Teaching complex material effectively via active and experiential strategies

McMaster University
Hamilton, ON, May 2, 2011

Introduction

“Obviously we are facing a very different group of students from those at Harvard. One of the most serious concern here has perhaps been the issue of low attendance — students would do anything but to attend the lectures — rather than how to teach.”

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WHY?

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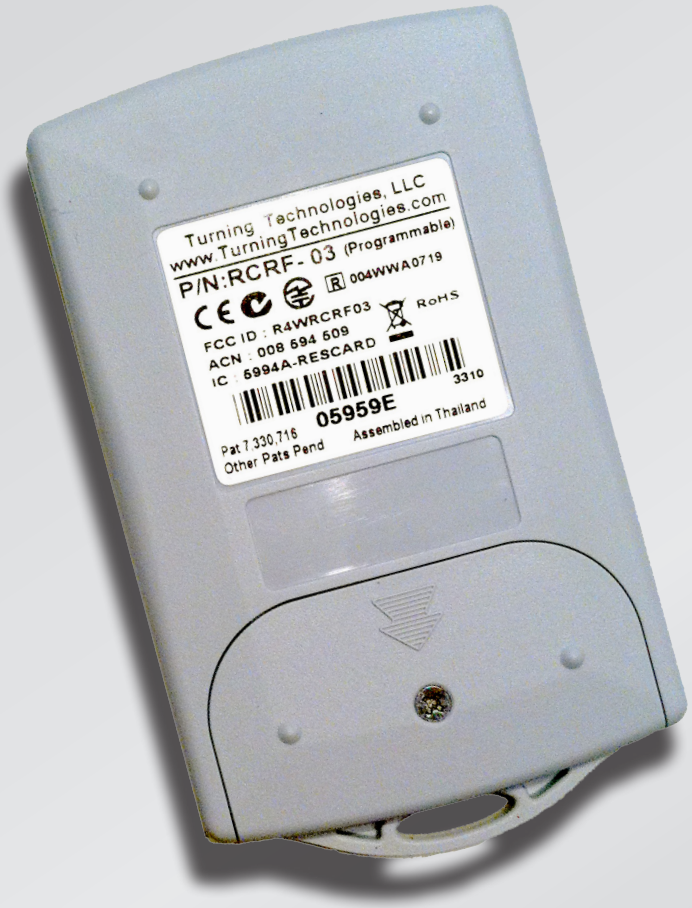

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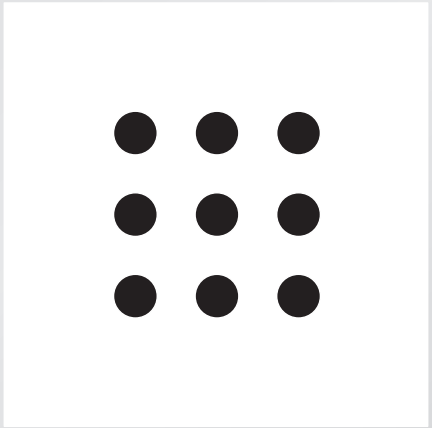
unique ID on back of clicker

www.TurningTechnologies.com

Let's try it!

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



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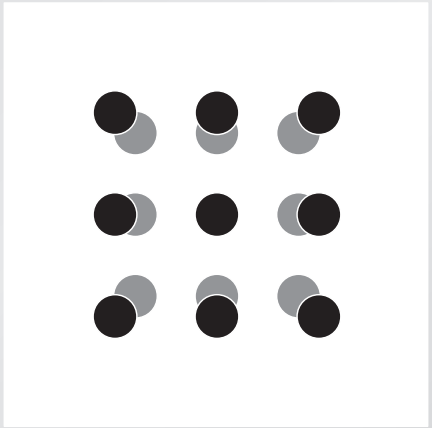
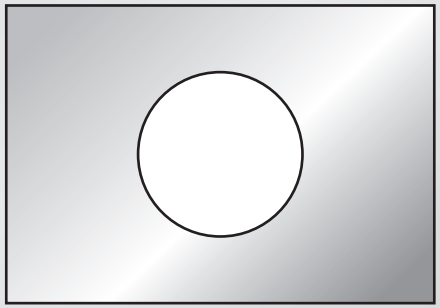


Let's try it!

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



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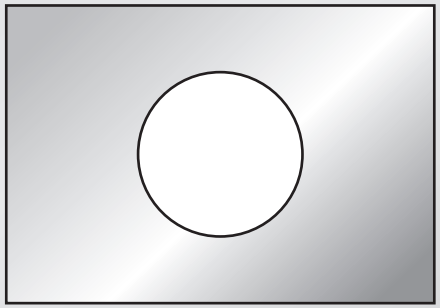
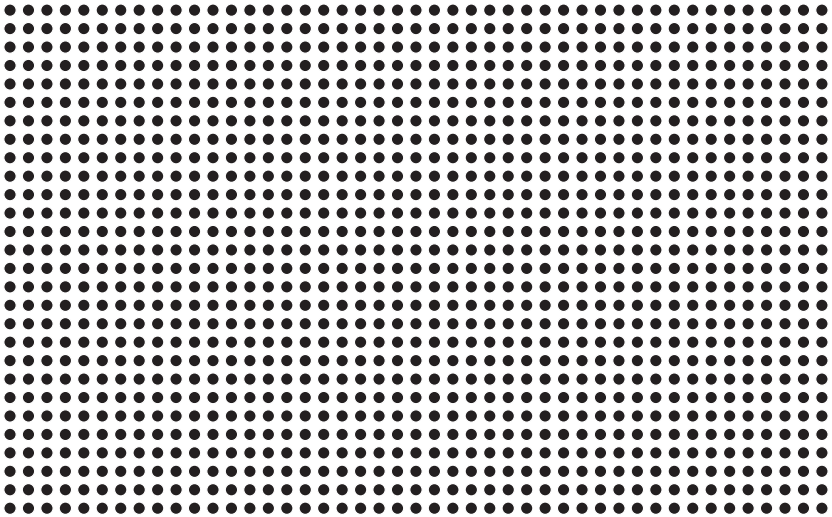


When the plate is uniformly heated, the diameter of the hole

A. increases.
B. stays the same.
C. decreases.

Let's try it!

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



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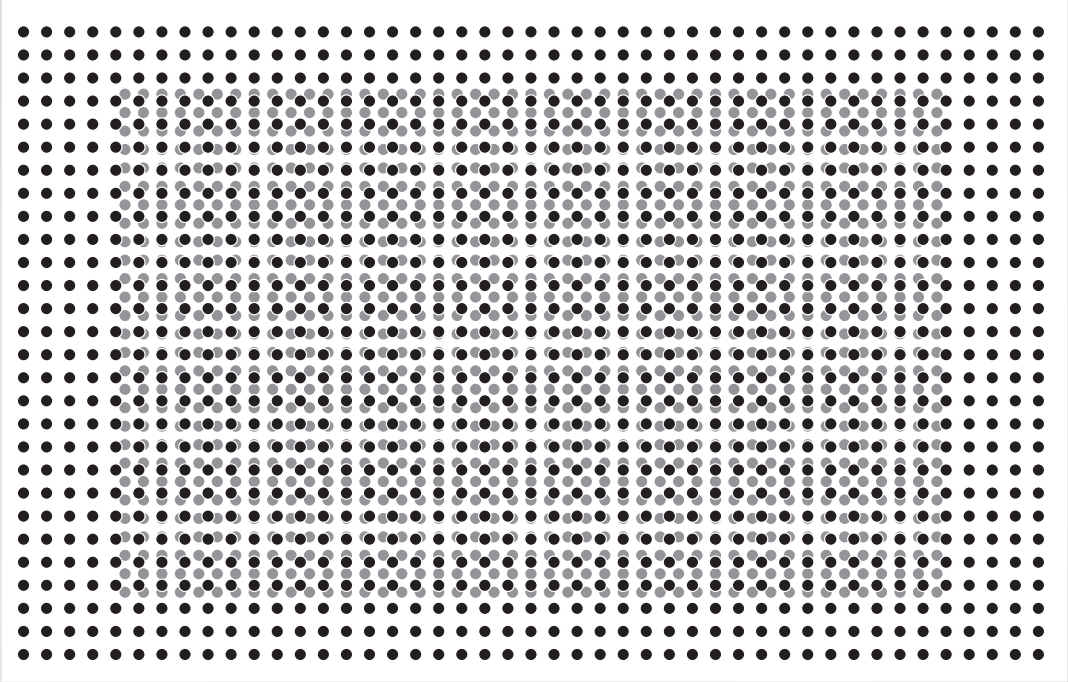
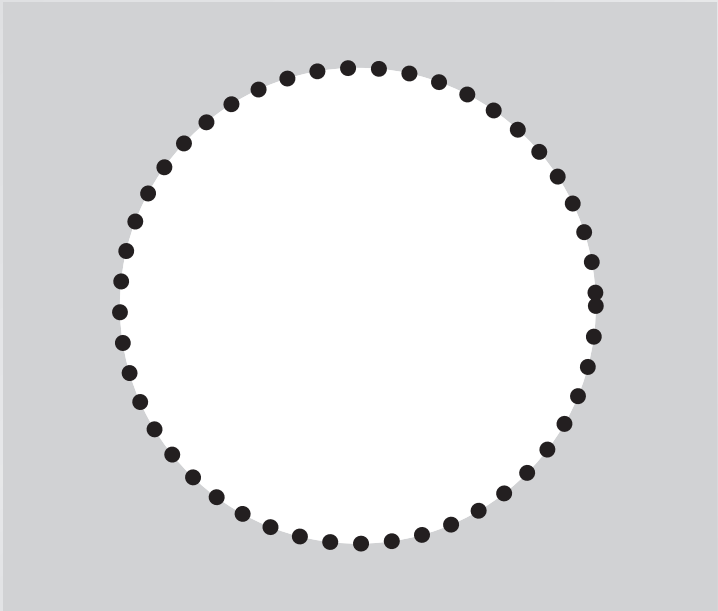


Let's try it!

consider the atoms at the rim of the hole



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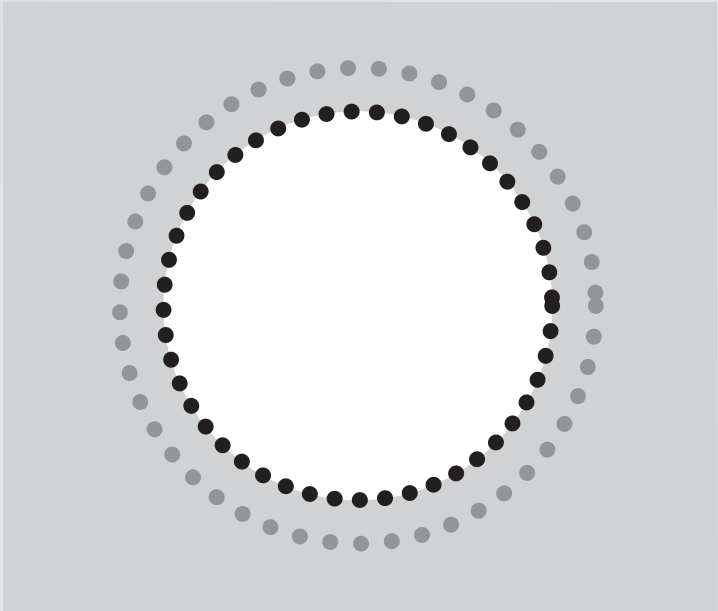

