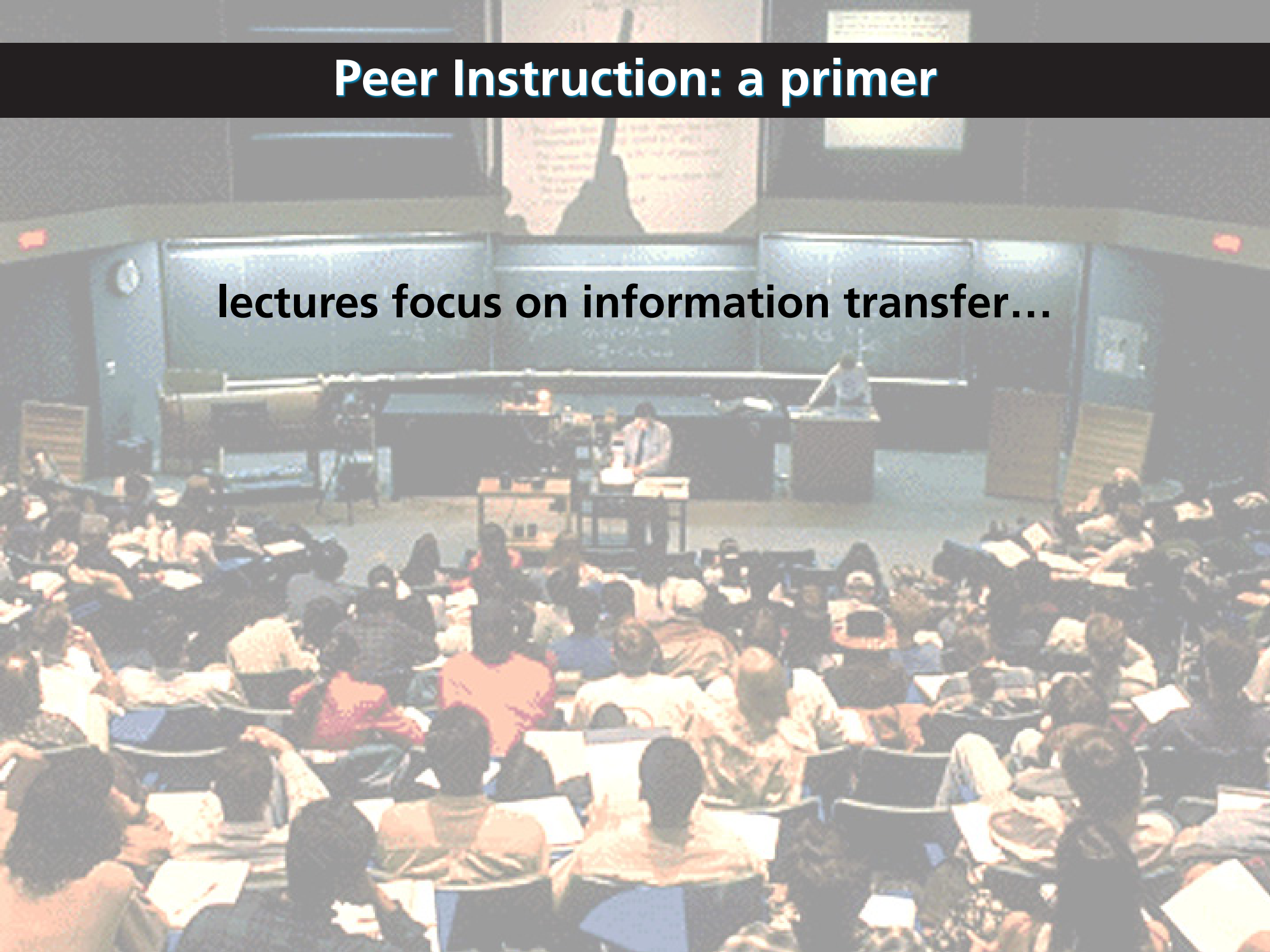
# Quick survey...

## Peer Instruction...

1. Never heard of it.
2. Don't use it in my classes, but I'm open to it.
3. Considering using it in my classes.
4. I have used it it in my classes a few times only.
5. I use it regularly in my classes.

# Peer Instruction: a primer

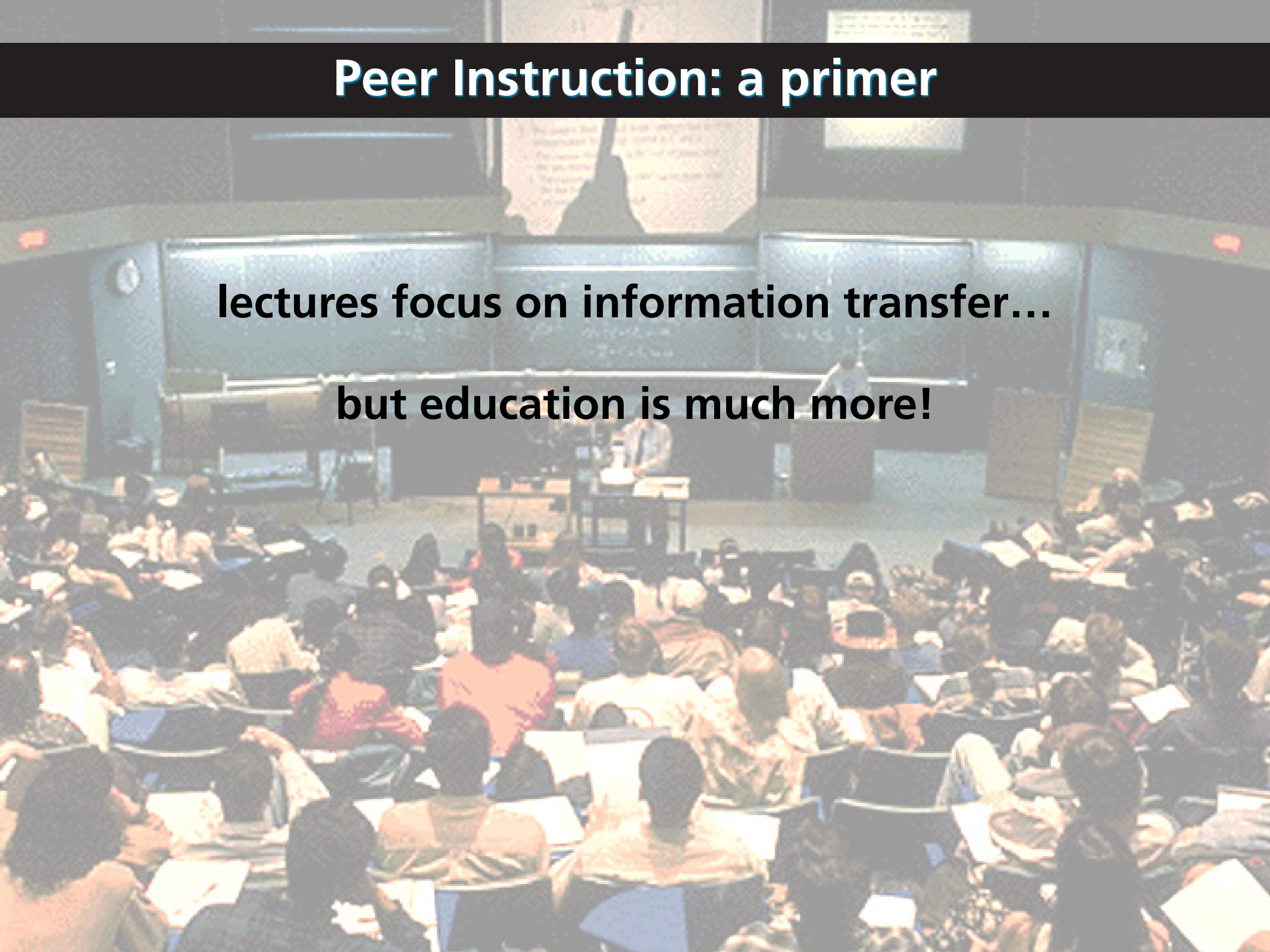
lectures focus on information transfer...



# Peer Instruction: a primer

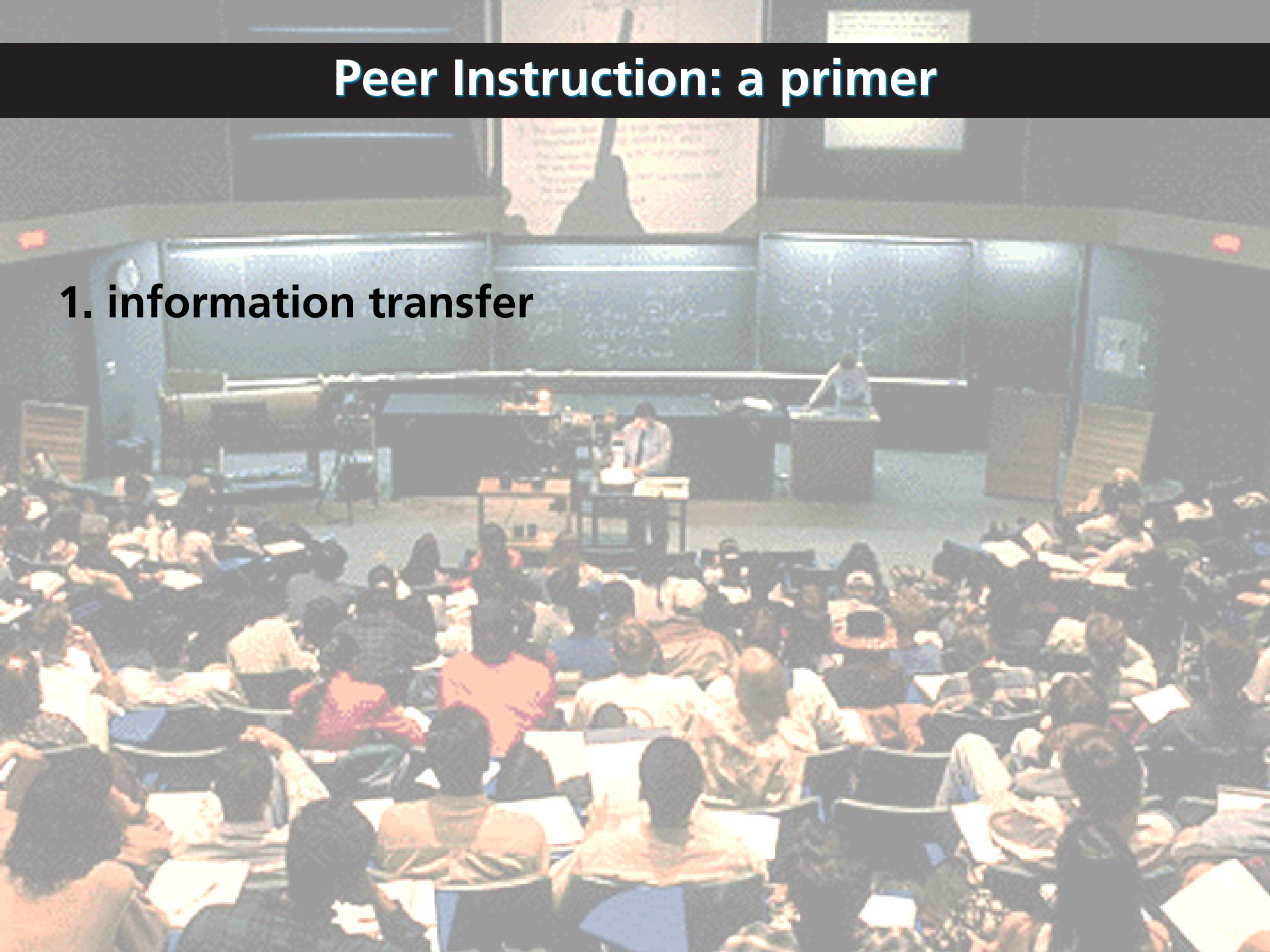
lectures focus on information transfer...

but education is much more!