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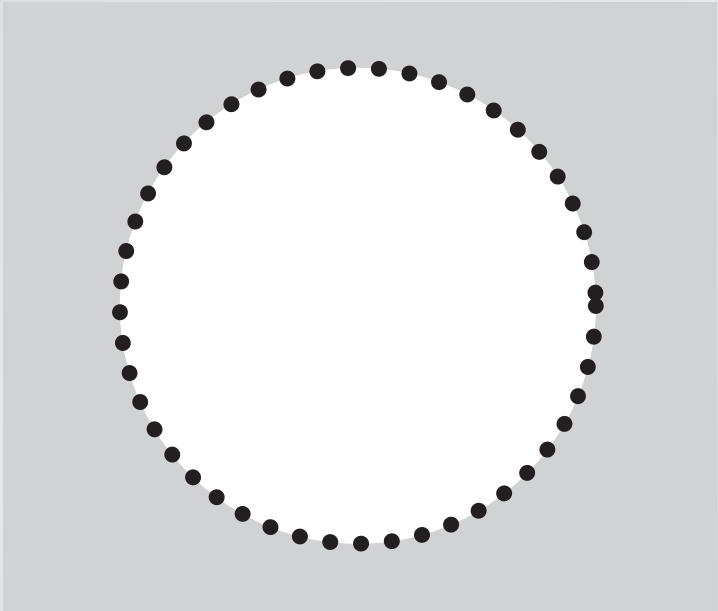

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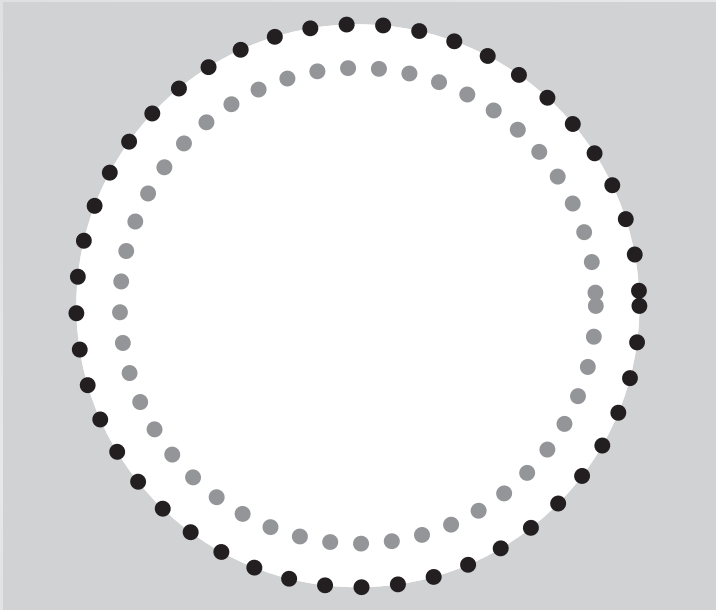


Let's try it!

Benefits:

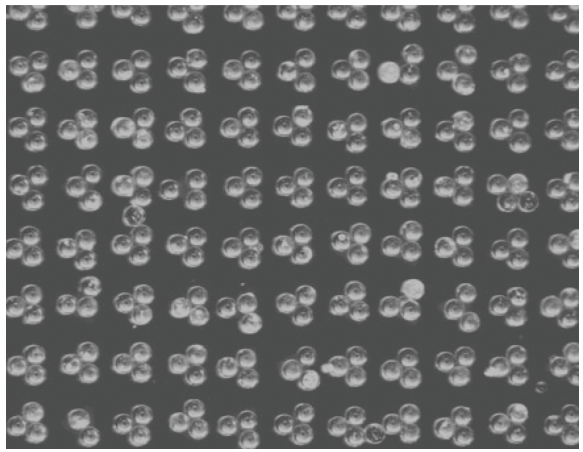
- helps develop conceptual models
- solidifies understanding
- provides feedback
- empowers students

Implementing PI & JiTT

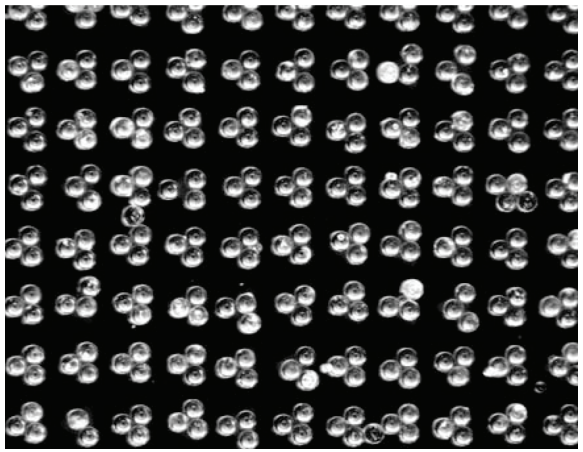
“How do you implement these methods in class where one is modelling a way of thinking (*i.e.*, design) rather than teaching specialized knowledge?”

Let's try it!

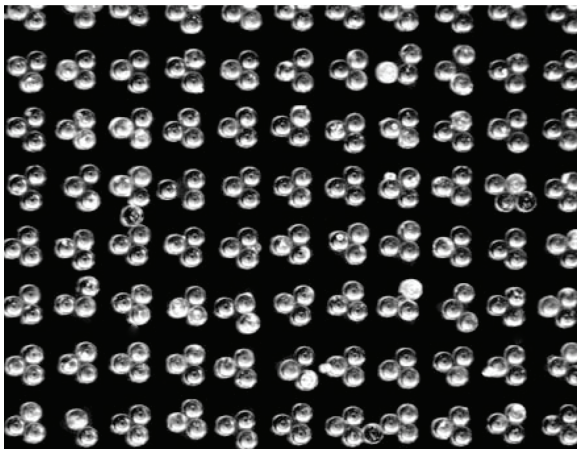
original



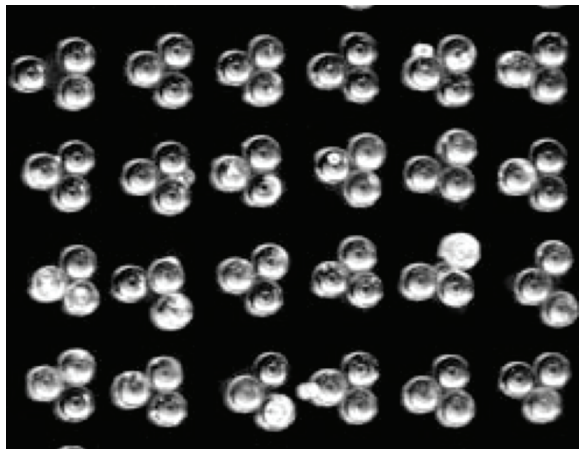
1. adjust contrast



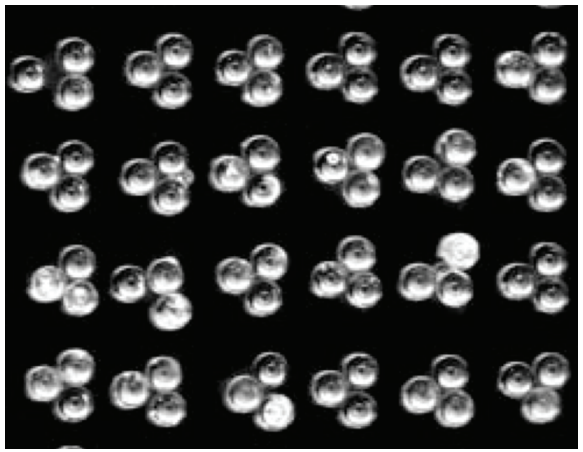
2. remove blemishes



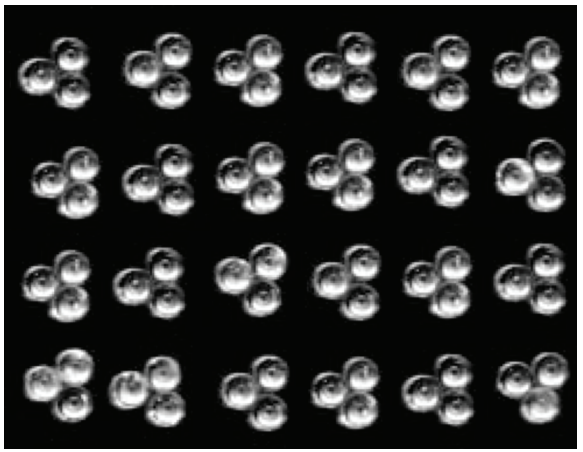
3. crop



4. remove outliers



5. reconstruct



Let's try it!

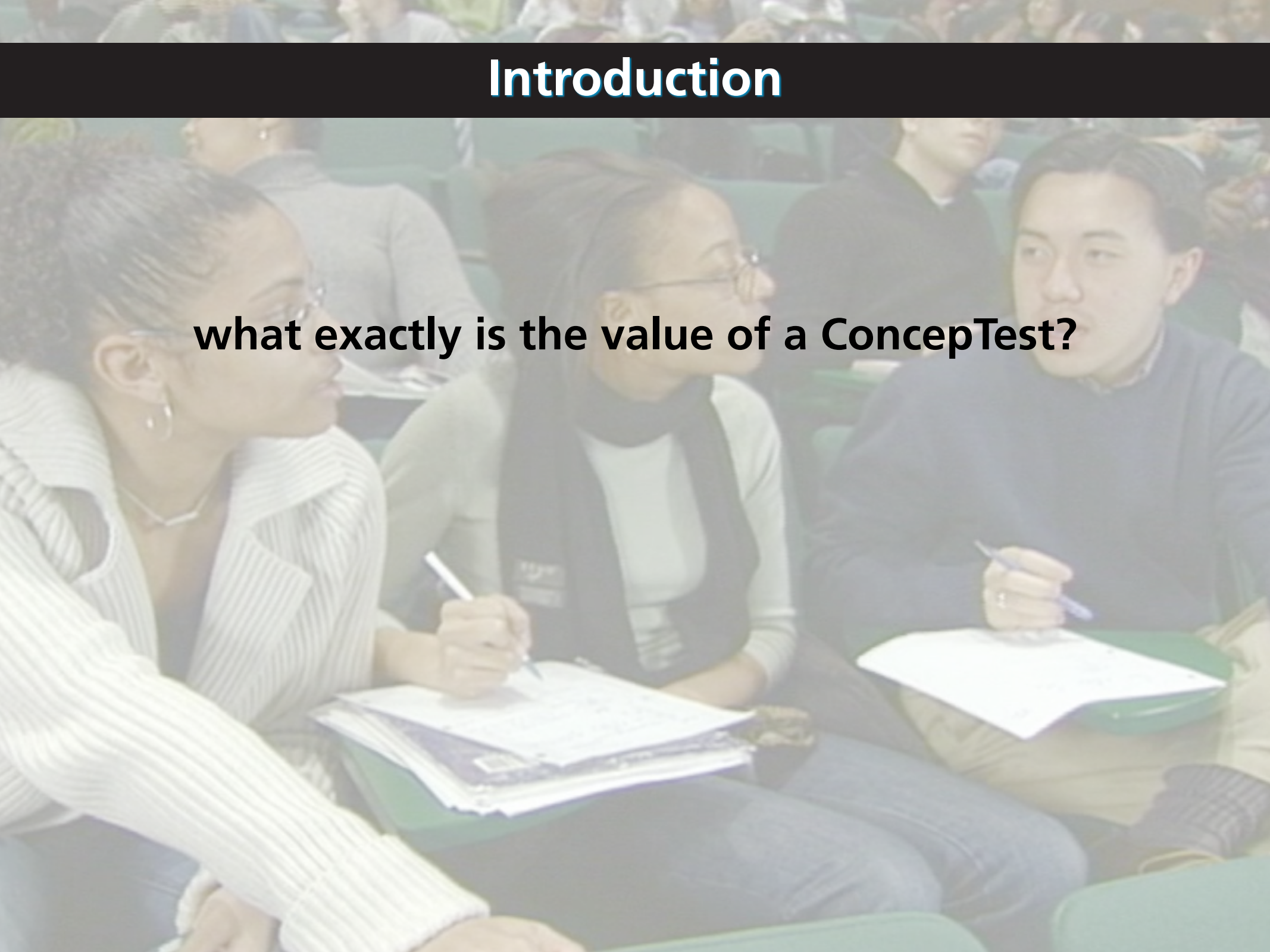
At which step were acceptable standards of ethics violated?

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

Introduction

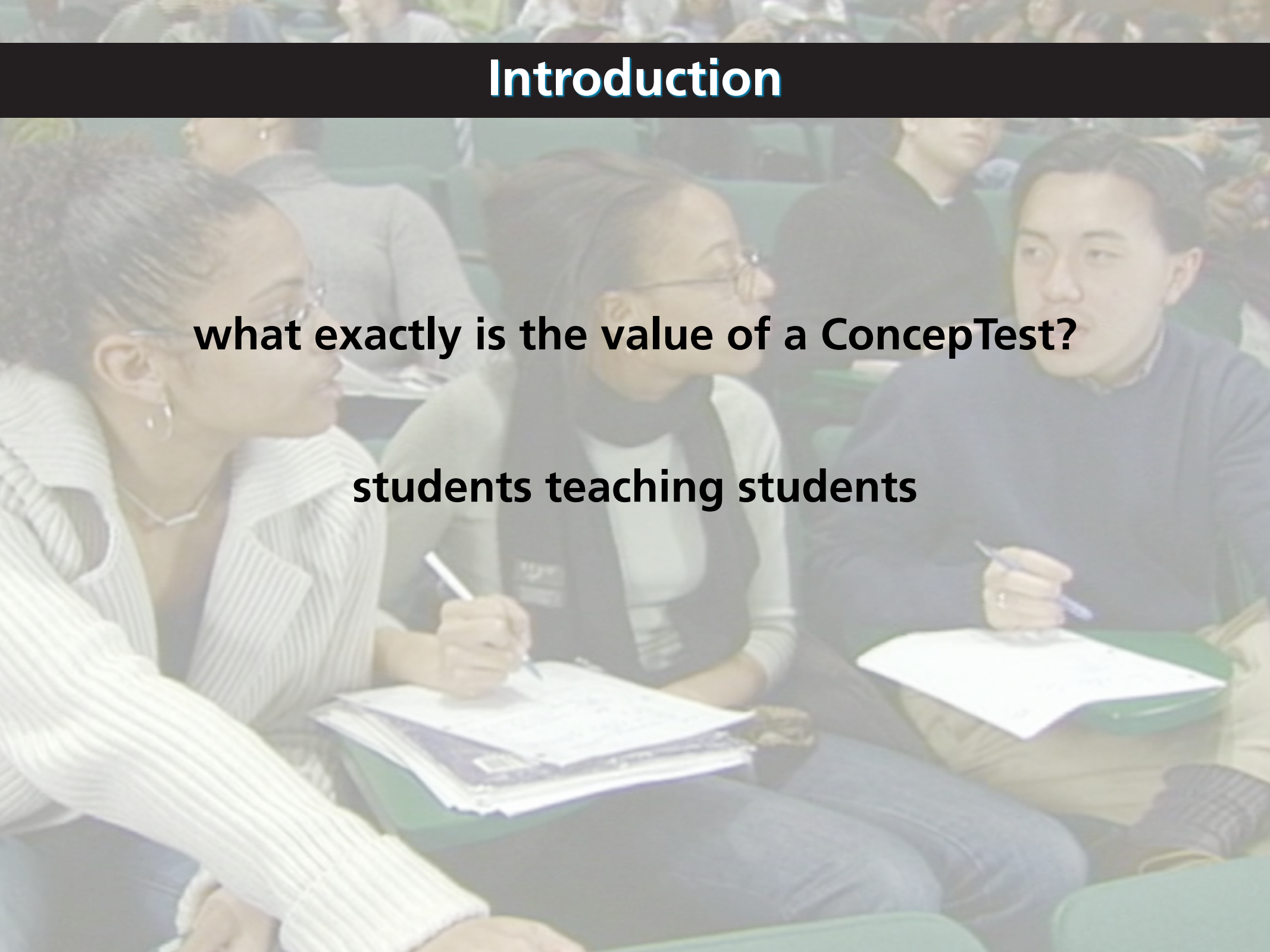
“I am concerned about achieving good attendance so that the new teaching methods will impact a large fraction of the class. Might this best be achieved by assigning marks in some way for in-class participation?”

Introduction



what exactly is the value of a ConcepTest?

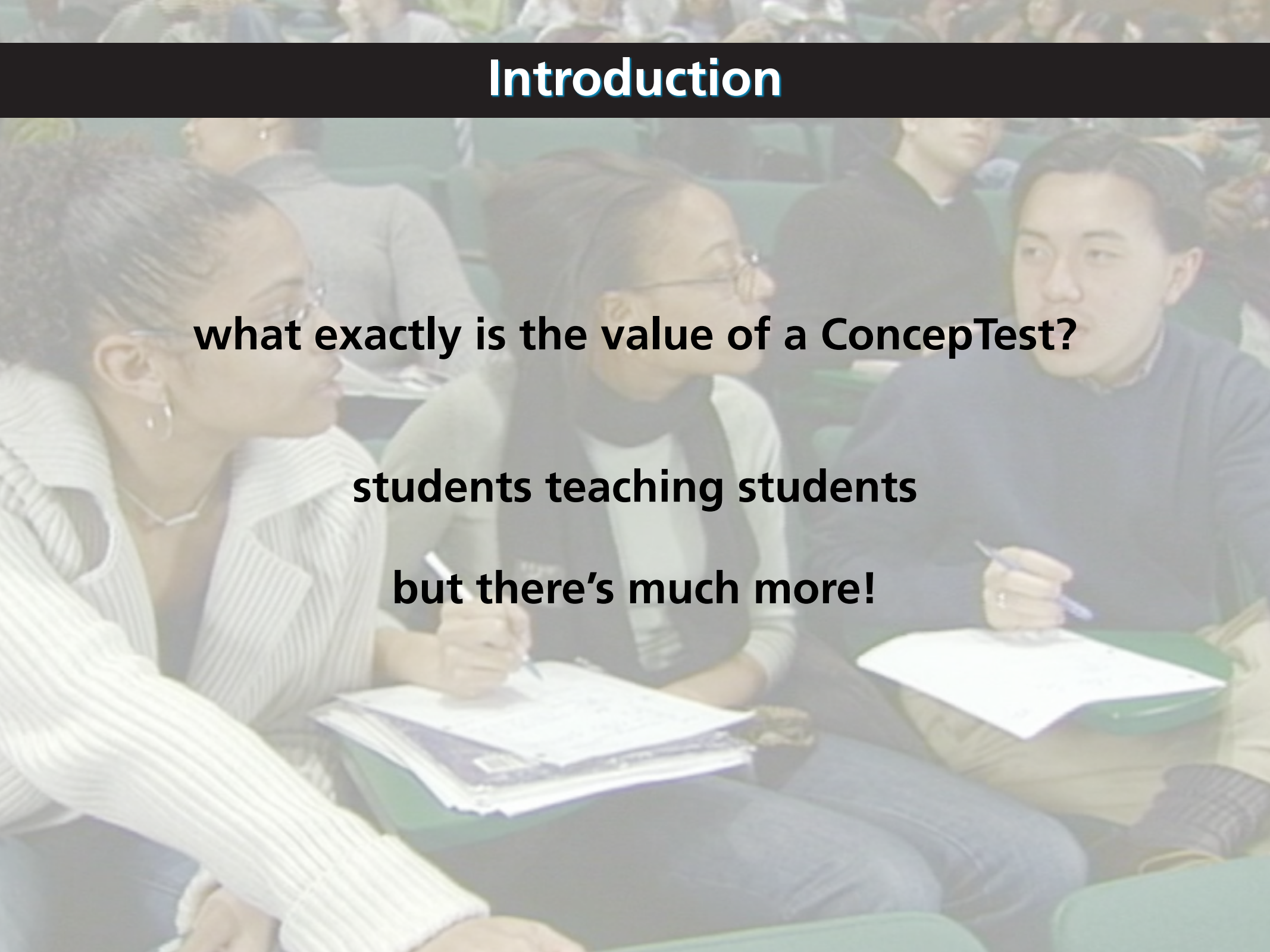
Introduction



what exactly is the value of a ConcepTest?