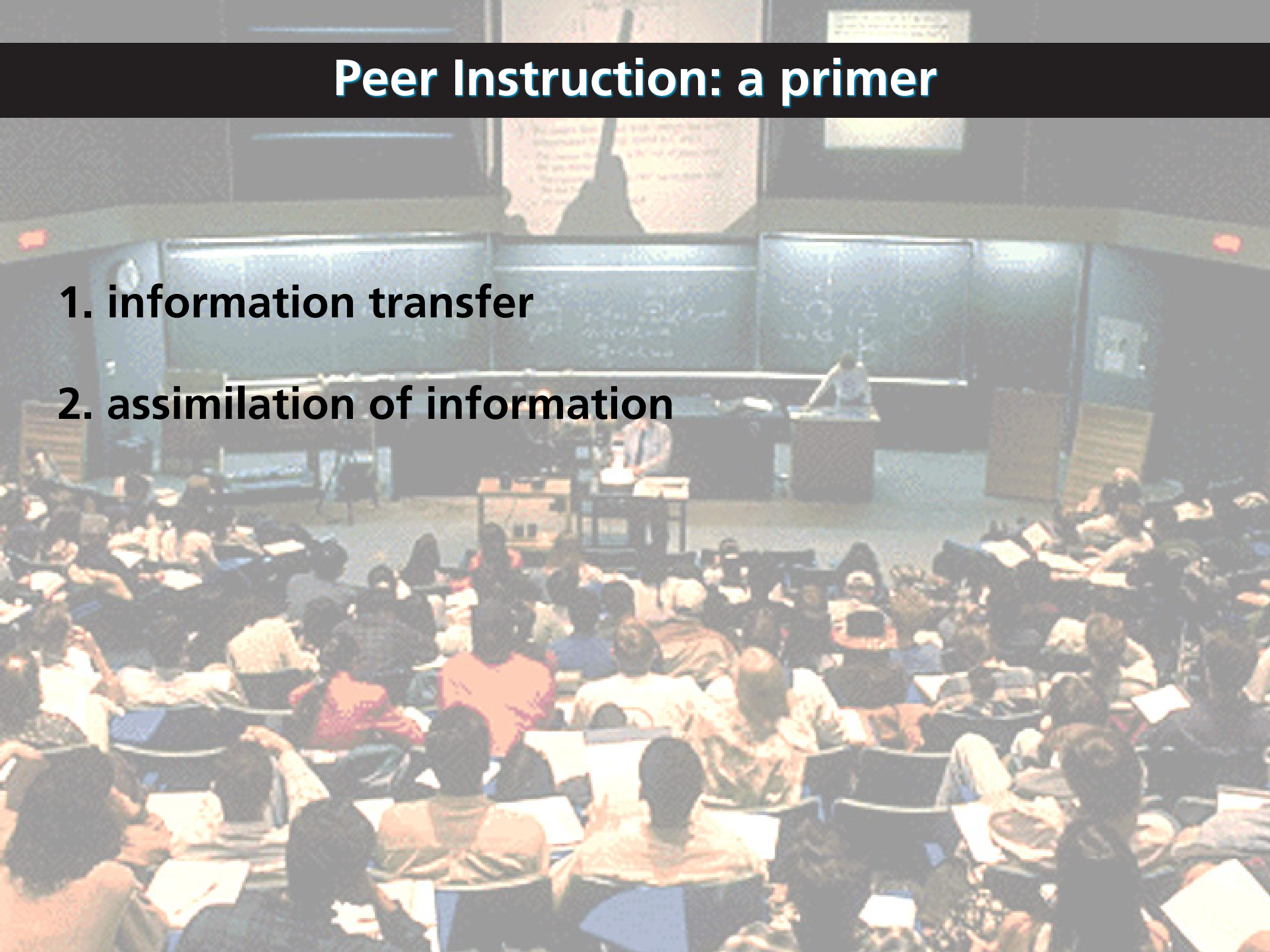
# Peer Instruction: a primer

## 1. information transfer



# Peer Instruction: a primer

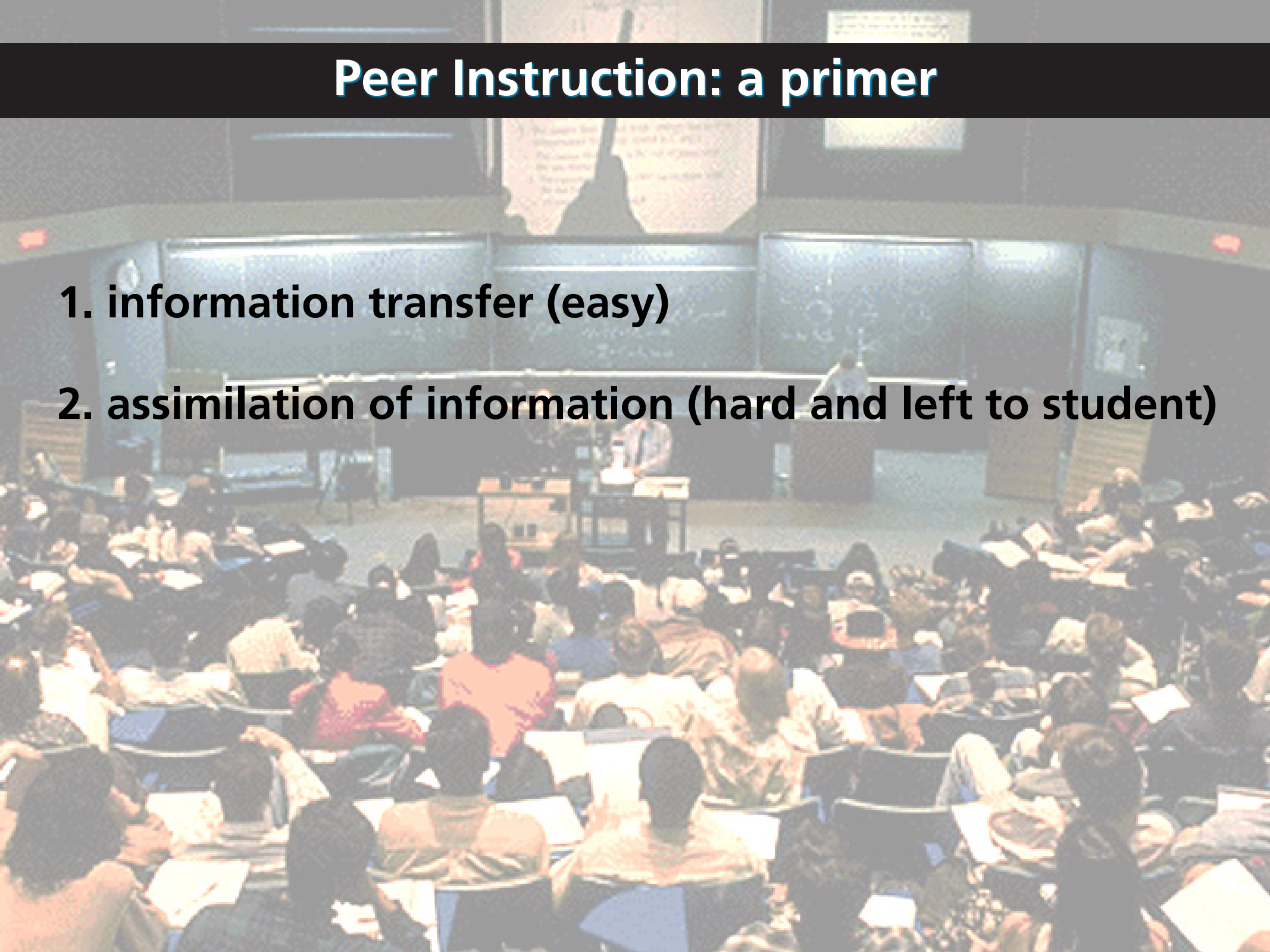
1. information transfer
2. assimilation of information





# Peer Instruction: a primer

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



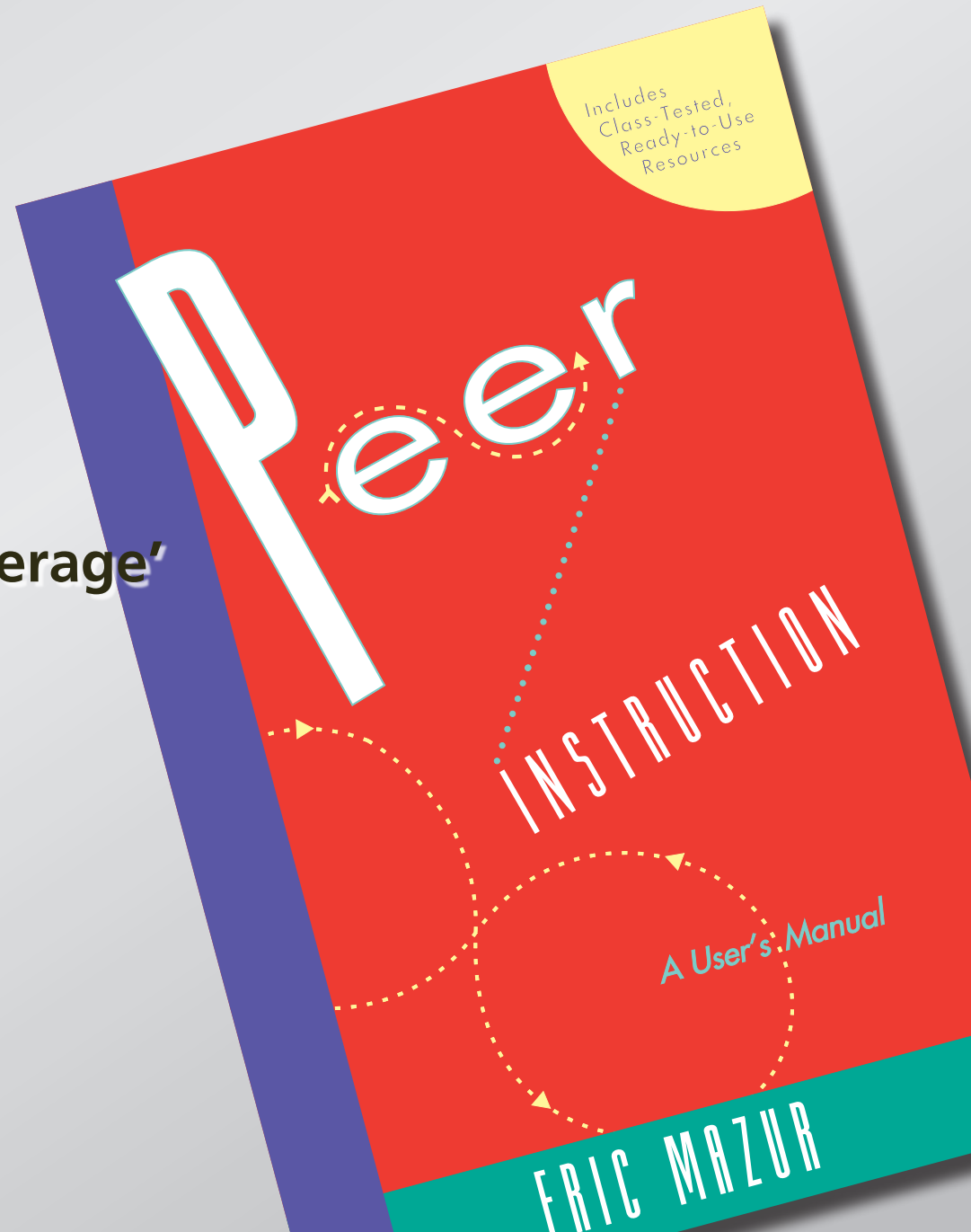
# Peer Instruction: a primer

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

# Peer Instruction: a primer

## Main features:

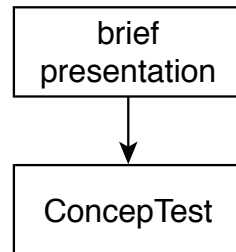
- pre-class reading
- in-class: depth, not 'coverage'
- ConcepTests