students teaching students

Introduction

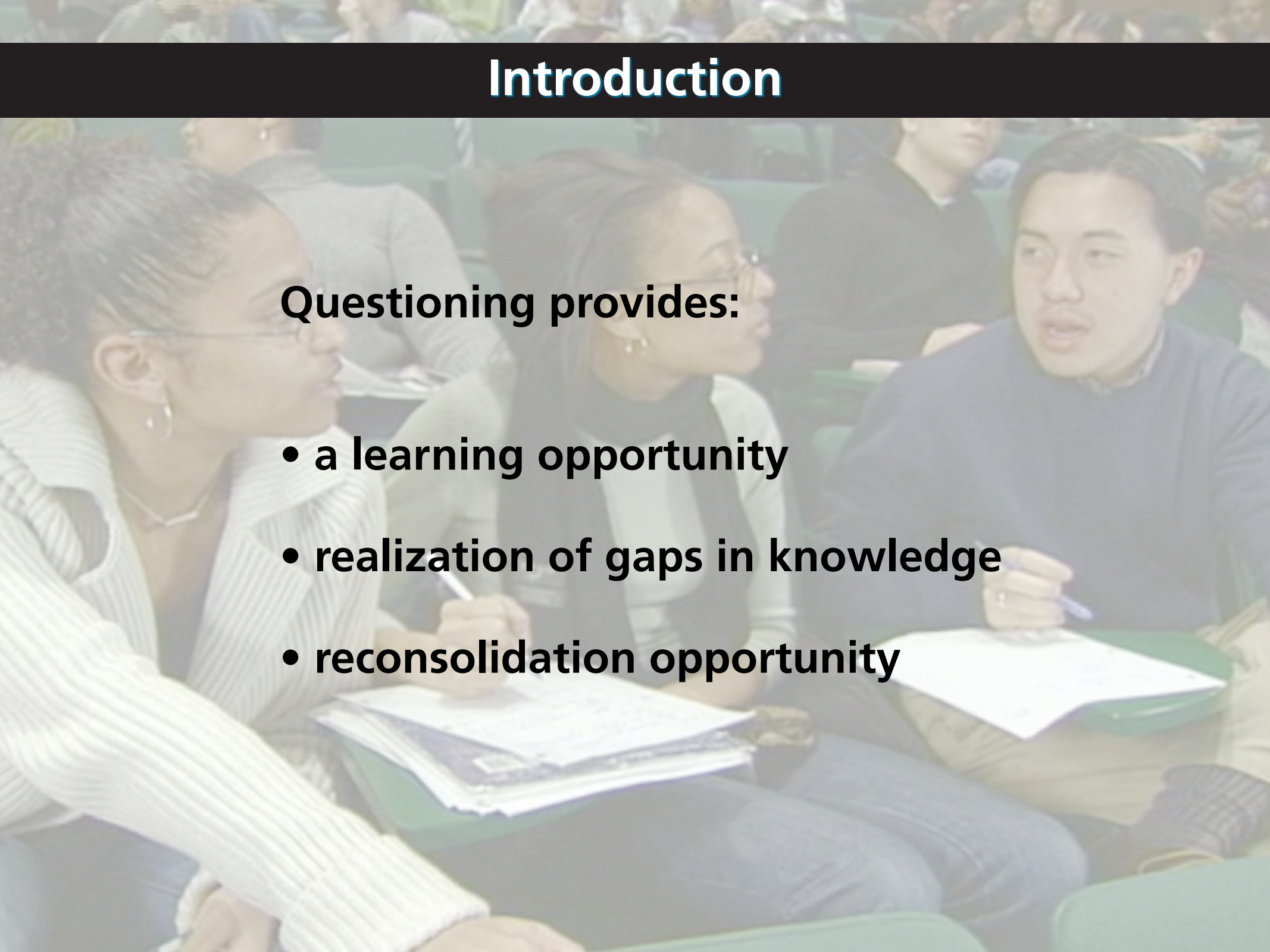


what exactly is the value of a ConcepTest?

students teaching students

but there's much more!

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 [illegible] and uninfluential in the learning process. Not only does retrieval produce learning, a retrieval event may actually represent a more powerful learning activity than an encoding event. This research suggests a conceptual [illegible] mind and learning that is different from [illegible] which encoding places knowledge in memory and retrieval simply accesses that knowledge. Because each act of retrieval alters memory, the act of reconstructing knowledge is considered essential to the process [illegible]

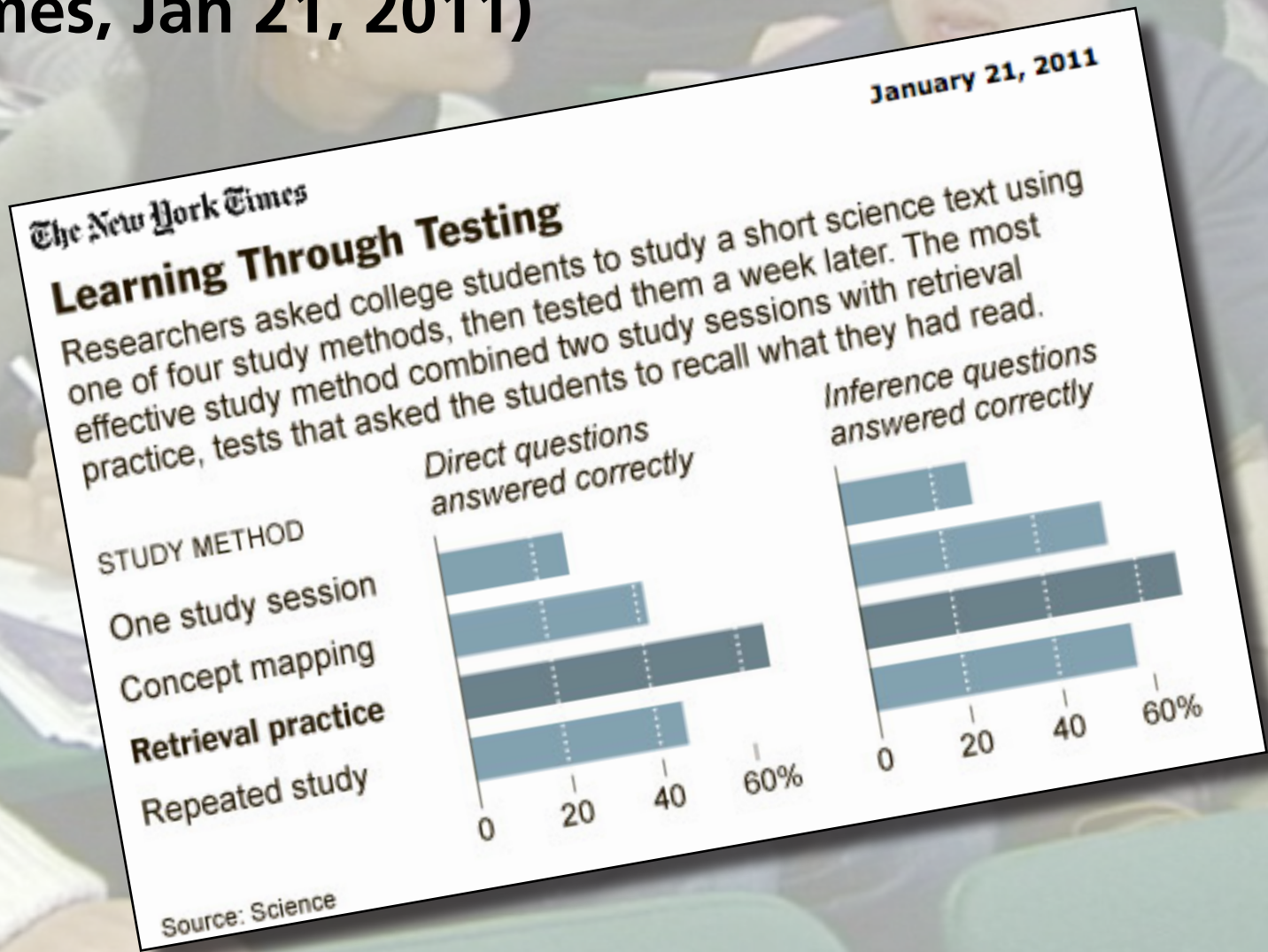
Most previous research on [illegible] has been conducted in the verbal learning tradition of memory research (*1*). [illegible] used have often not reflected [illegible] formation students learn in educational settings (*13*). Most previous [illegible] used assessments thought to measure meaningful learning, 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 [illegible] they are learning. Under these conditions [illegible] clears the defining characteristics [illegible] It requires [illegible] studying and [illegible] concepts [illegible]

Department of Psychological Sciences, Purdue University, West [illegible] should be addressed. E-mail: [illegible] 47907, USA.

Introduction

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

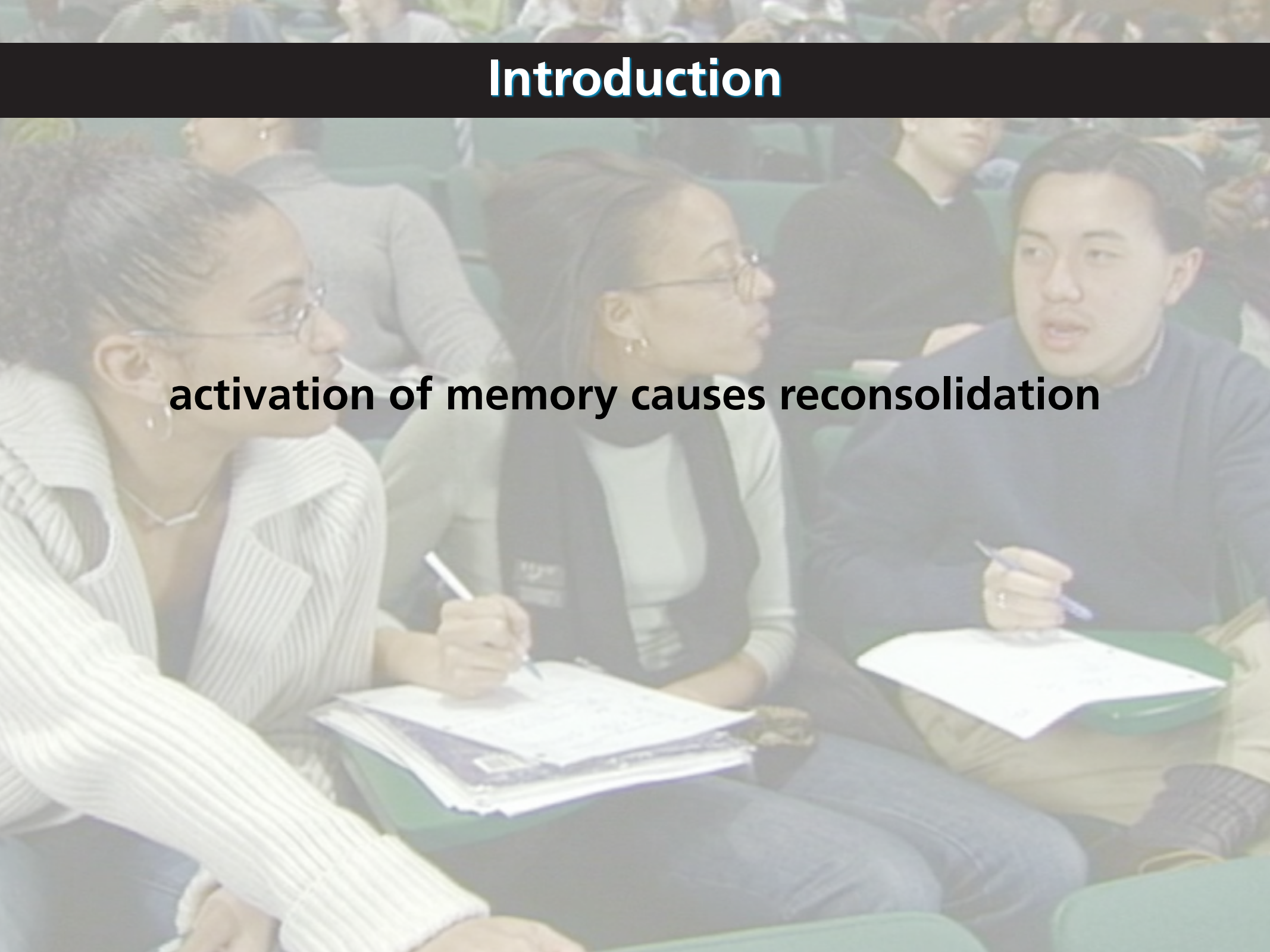


Introduction

“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

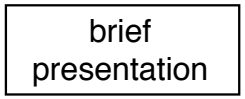


activation of memory causes reconsolidation

Outline

- anatomy of a ConcepTest
- ConcepTest management
- PI & JiTT implementation

Anatomy of a ConcepTest



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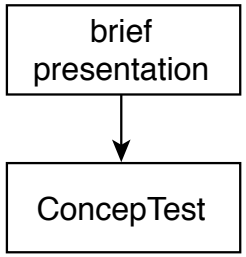

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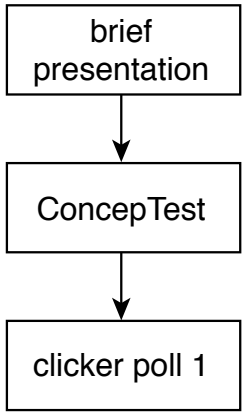

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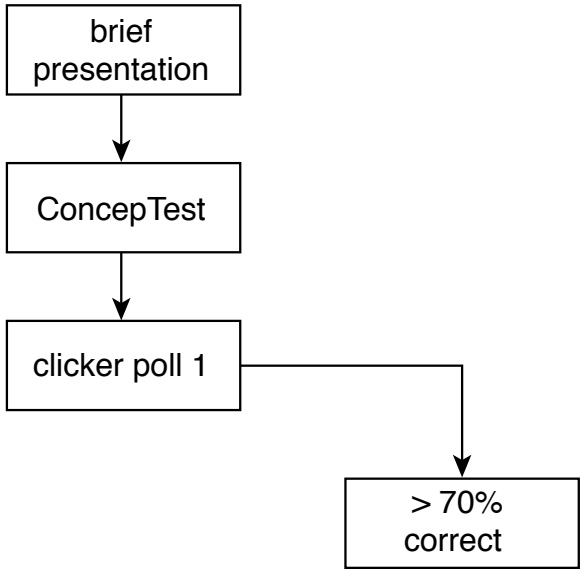

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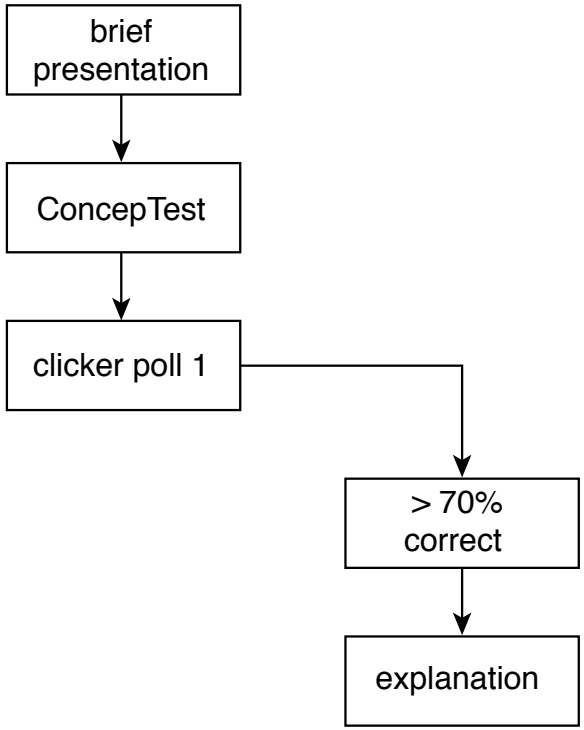

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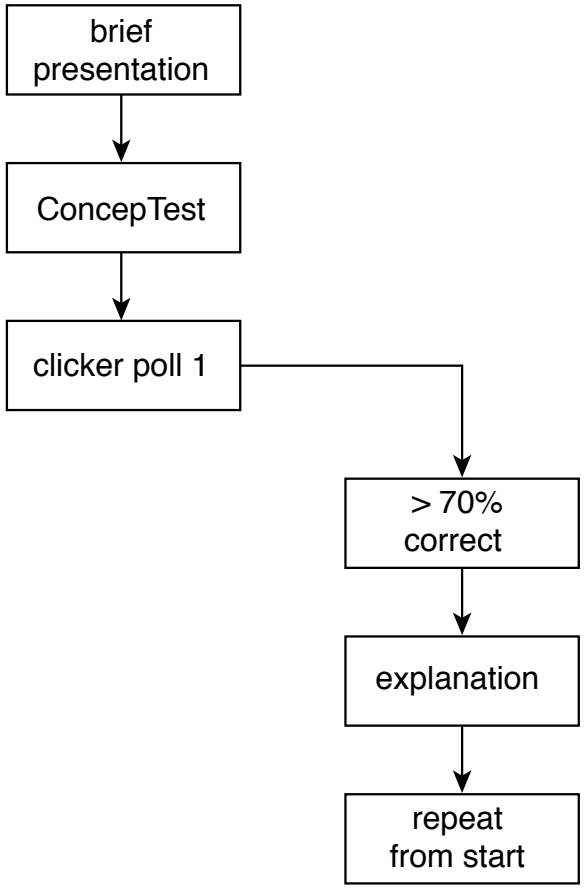

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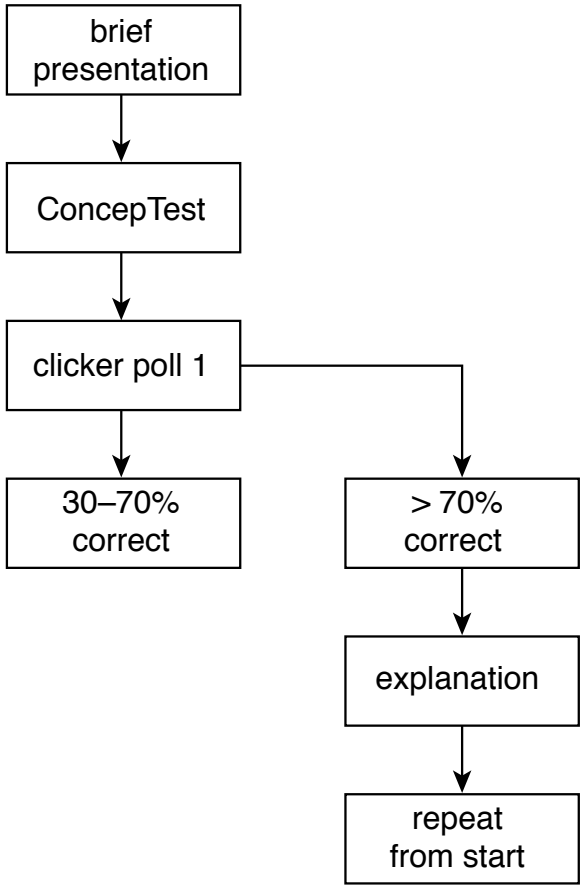

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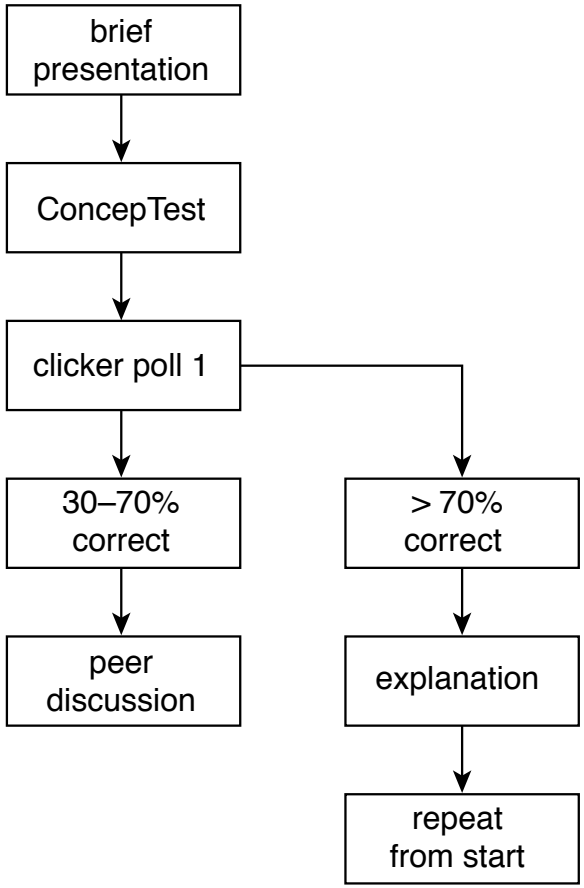

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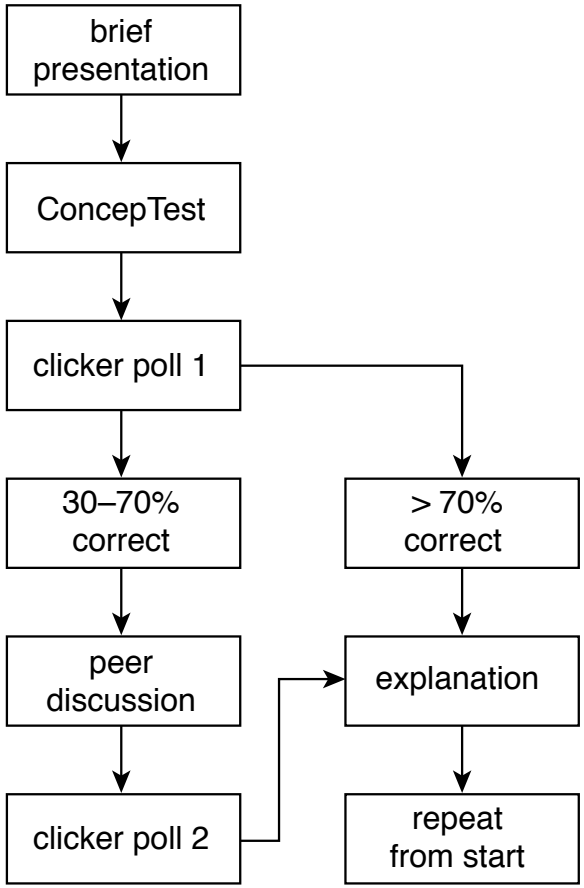