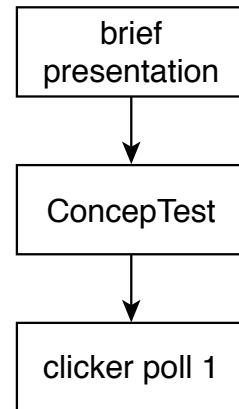
# Peer Instruction: a primer

brief  
presentation

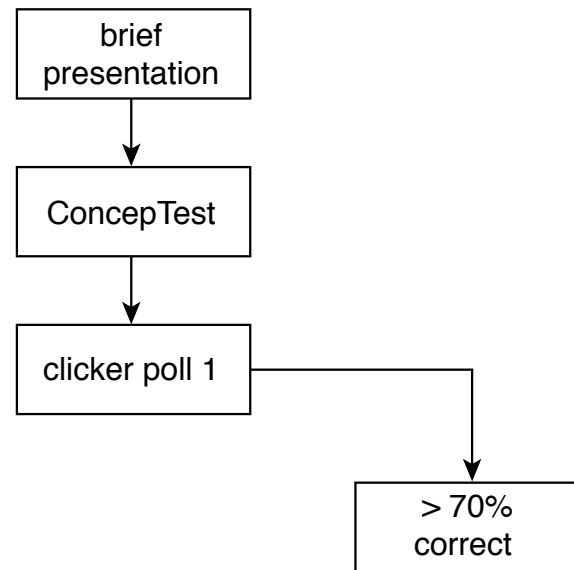
# Peer Instruction: a primer



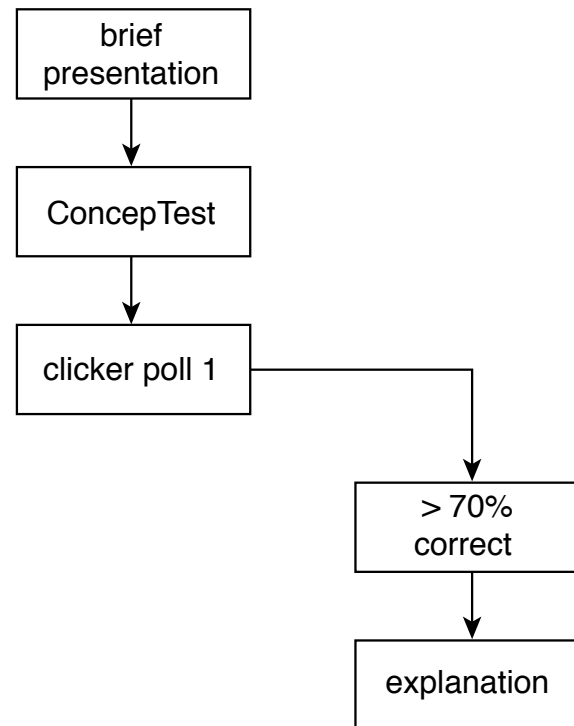
# Peer Instruction: a primer



# Peer Instruction: a primer

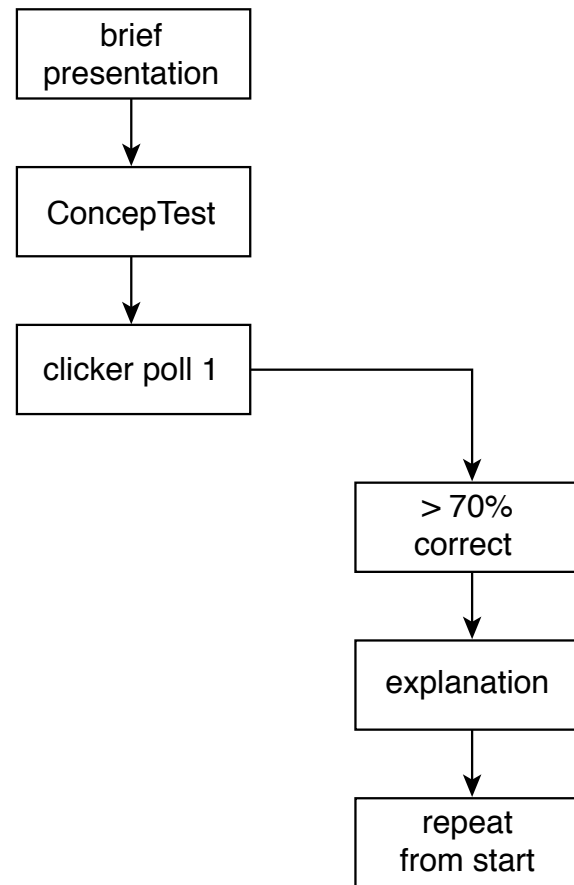


# Peer Instruction: a primer

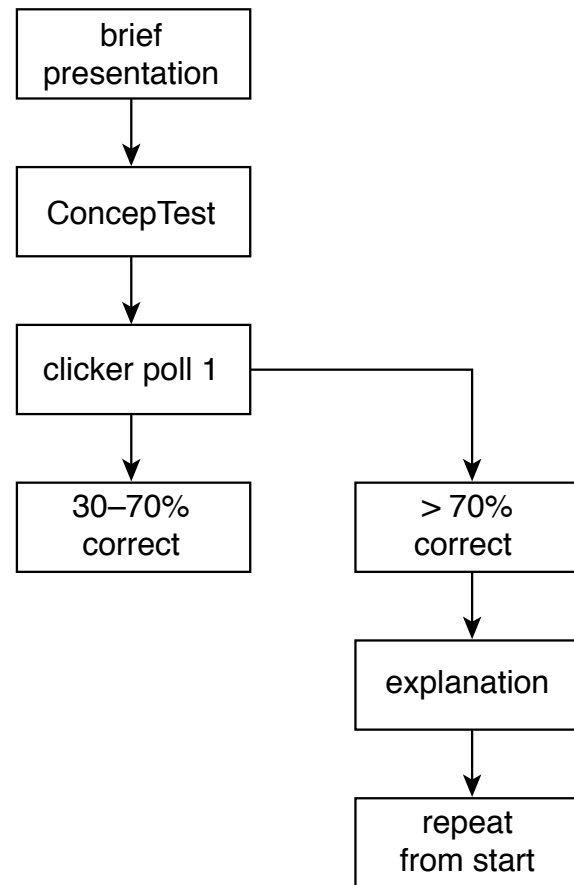




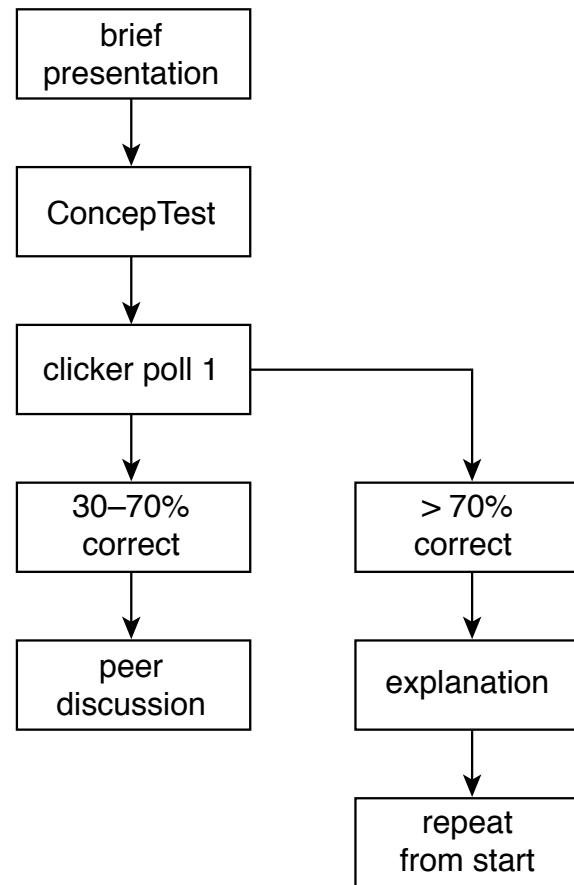
# Peer Instruction: a primer



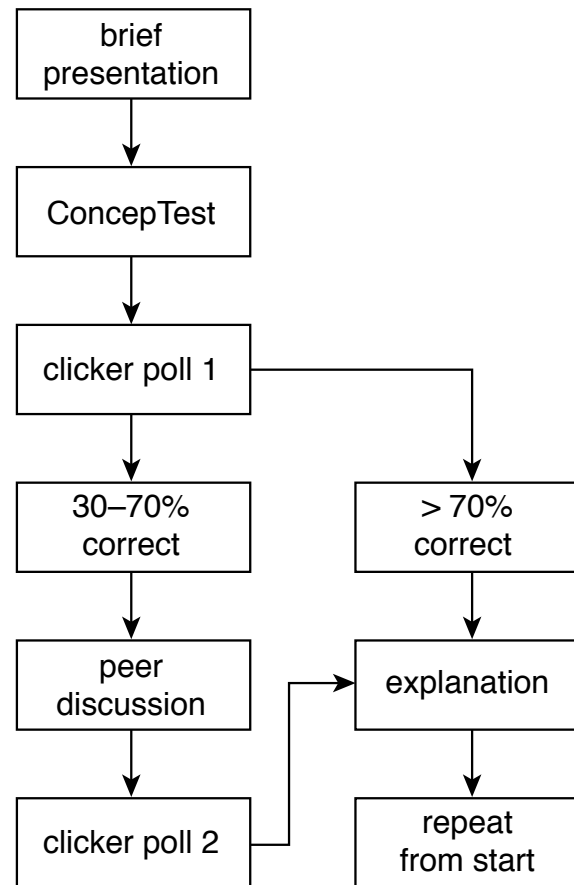
# Peer Instruction: a primer



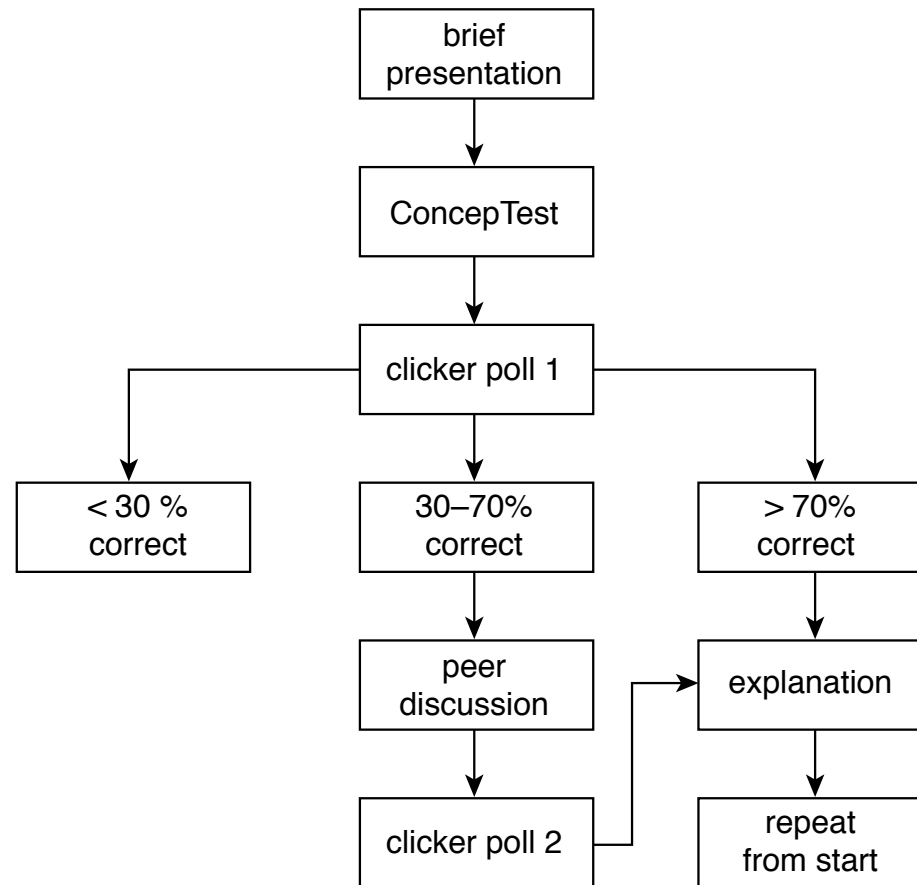
# Peer Instruction: a primer



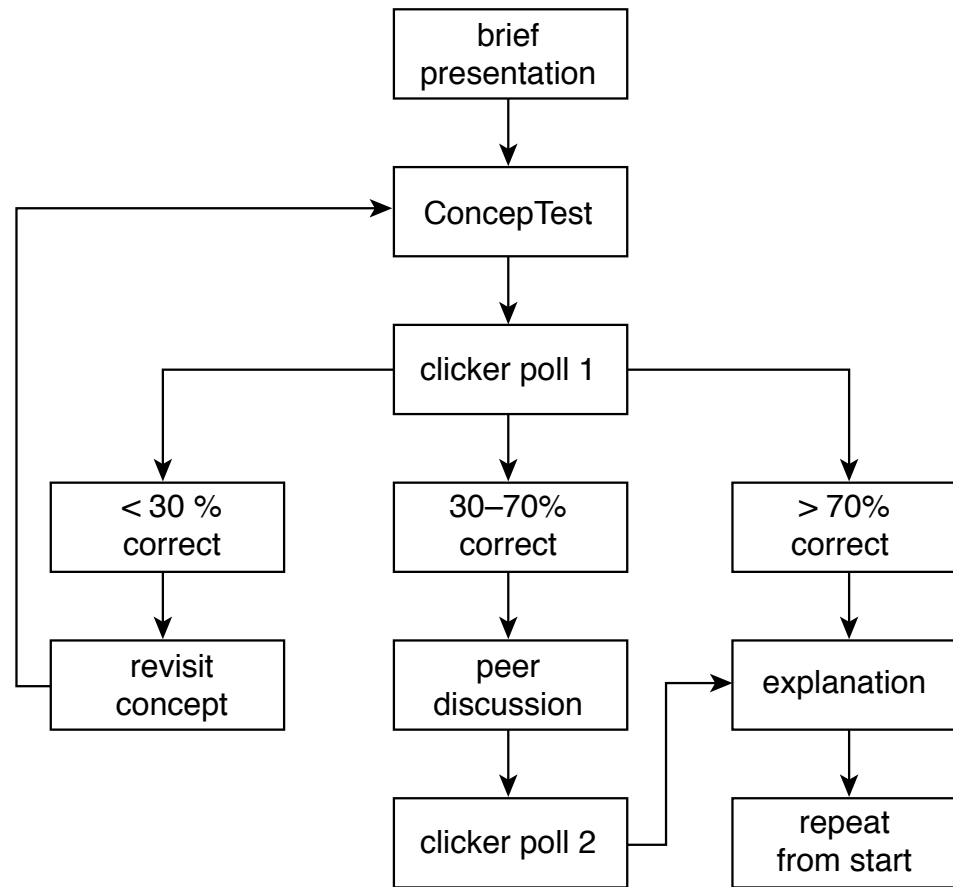
# Peer Instruction: a primer



# Peer Instruction: a primer

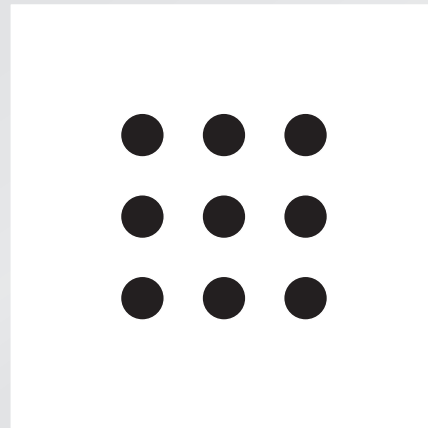


# Peer Instruction: a primer



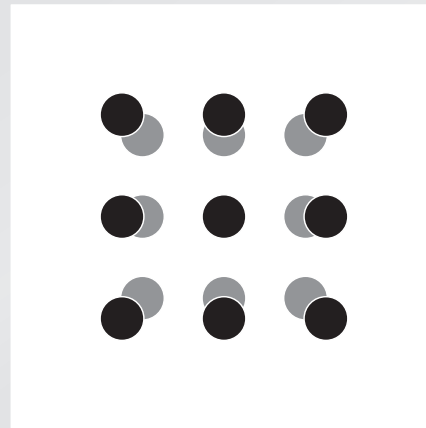
# Let's try it!

When metals heat up, they expand because all atoms get farther away from each other.



# Let's try it!

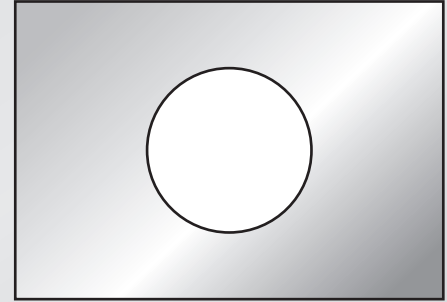
When metals heat up, they expand because all atoms get farther away from each other.





# Let's try it!

Consider a rectangular metal plate with a circular hole in it.

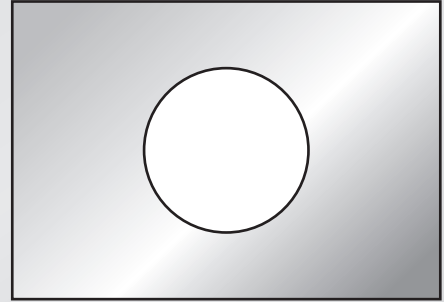


# Let's try it!

Consider a rectangular metal plate with a circular hole in it.

When the plate is uniformly heated, the diameter of the hole

1. increases.
2. stays the same.
3. decreases.

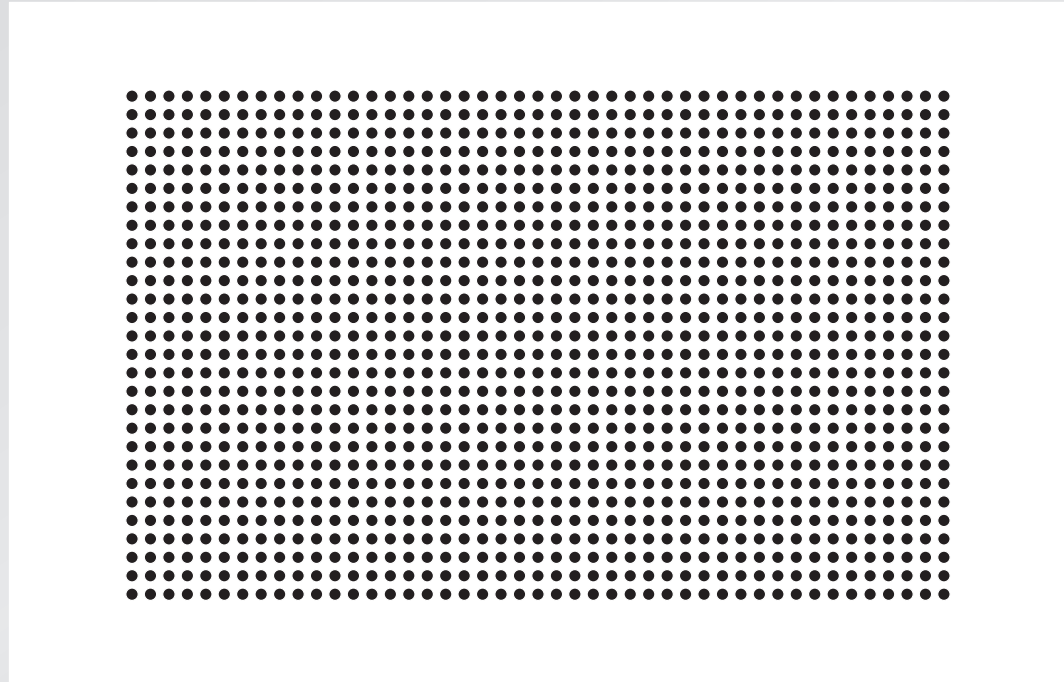


**Let's try it!**

*It's easy to fire up the audience!*

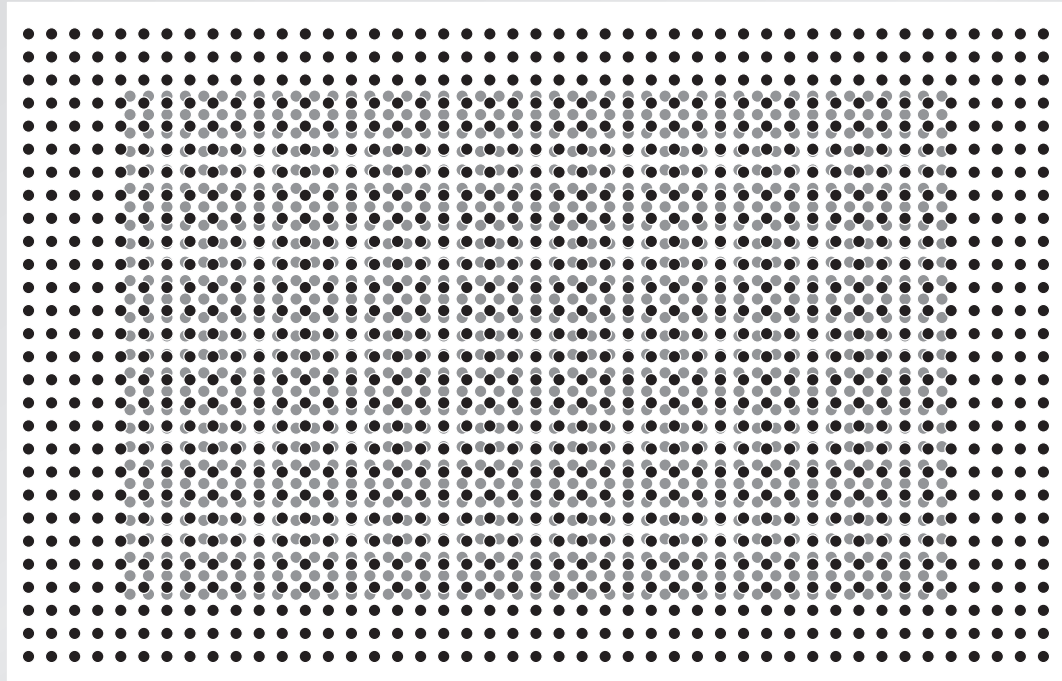
# Let's try it!

**remember: all atoms must get farther away from each other!**



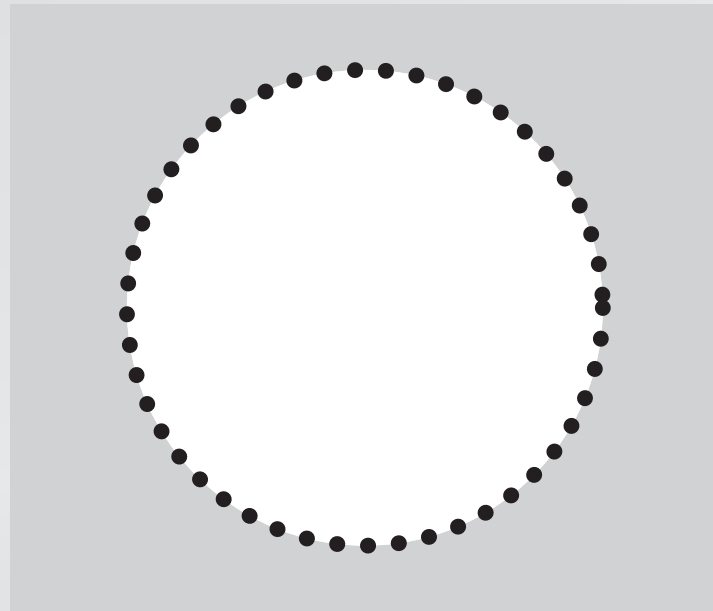
# Let's try it!

**remember: all atoms must get farther away from each other!**



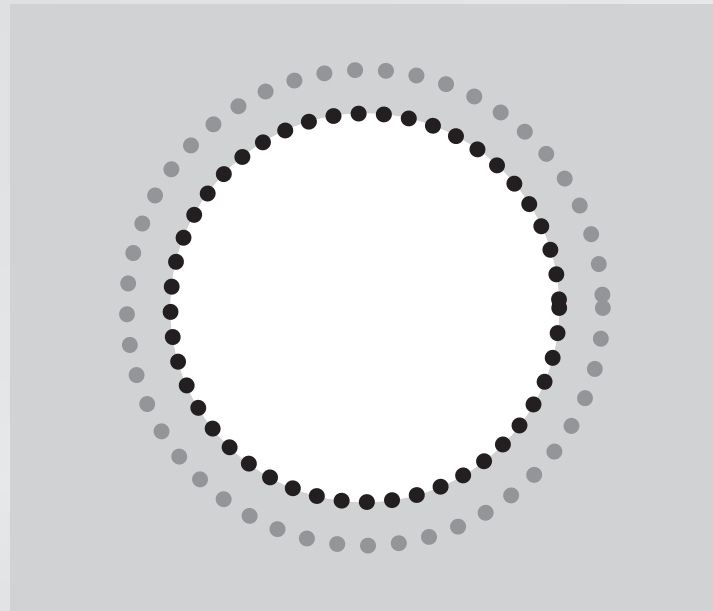
# Let's try it!

consider the atoms at the rim of the hole



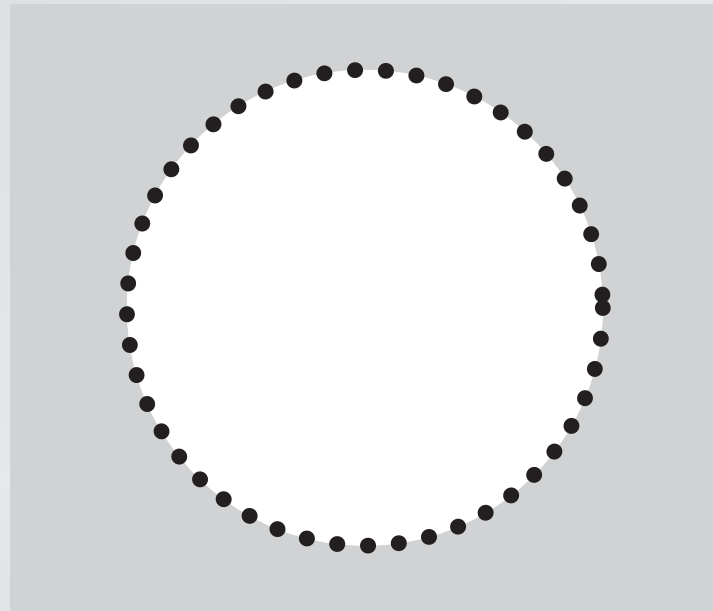
# Let's try it!

consider the atoms at the rim of the hole



# Let's try it!

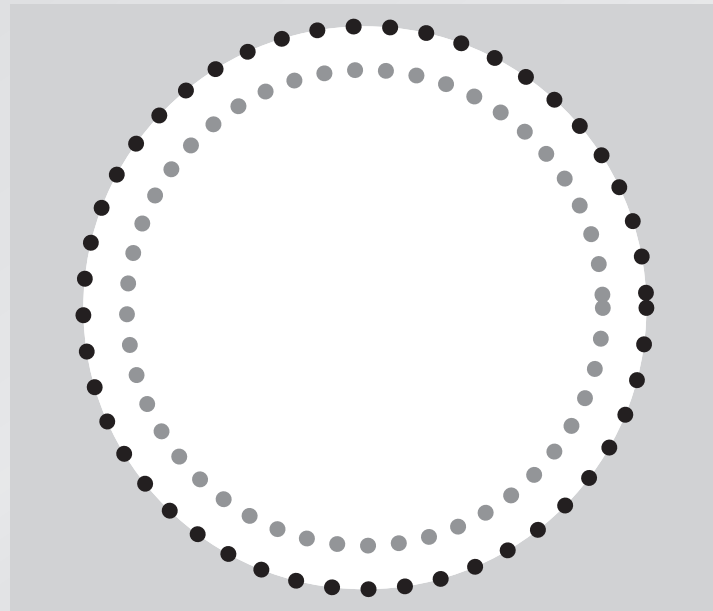
consider the atoms at the rim of the hole





# Let's try it!

consider the atoms at the rim of the hole



# Consider this

Professors A and B teach the same mechanics class at the same college during different semesters. Professor A uses the traditional approach to teaching and lectures. Professor B uses Peer Instruction and students respond to the questions using clickers. Each class is evaluated using the traditional end-of-semester questionnaire and using the FCI to measure students' comprehension of mechanics. Both professors are middle-aged and male. The results are as follows.

**A: student evaluation: 1.5/5.0;  $\langle g \rangle = 0.42$**

**B: student evaluation: 3.7/5.0;  $\langle g \rangle = 0.57$**

# Consider this

Professor	A	B
pedagogy	traditional	PI with clickers
student evaluation	1.5/5.0	3.7/5.0
FCI <g>	0.42	0.57

What might account for the large difference in evaluation?

I. professor personality

II. technology

III. pedagogy

1. I only

2. II only

3. III only

4. II and III

5. I, II, and III

6. other combination

# Consider this

**a couple of points worth noting:**

# Consider this

**a couple of points worth noting:**

- 1. you got engaged**

# Consider this

a couple of points worth noting:

1. you got engaged
2. no "correct" answer

# Consider this

a couple of points worth noting:

1. you got engaged
2. no "correct" answer
3. you got engaged

# Consider this

**a couple of points worth noting:**

- 1. you got engaged**
- 2. no “correct” answer**
- 3. you got engaged**
- 4. you don’t need a correct answer!**



# 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

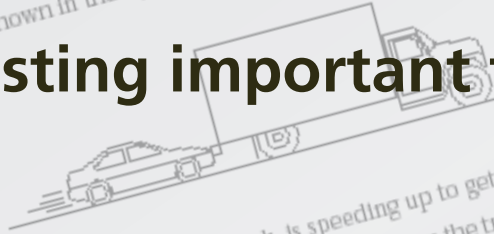
- **convince yourself (and your colleagues)**
- **set learning goals**
- **select approaches**
- **identify resources**

# 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. 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.
  - \_\_\_ 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.

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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.

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

# 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.

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.**

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:

Developing a model  
Applying that model

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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.

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

# 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.

**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?



# 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?

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

# 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?

Requires:

Using a calculator

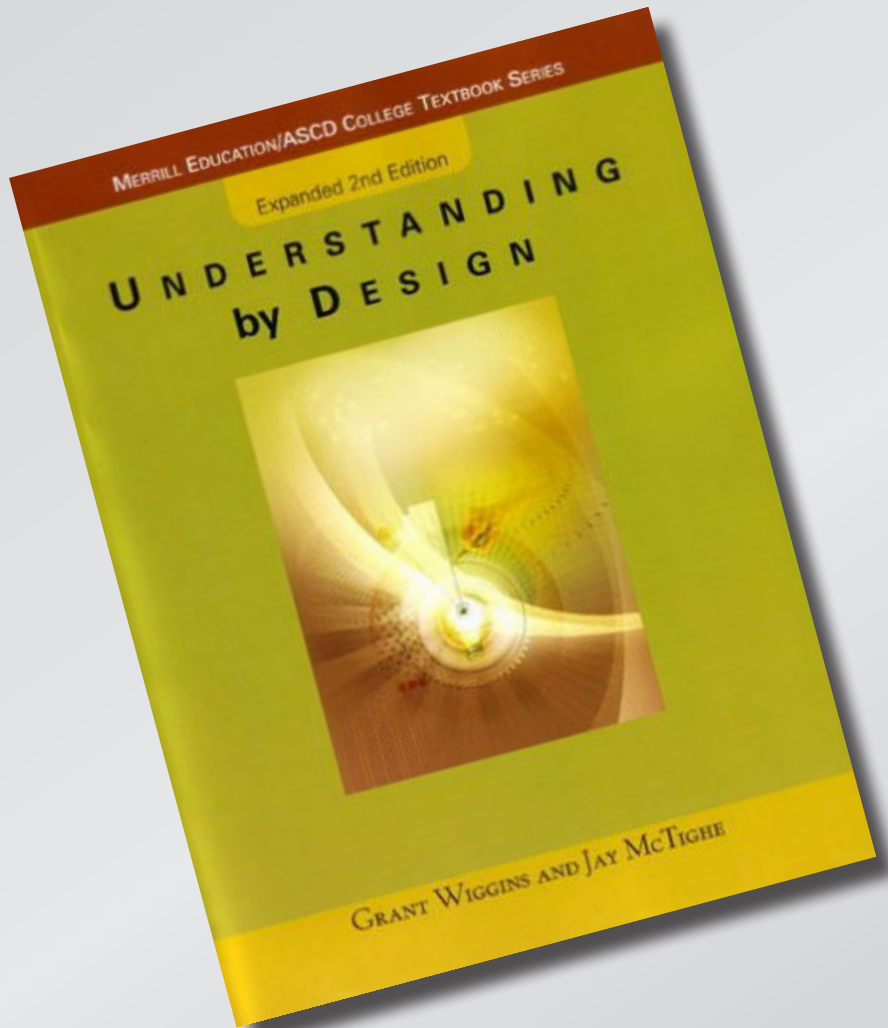
$$t_{wait} = \frac{T_{shop}}{N_{spaces}}$$