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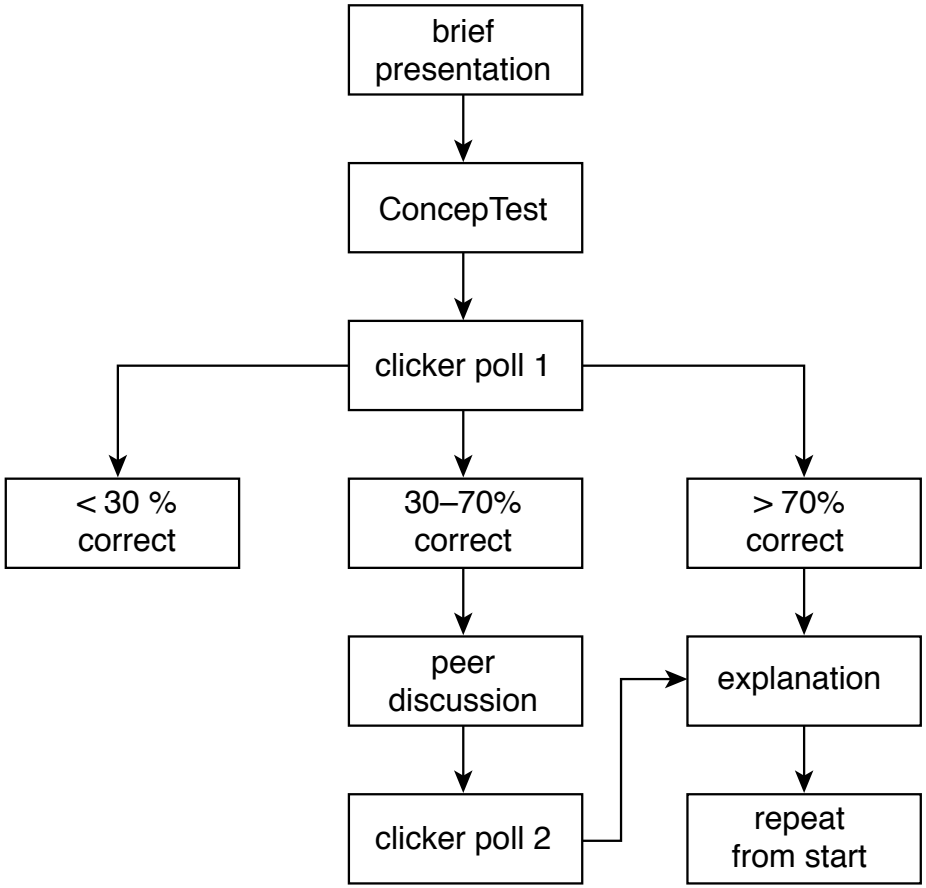

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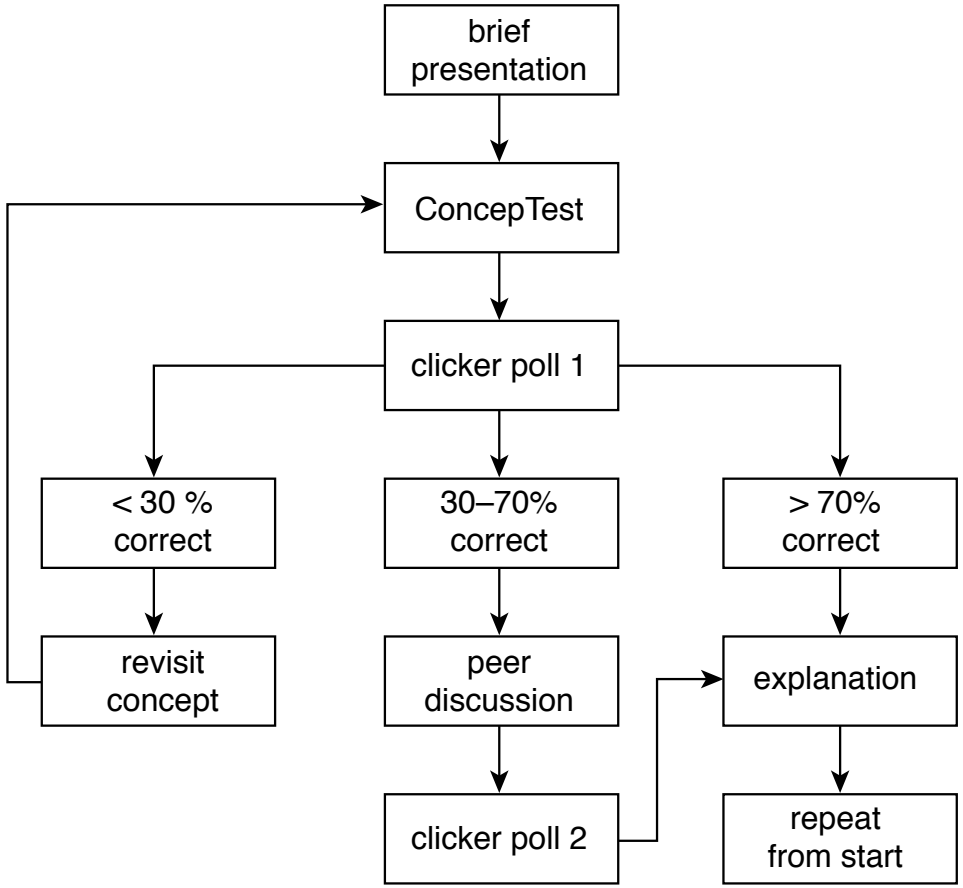

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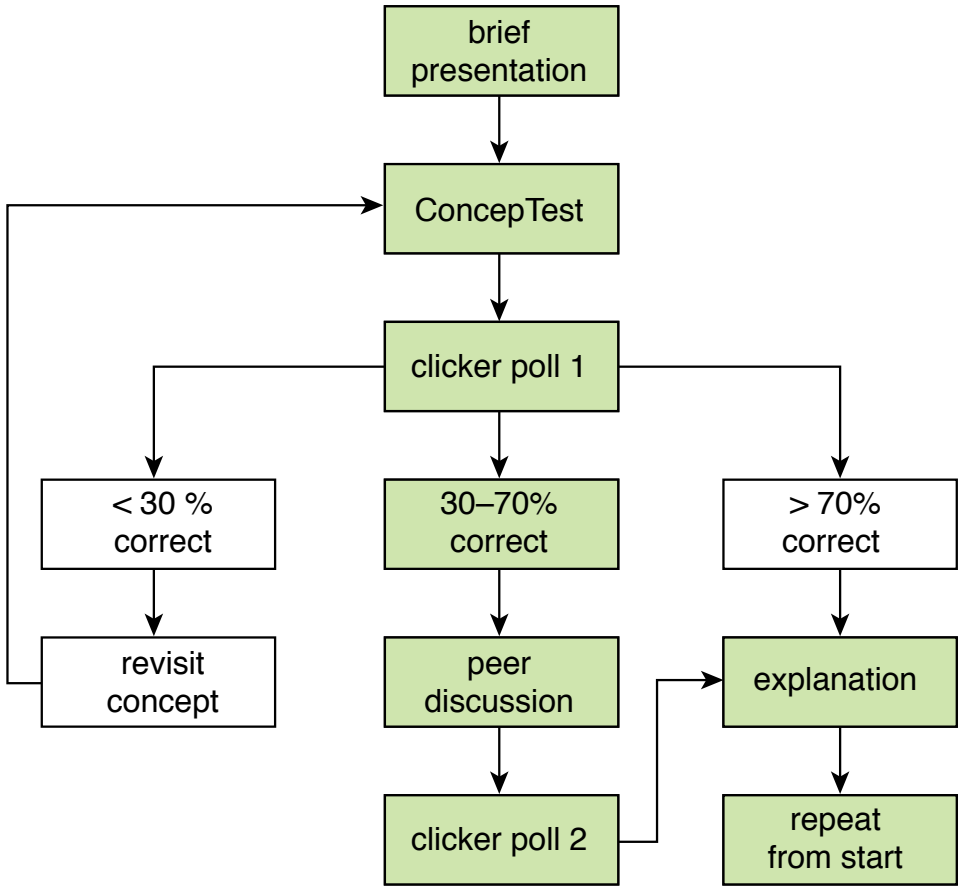

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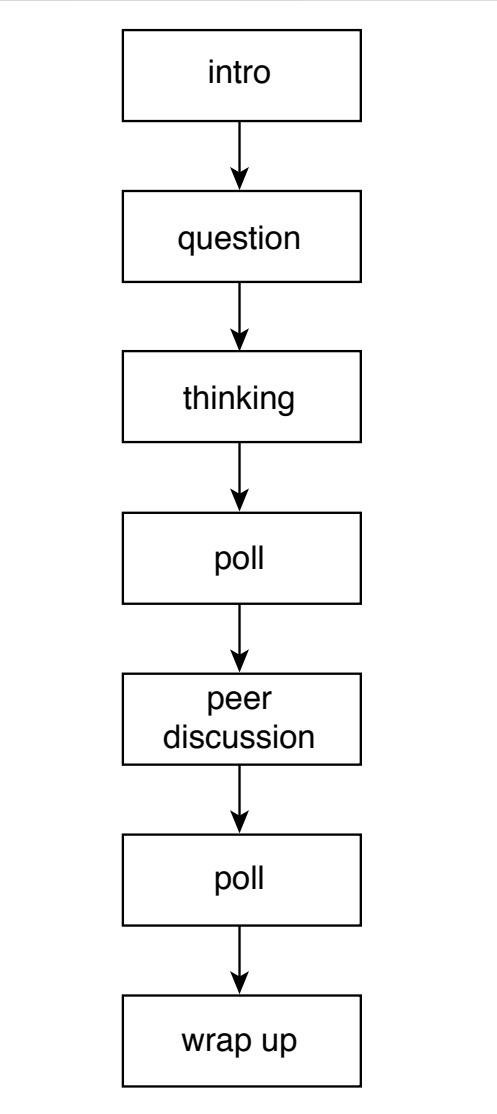