# Setting the stage

**Need to test meaningful skills!**

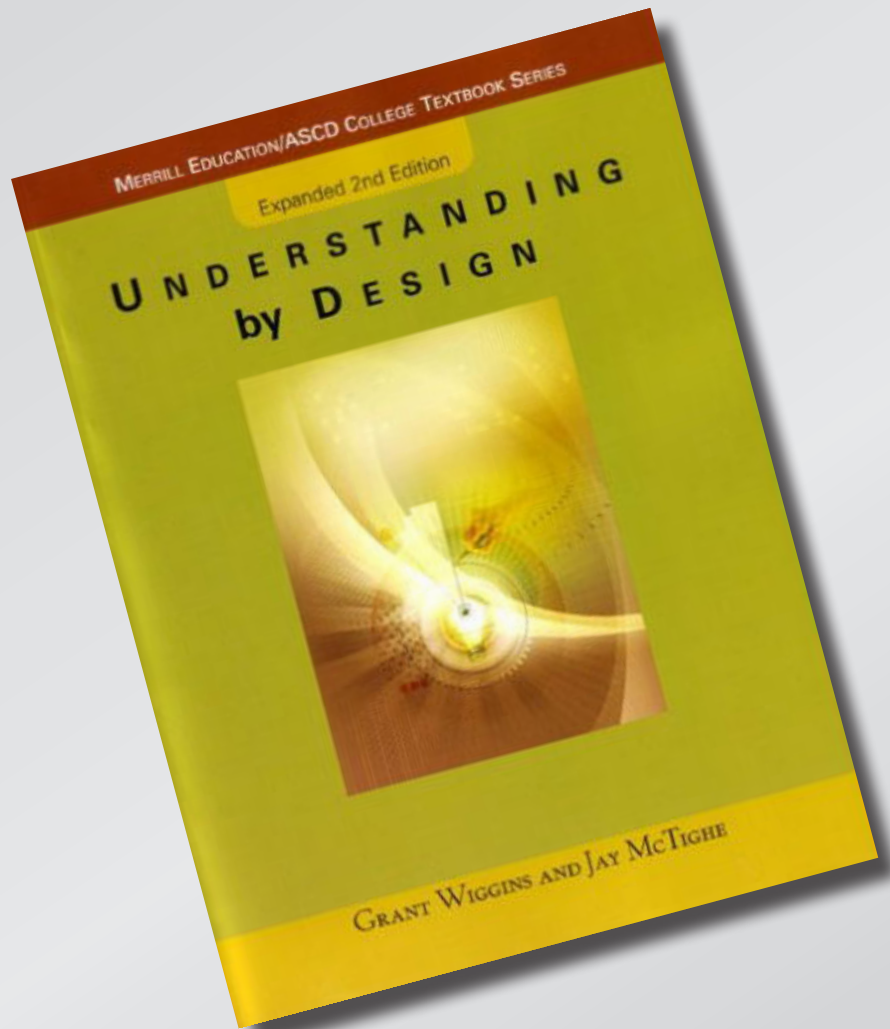
# Setting the stage

## Setting learning goals



# Setting the stage

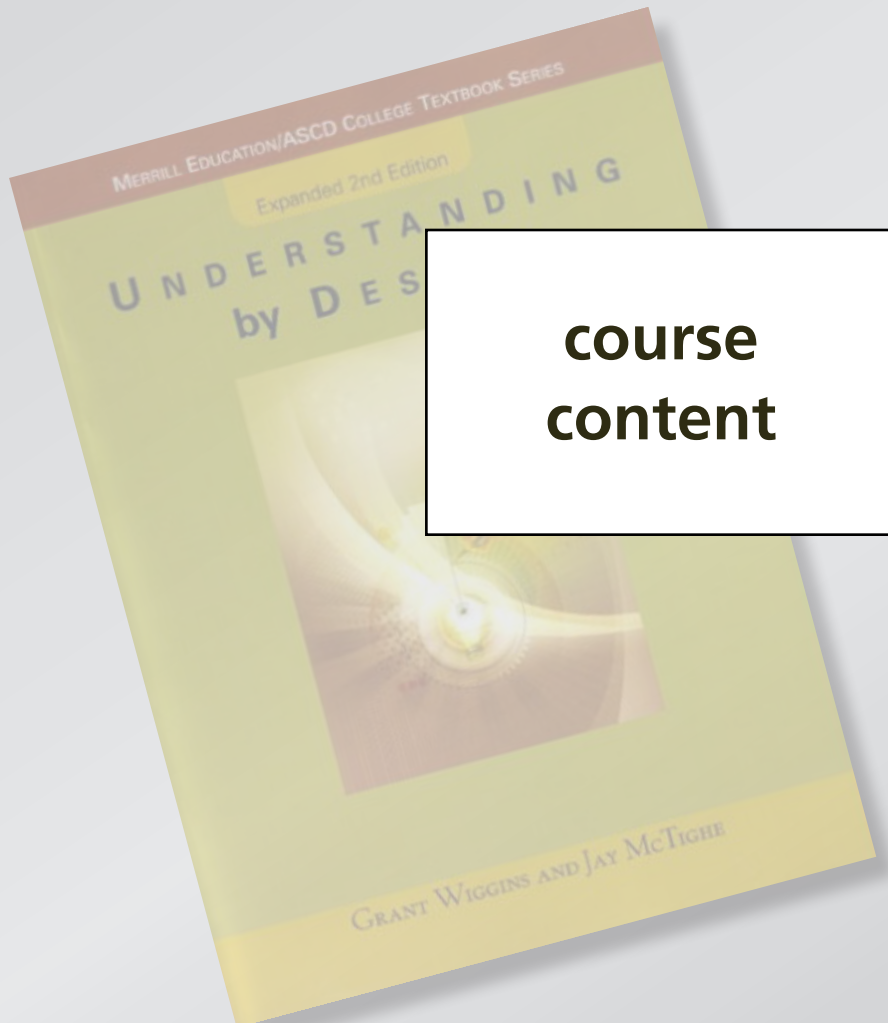
## Setting learning goals



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

# Setting the stage

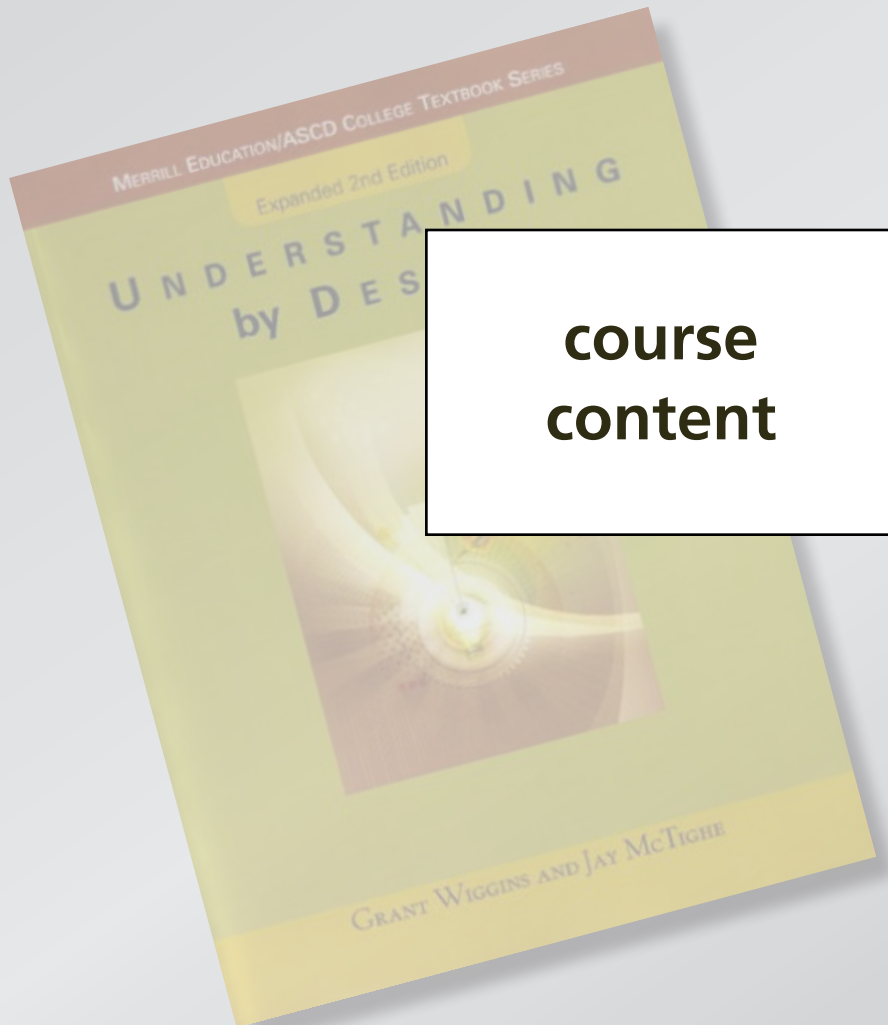
## Traditional approach to course planning



**course  
content**

# Setting the stage

## Traditional approach to course planning



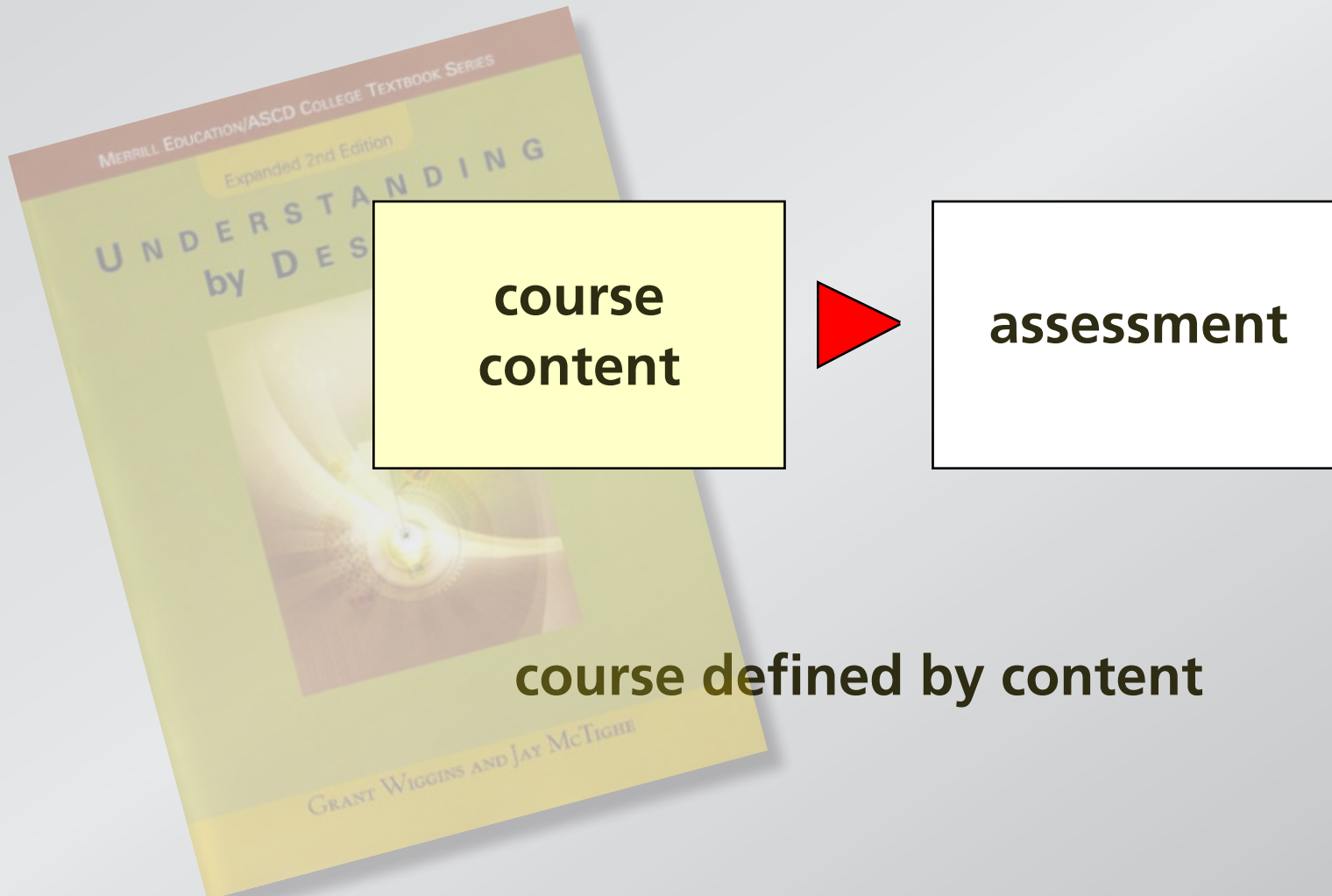
**course  
content**



**assessment**

# Setting the stage

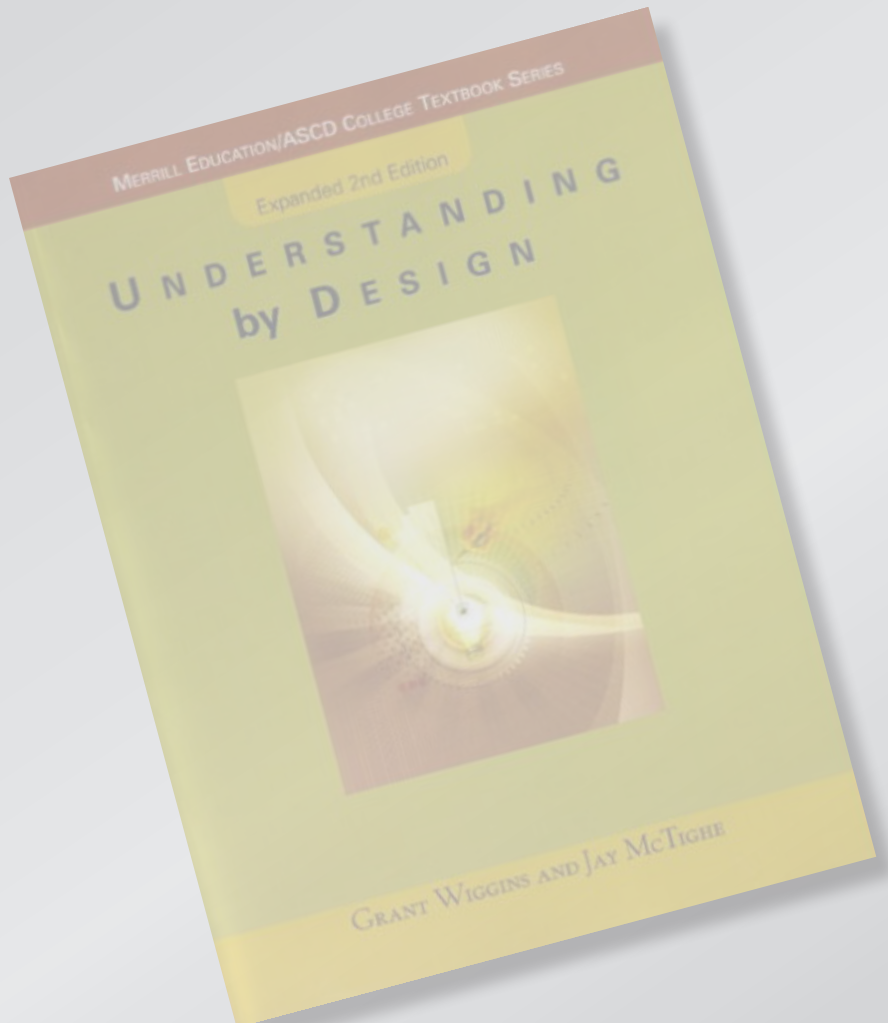
## Traditional approach to course planning





# Setting the stage

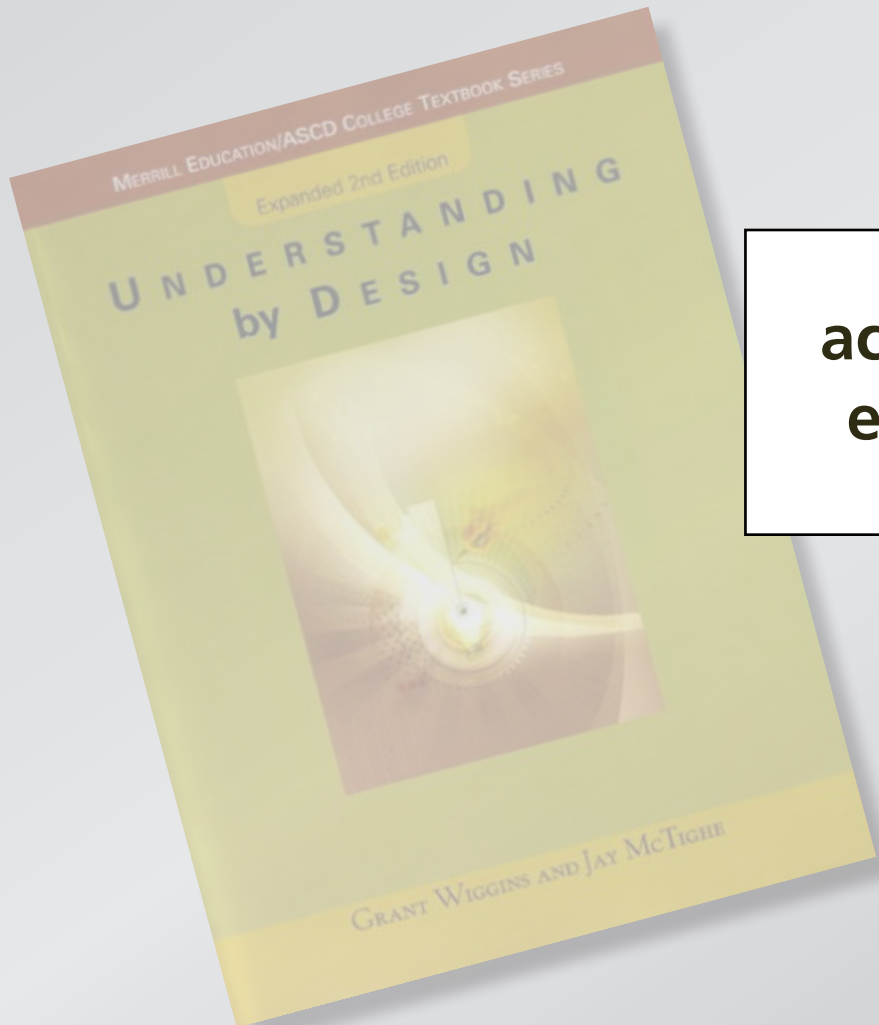
## Backward design



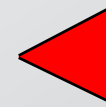
**desired  
outcomes**

# Setting the stage

## Backward design



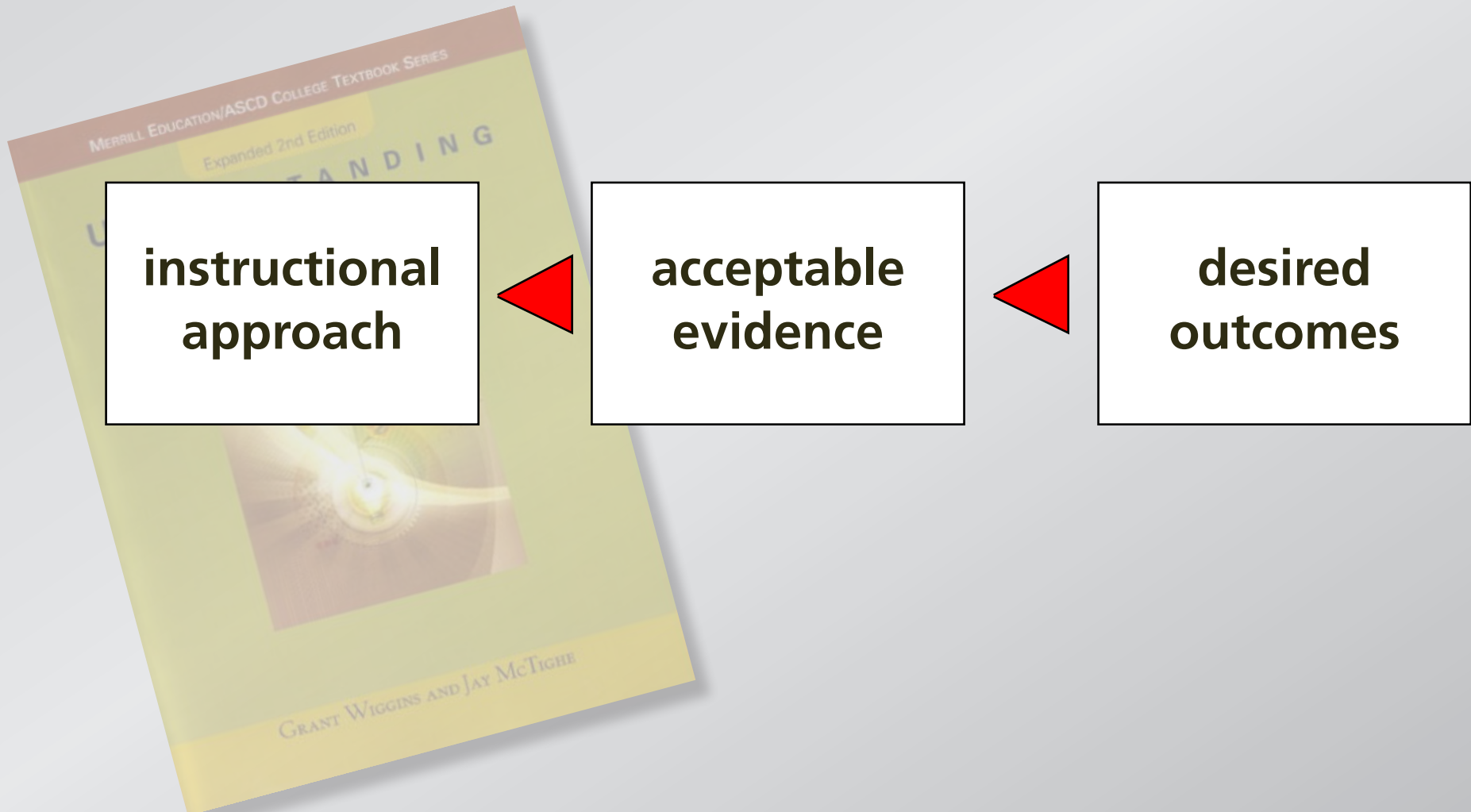
**acceptable  
evidence**



**desired  
outcomes**

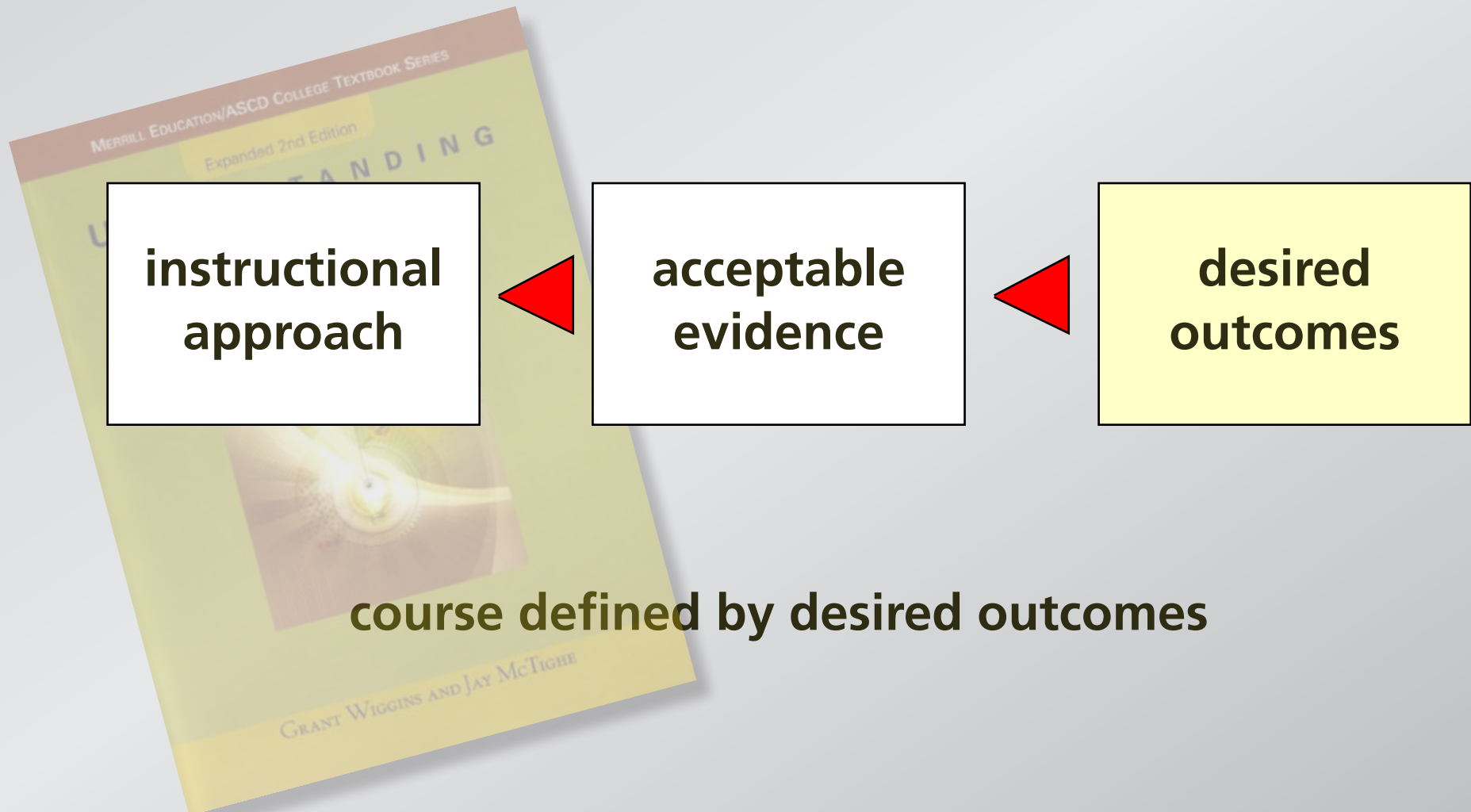
# Setting the stage

## Backward design



# Setting the stage

## Backward design



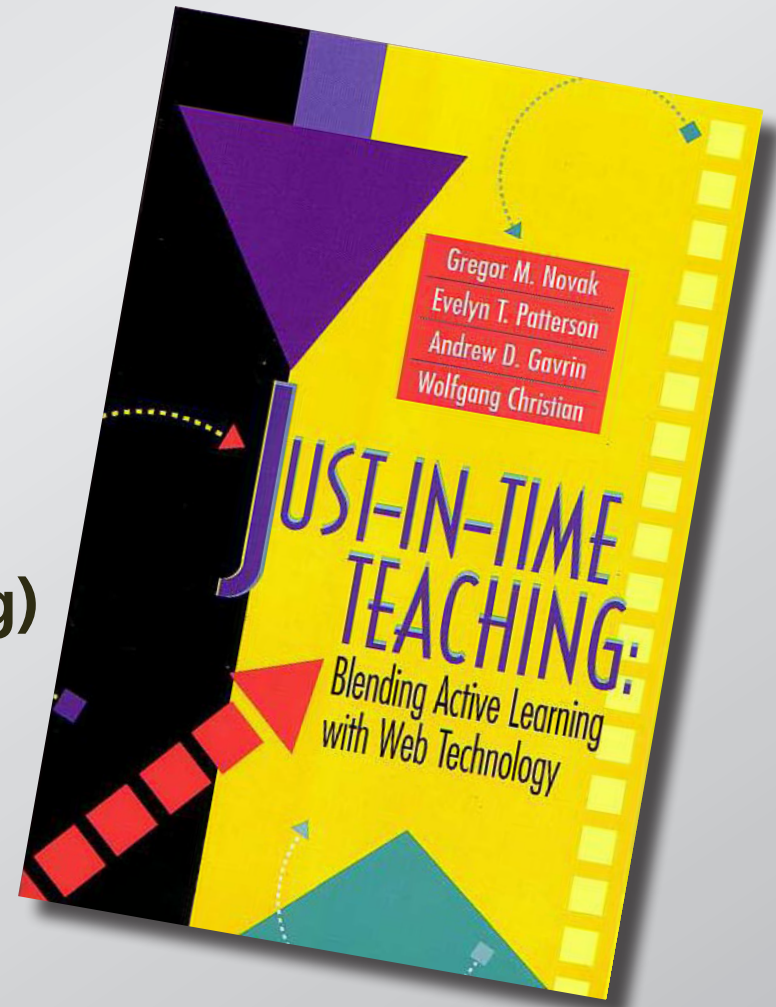
# Setting the stage

**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))

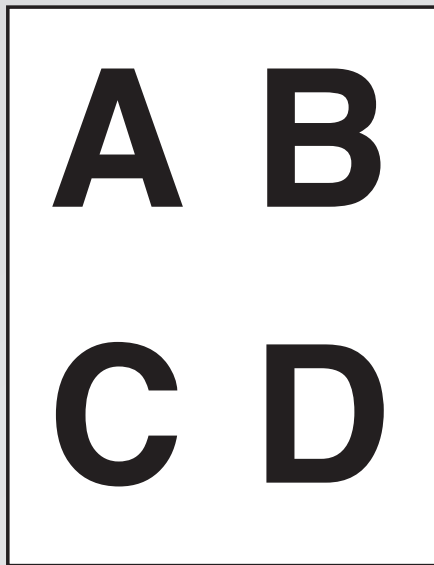


# Setting the stage

**Are clickers a required resource?**

# Setting the stage

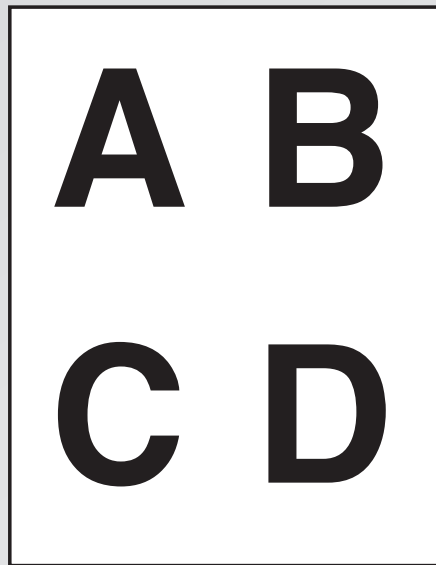
Flashcards: simple and effective





# 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.



# Setting the stage

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)**

# 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)**

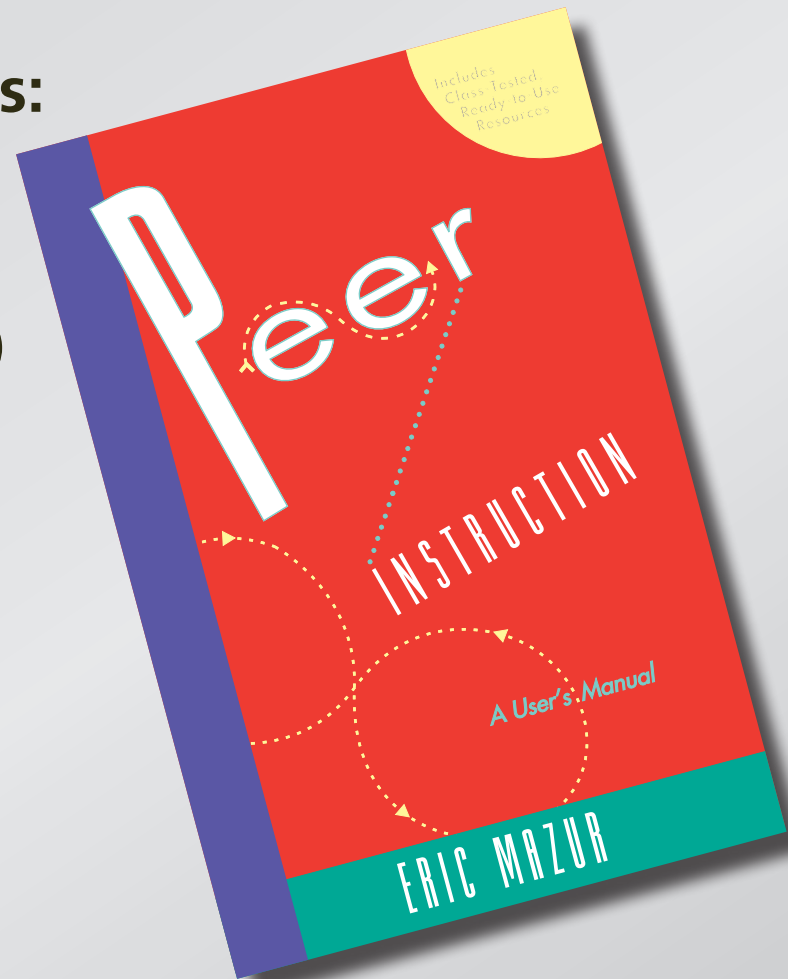
# Making it happen

- **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:

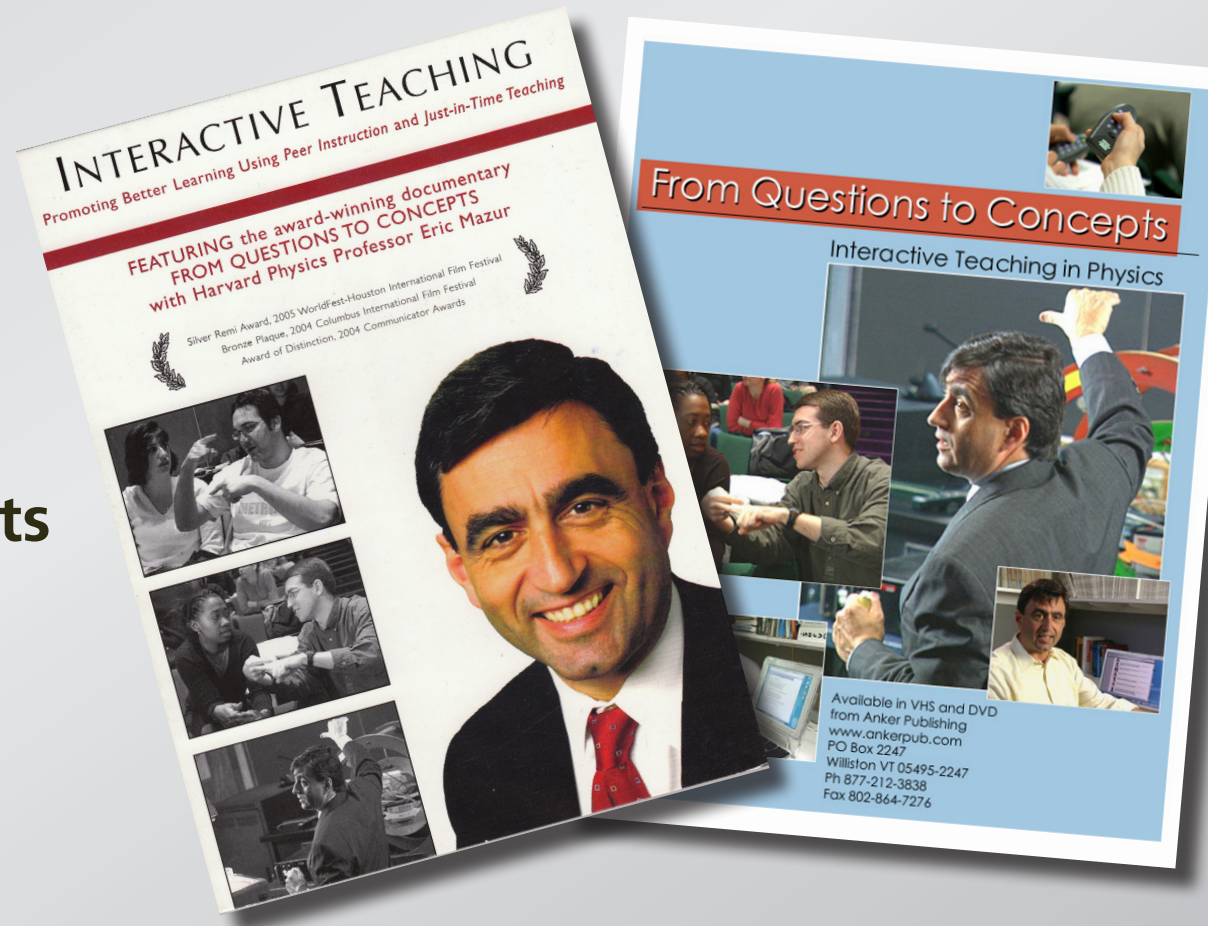
- Physics (Prentice Hall)
- Chemistry (Prentice Hall)
- Astronomy (Prentice Hall)
- Calculus (Wiley)



# 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?

1. Delta Airlines
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- 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