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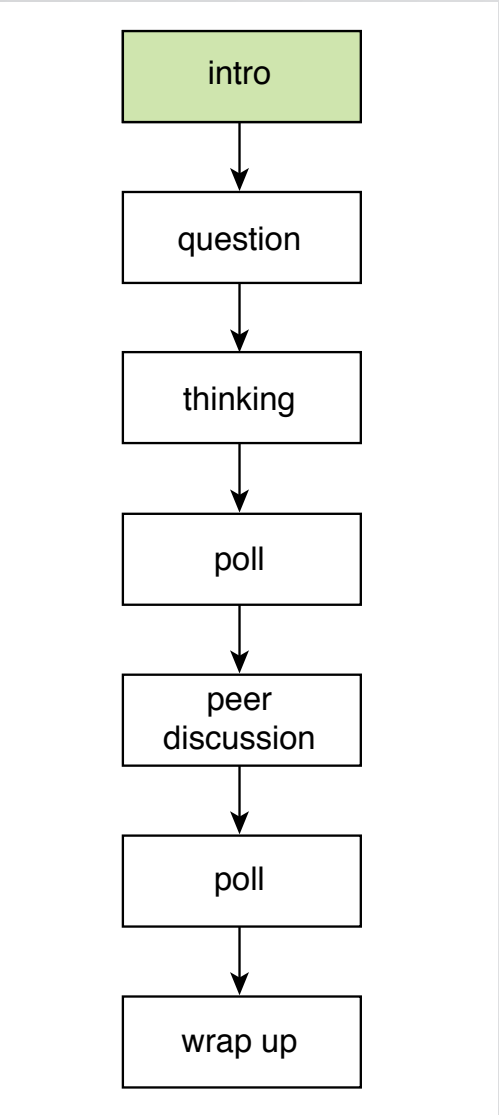
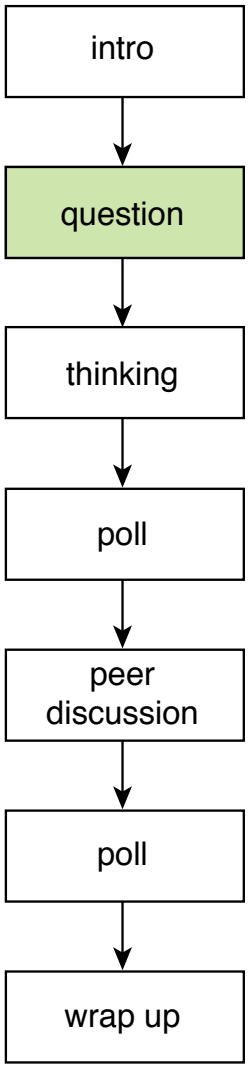


setting context

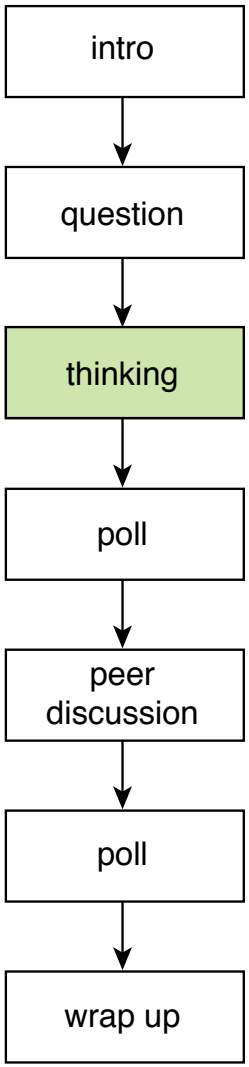
Anatomy of a ConcepTest



setting context

posing question

Anatomy of a ConcepTest

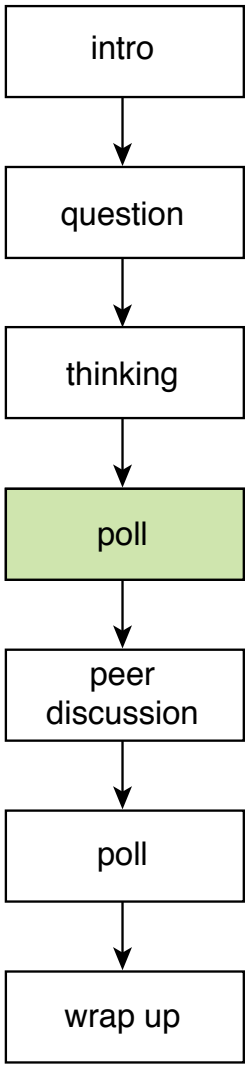


setting context

posing question

reflection

Anatomy of a ConcepTest



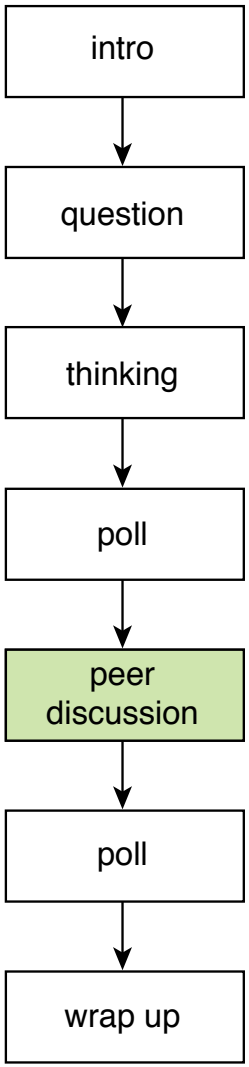
setting context

posing question

reflection

baseline data

Anatomy of a ConcepTest



setting context

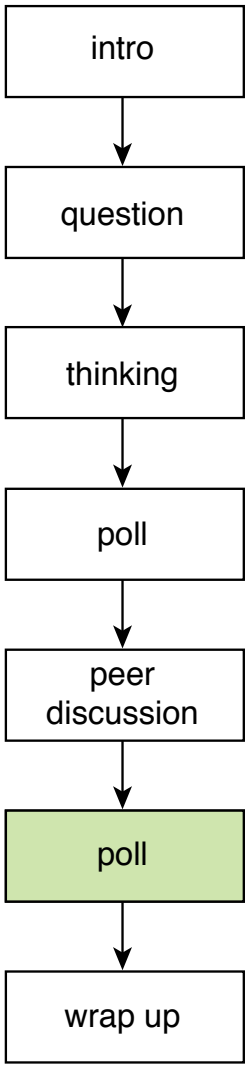
posing question

reflection

baseline data

peer instruction

Anatomy of a ConcepTest



setting context

posing question

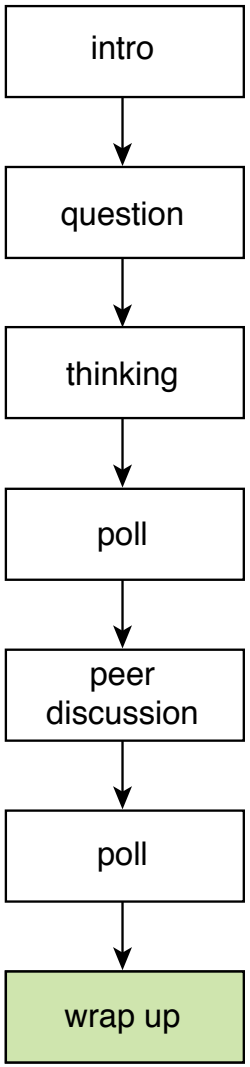
reflection

baseline data

peer instruction

gain data

Anatomy of a ConcepTest



setting context

posing question

reflection

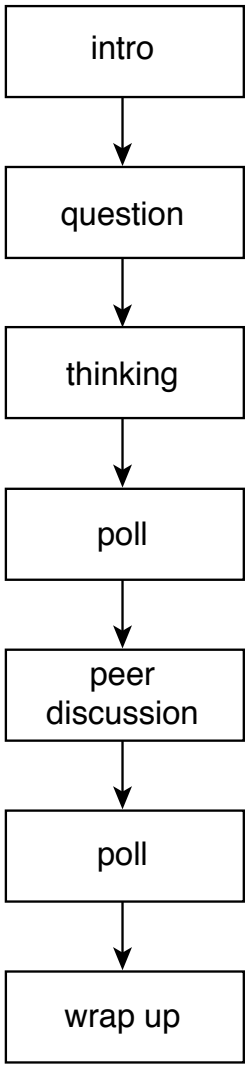
baseline data

peer instruction

gain data

closure

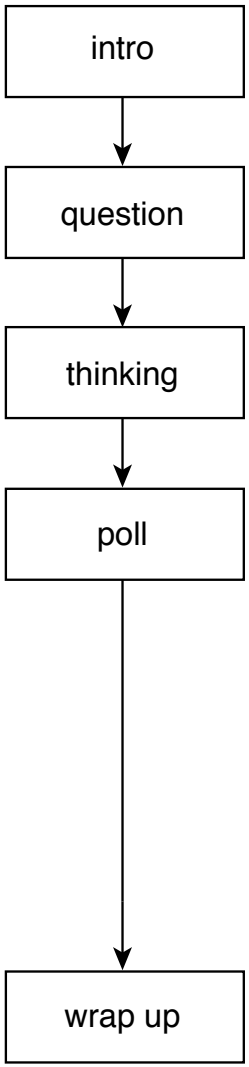
Anatomy of a ConcepTest



setting context	5 min (max)
posing question	1 min
reflection	1–2 min
baseline data	
peer instruction	2–3 min
gain data	
closure	5 min (max)

Anatomy of a ConcepTest

potential shortcuts

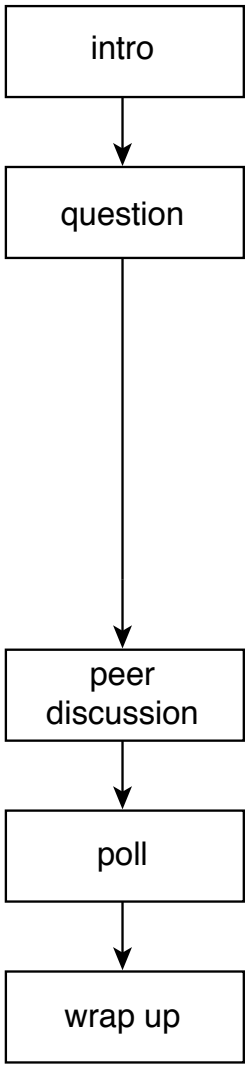


2–3 min saved, but…

takes the “Peer” out of “Peer Instruction”