**hole in plate/circumference**

**model**

**Professor A/B**

**discussion**

**airline**

**fact**

# Making it happen

hole in plate/circumference

model

Professor A/B

discussion

airline

fact

fact-recall not engaging



# Making it happen

**Good conceptual questions (ConceptTests):**

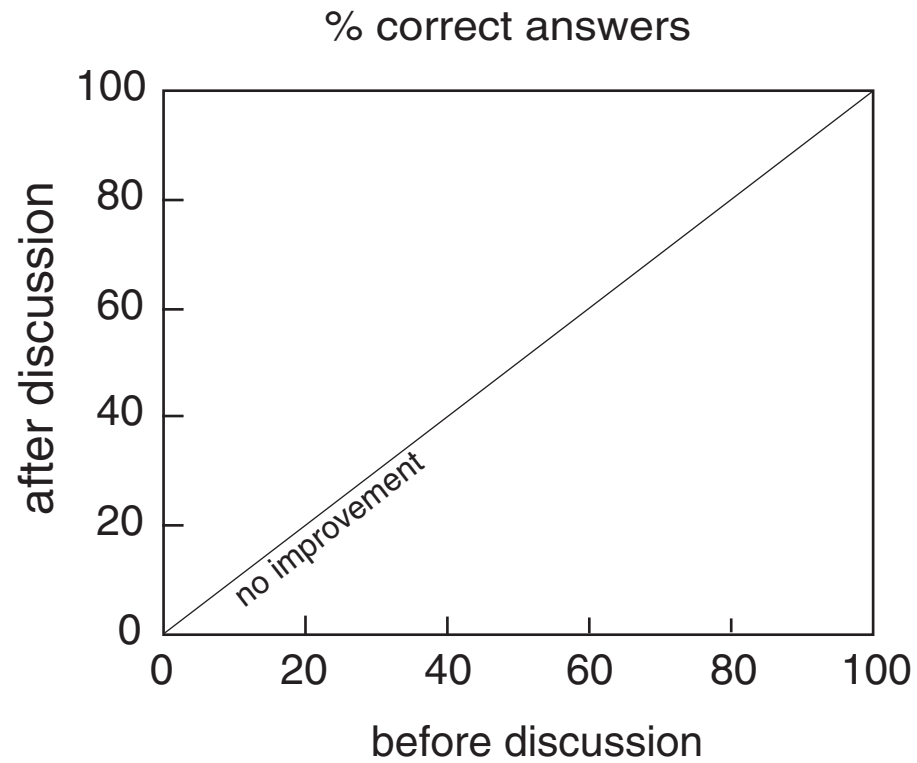
- **are based on common student difficulties**
- **focus on single concept**
- **require more than “plug and chug”**
- **are clear and concise**
- **are of manageable difficulty**

# Making it happen

**must adjust level to audience**

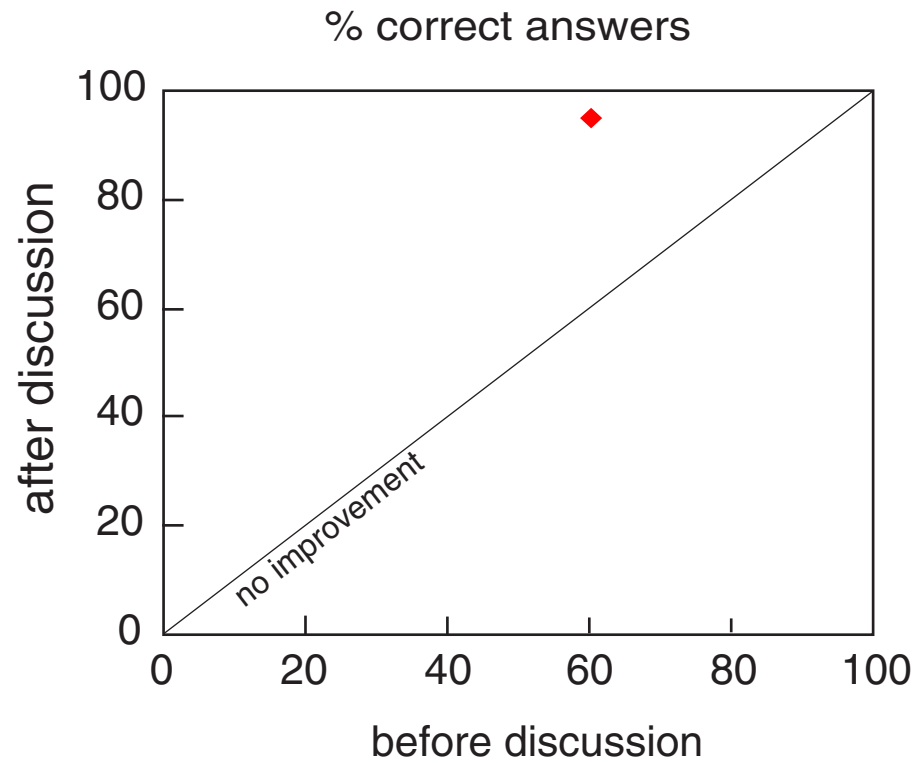
# Making it happen

## ConceptTest data



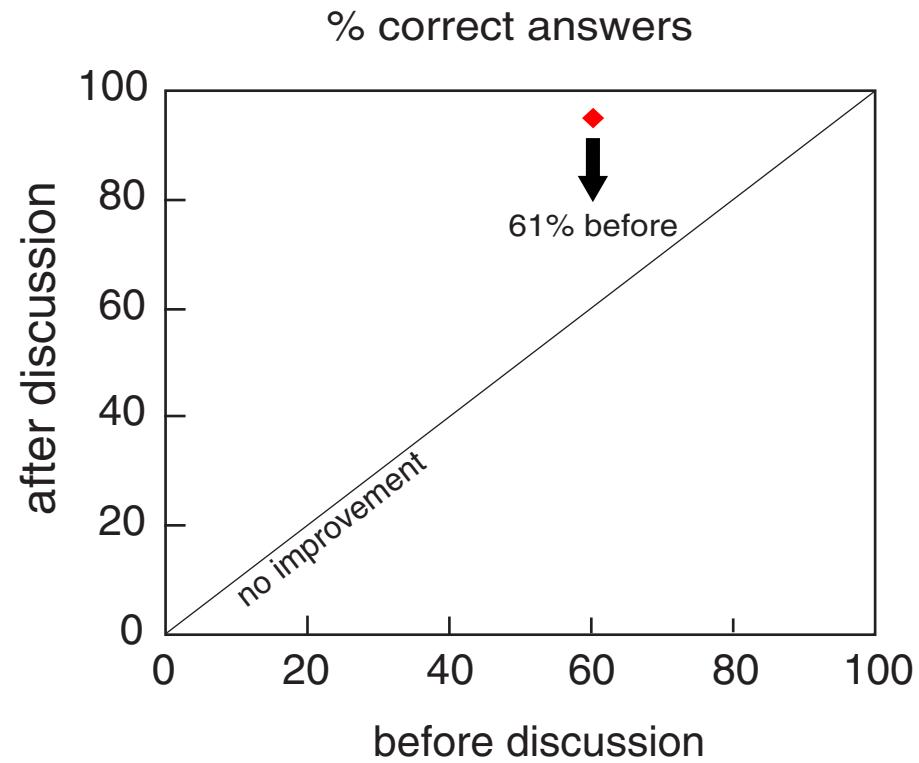
# Making it happen

## ConceptTest data



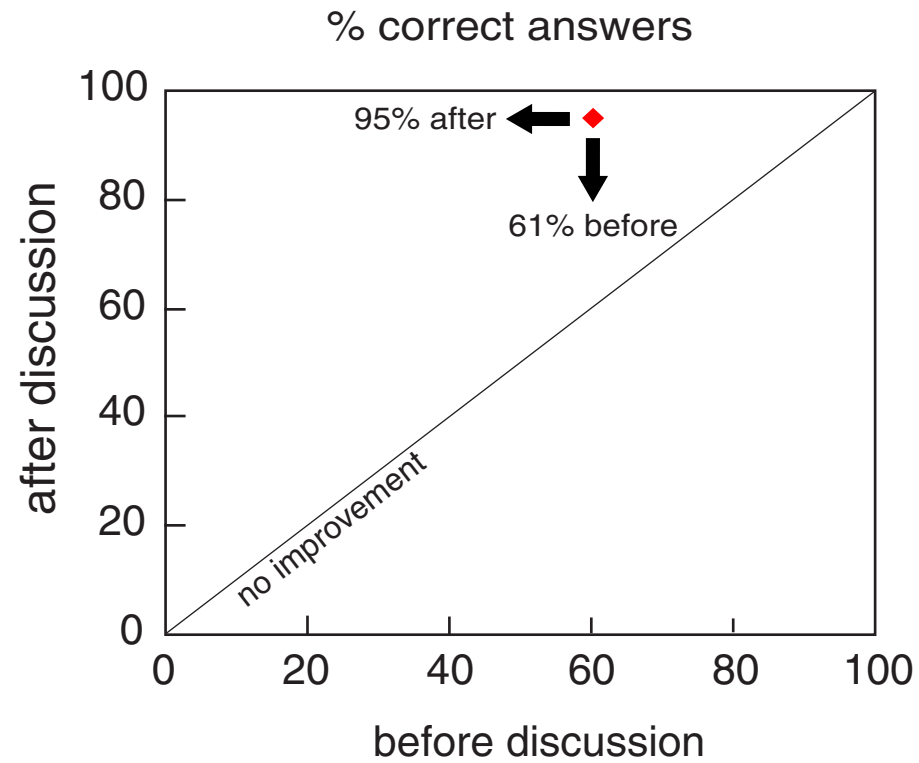
# Making it happen

## ConceptTest data



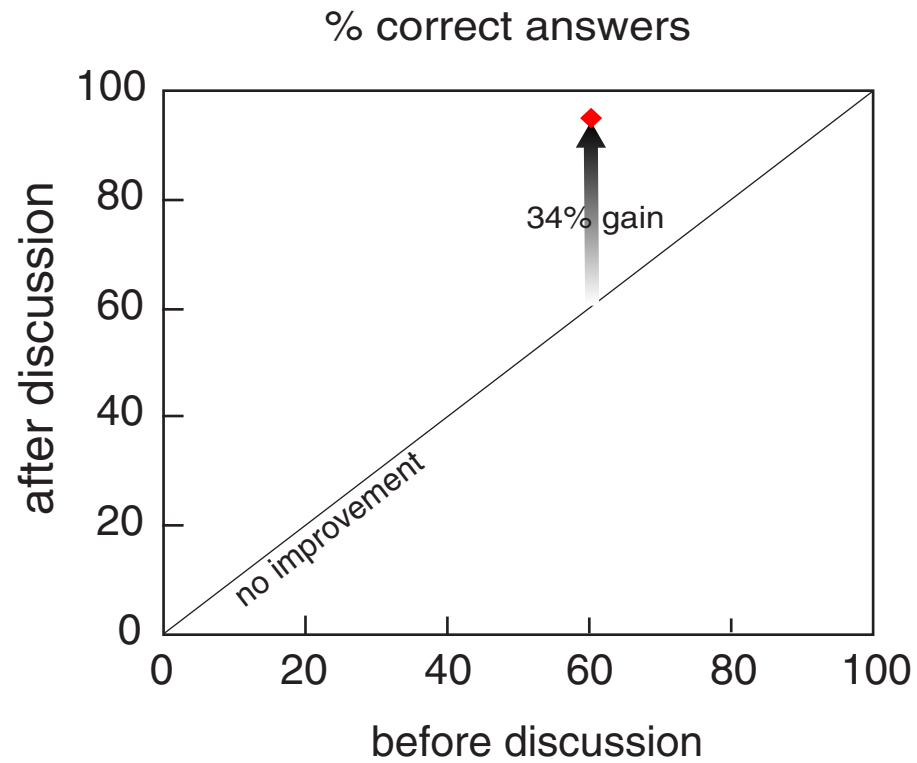
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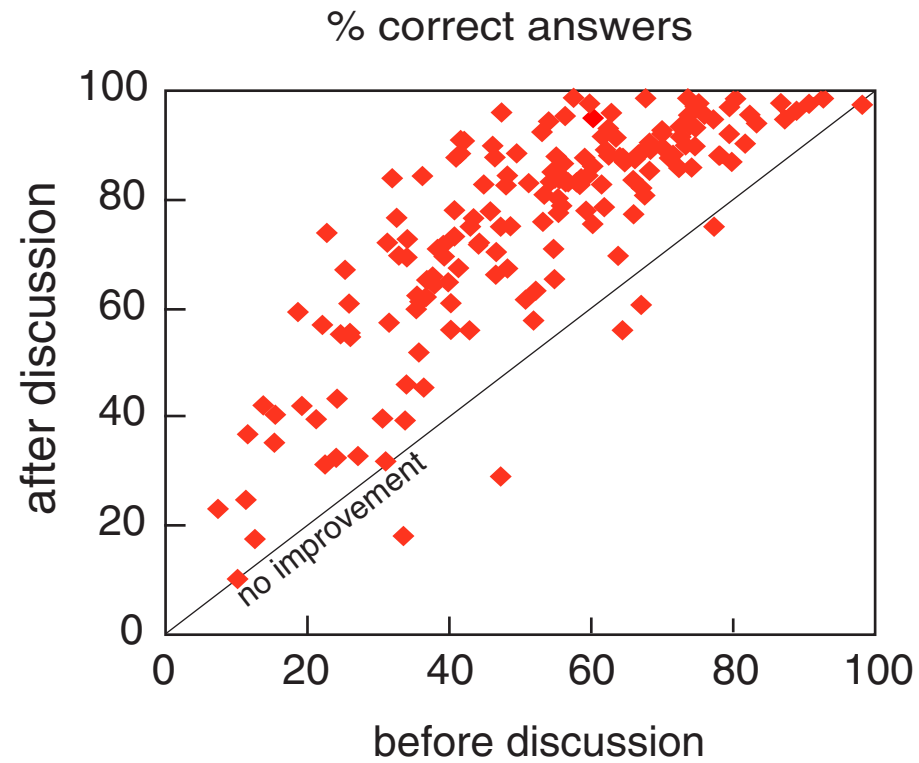
# Making it happen

## ConceptTest data



# Making it happen

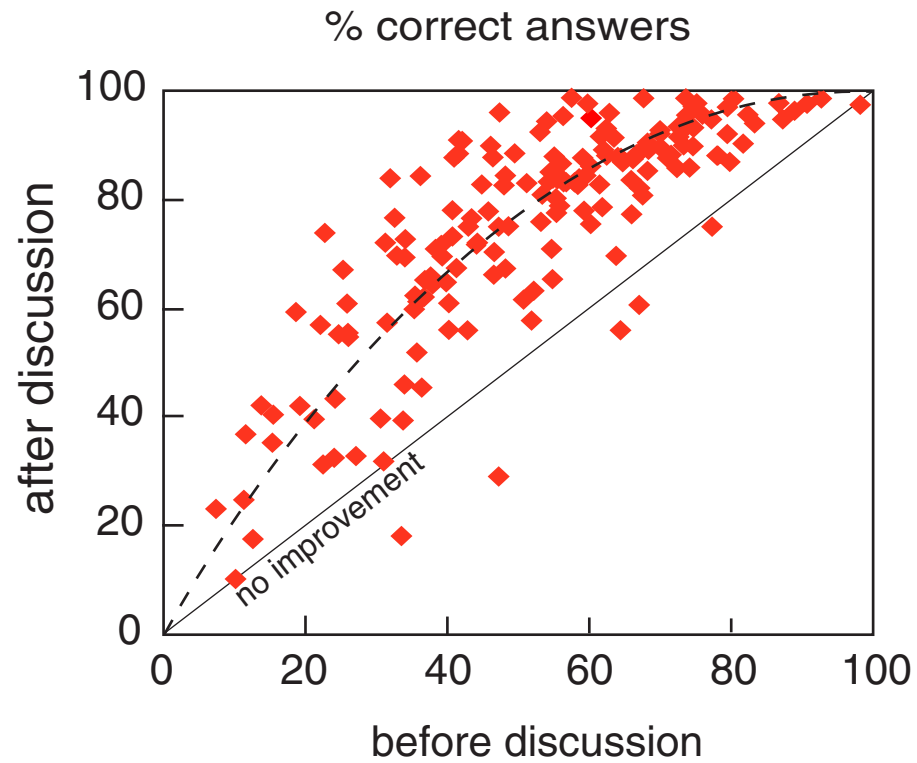
## ConceptTest data





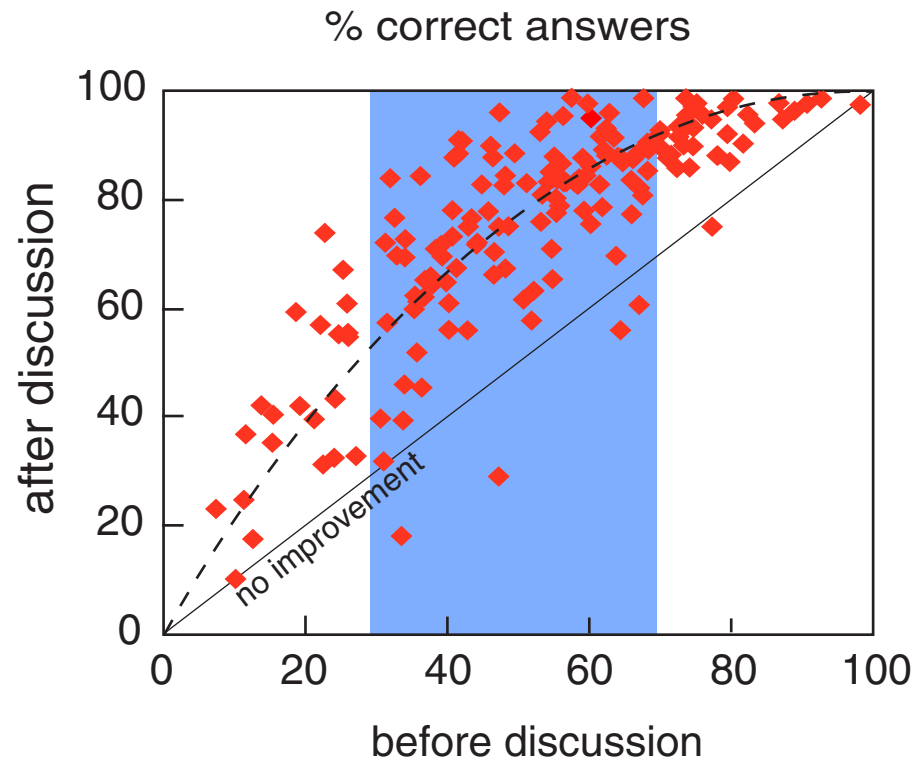
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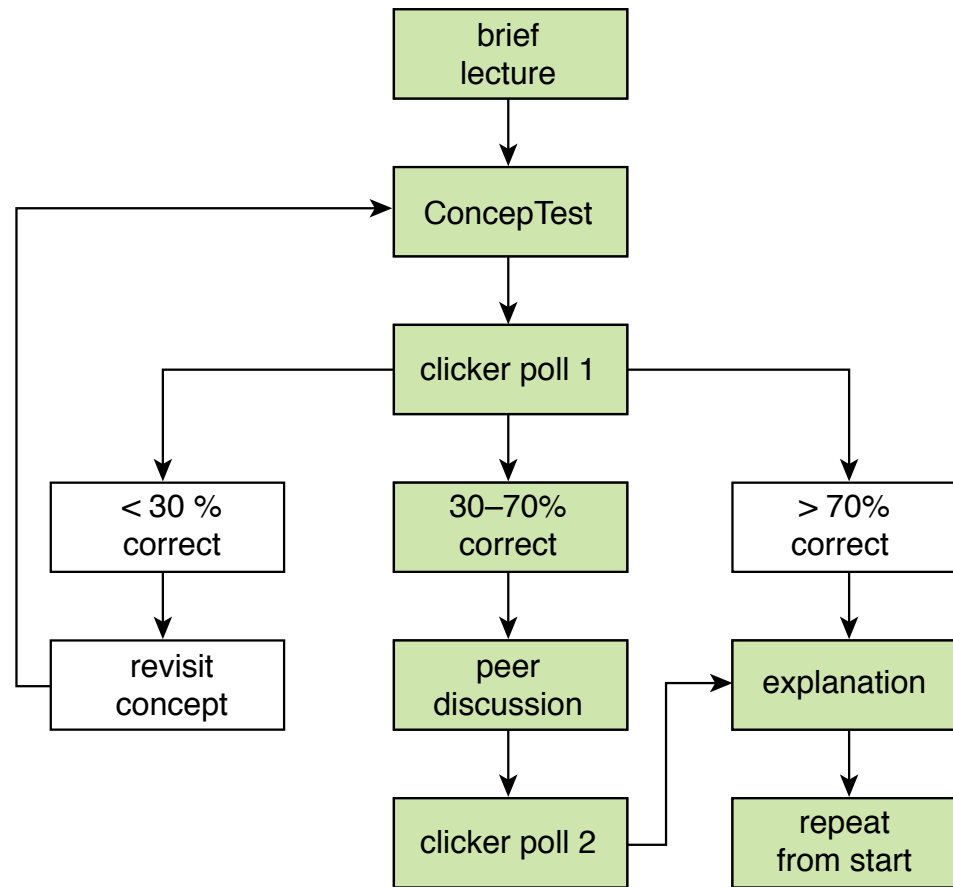


# Making it happen

## ConceptTest data



# Peer Instruction: a primer



# Outline

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

# Overcoming barriers

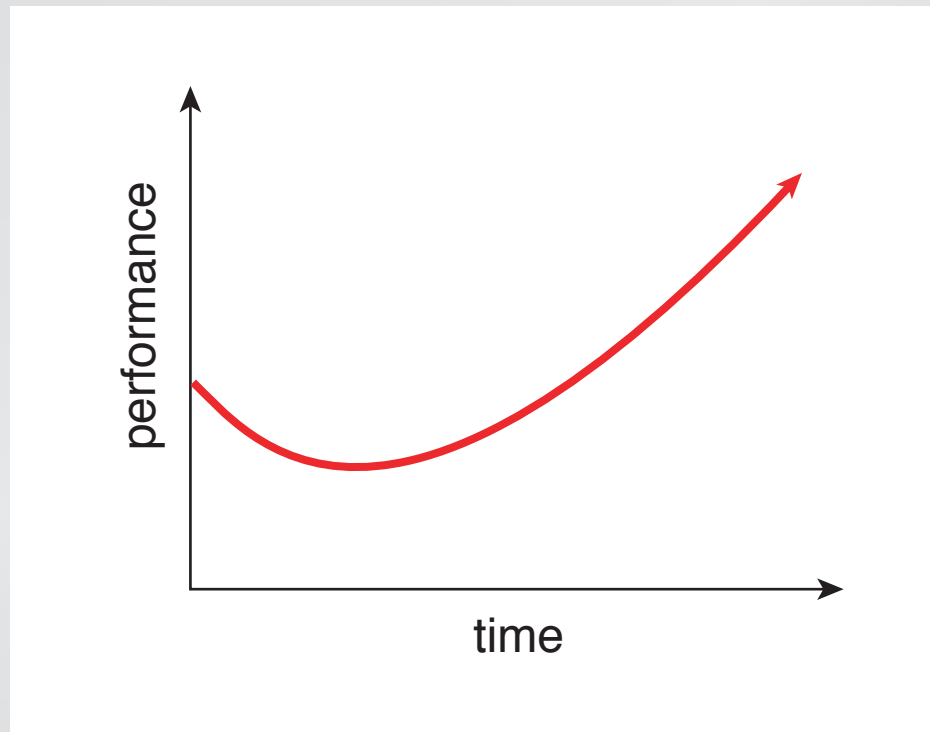
**What are some potential barriers?**

# 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

---

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# Overcoming barriers

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# Overcoming barriers

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

# Overcoming barriers

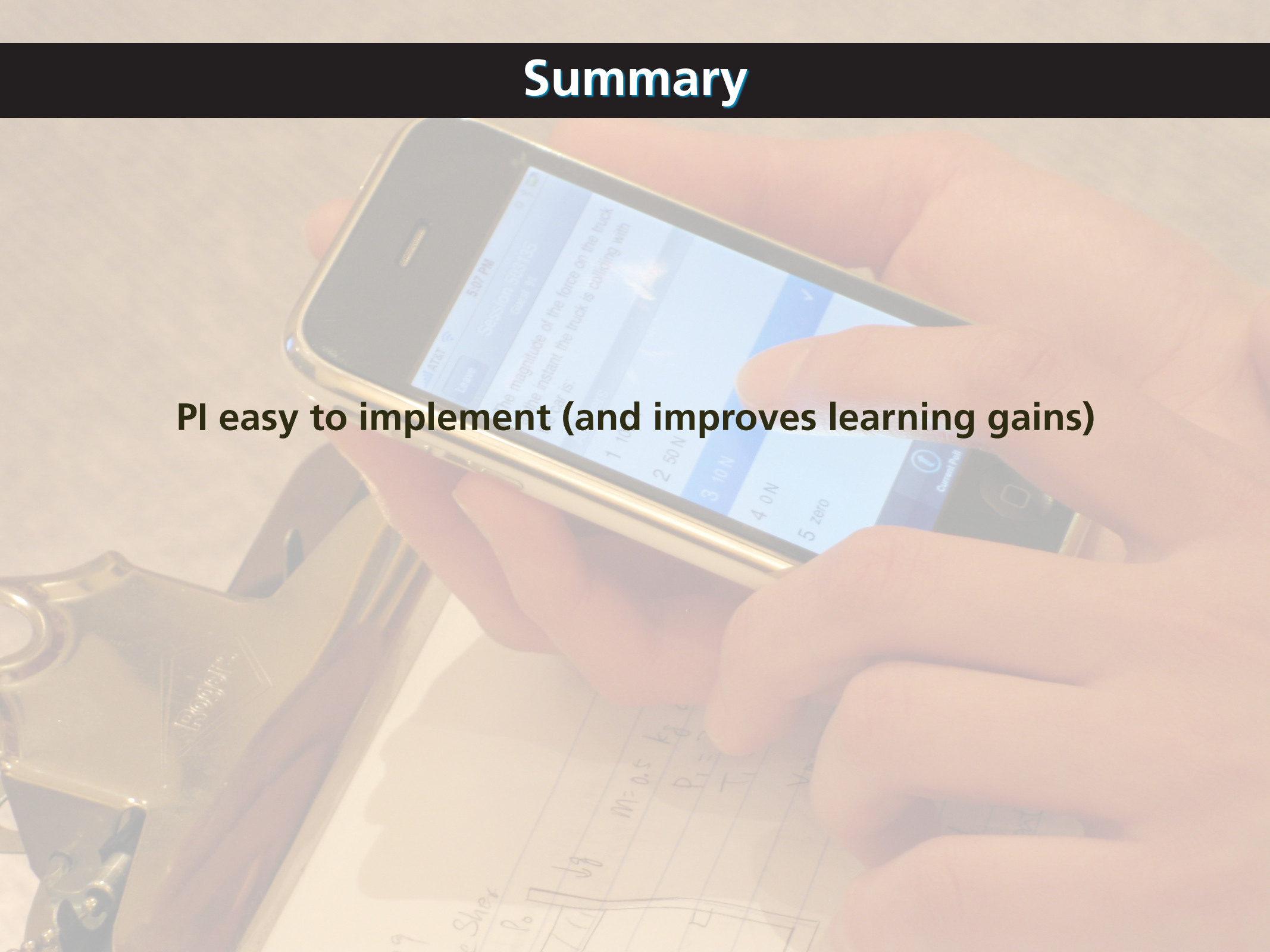
**But PI leads to better learning and retention  
(neither of which is traditionally measured)**

# 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-www.harvard.edu>**

**response cards:**

**[www.turningtechnologies.com](http://www.turningtechnologies.com)**

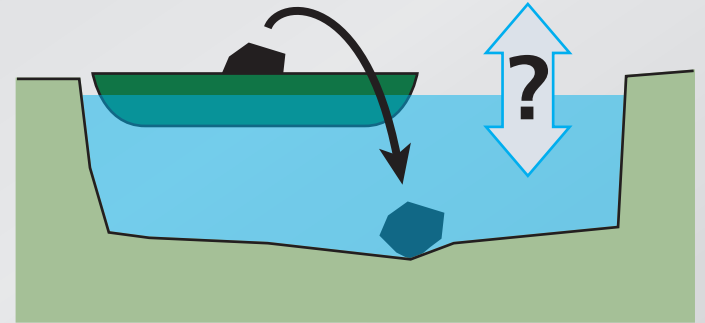
**Follow me!**



**eric\_mazur**

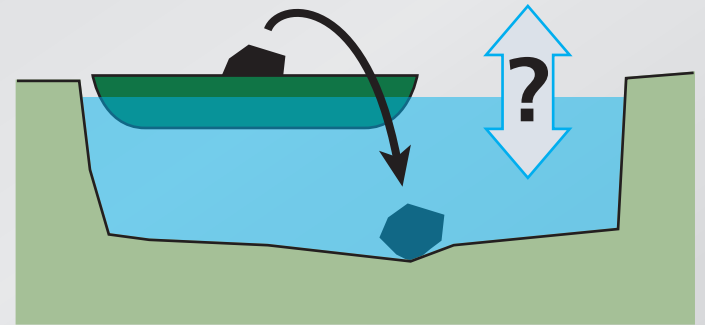
# Let's try it!

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.

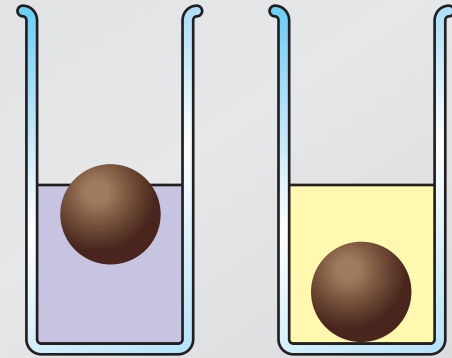
**Let's try it!**

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



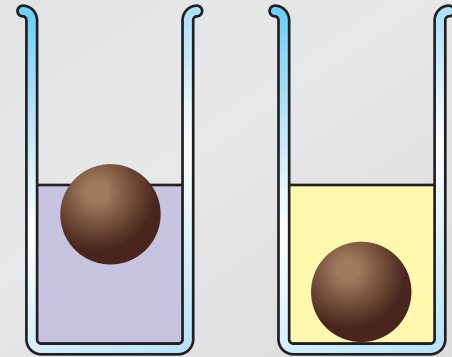
# Let's try it!

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



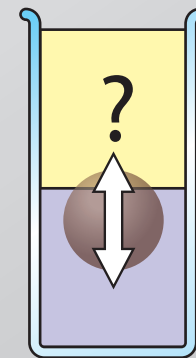
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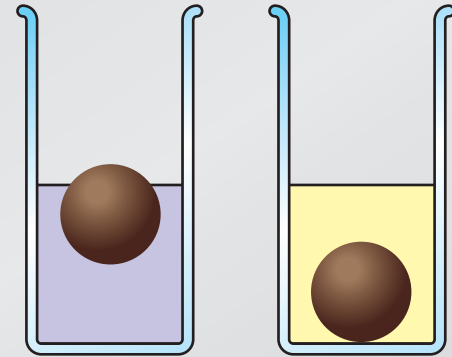
If we slowly pour the oil on top of the water so it completely covers the object, the object

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



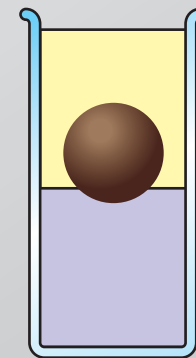
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**Let's try it!**

*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.