Anatomy of a ConcepTest

potential shortcuts



1–2 min saved, but…

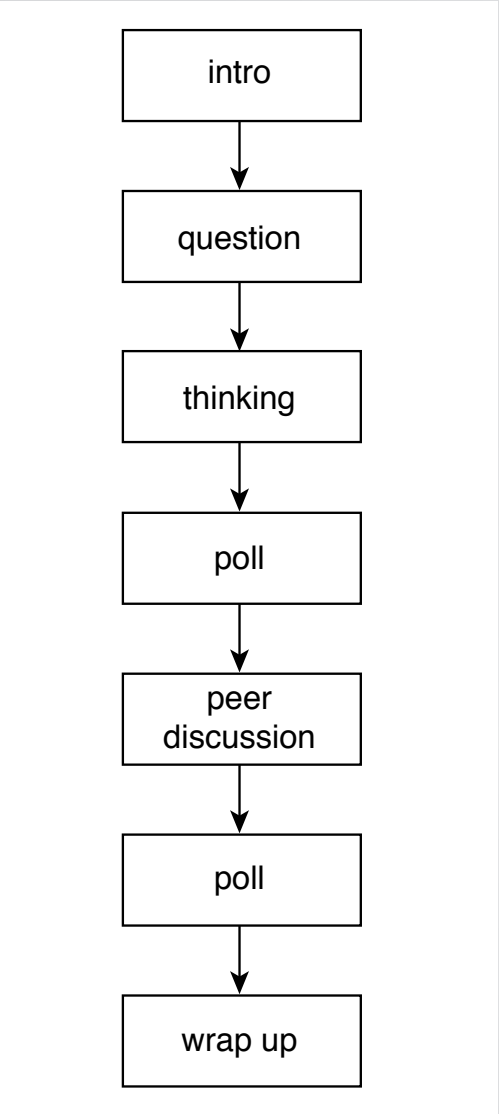
no opportunity to commit before discussion

Outline

- anatomy of a ConcepTest
- **ConcepTest management**
- implementing PI & JiTT

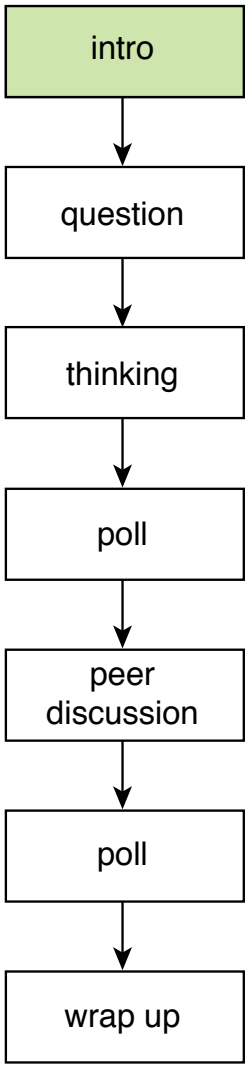
ConcepTest management

engendering “deep learning”



ConcepTest management

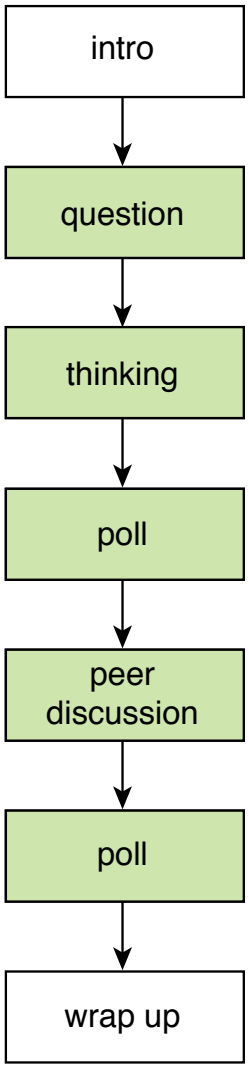
engendering “deep learning”



pre-class activity determines context

ConcepTest management

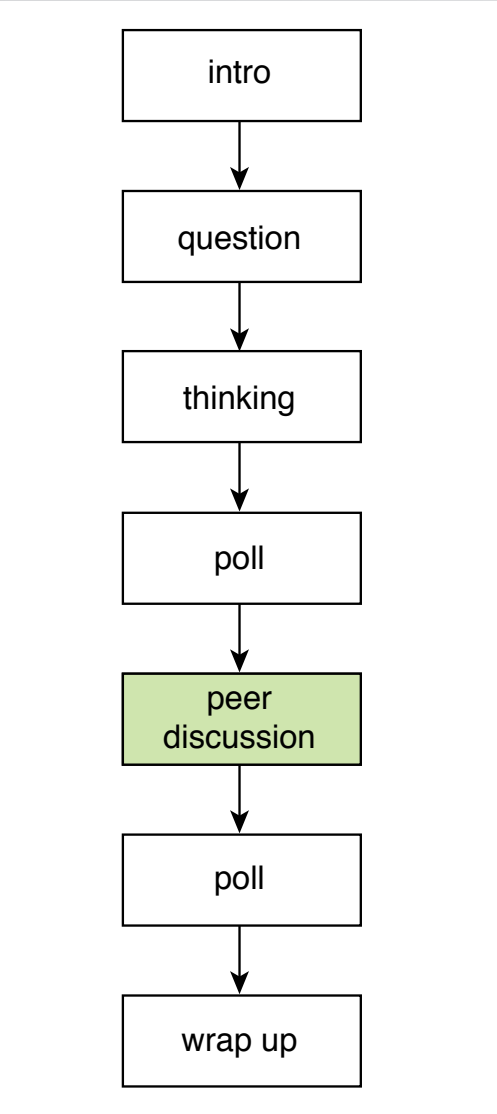
engendering “deep learning”



question transfers concepts to new context

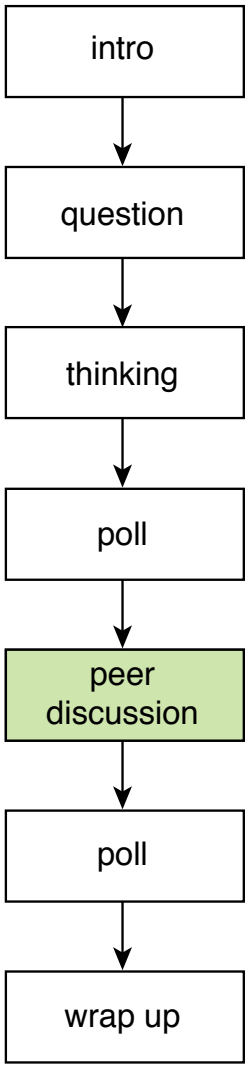
ConcepTest management

importance of peer discussion



ConcepTest management

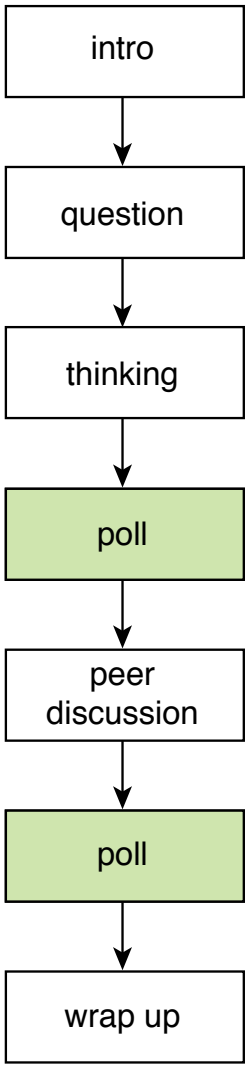
importance of peer discussion



vary activity

ConcepTest management

importance of peer discussion



vary activity, measure poll-repoll gain

ConcepTest management

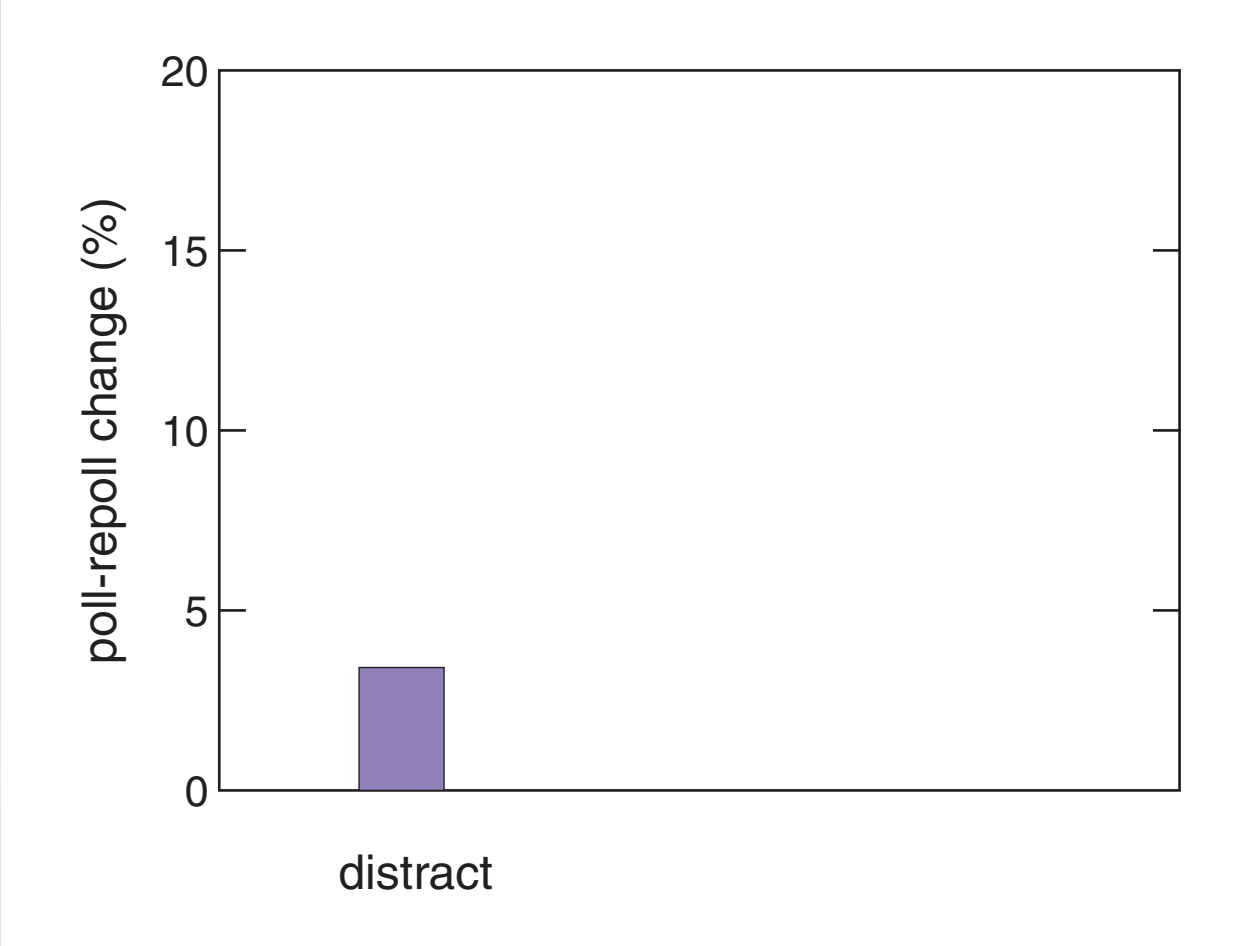
importance of peer discussion

compare poll-repoll gain for 3 activities:

- distract
- reflect
- discuss

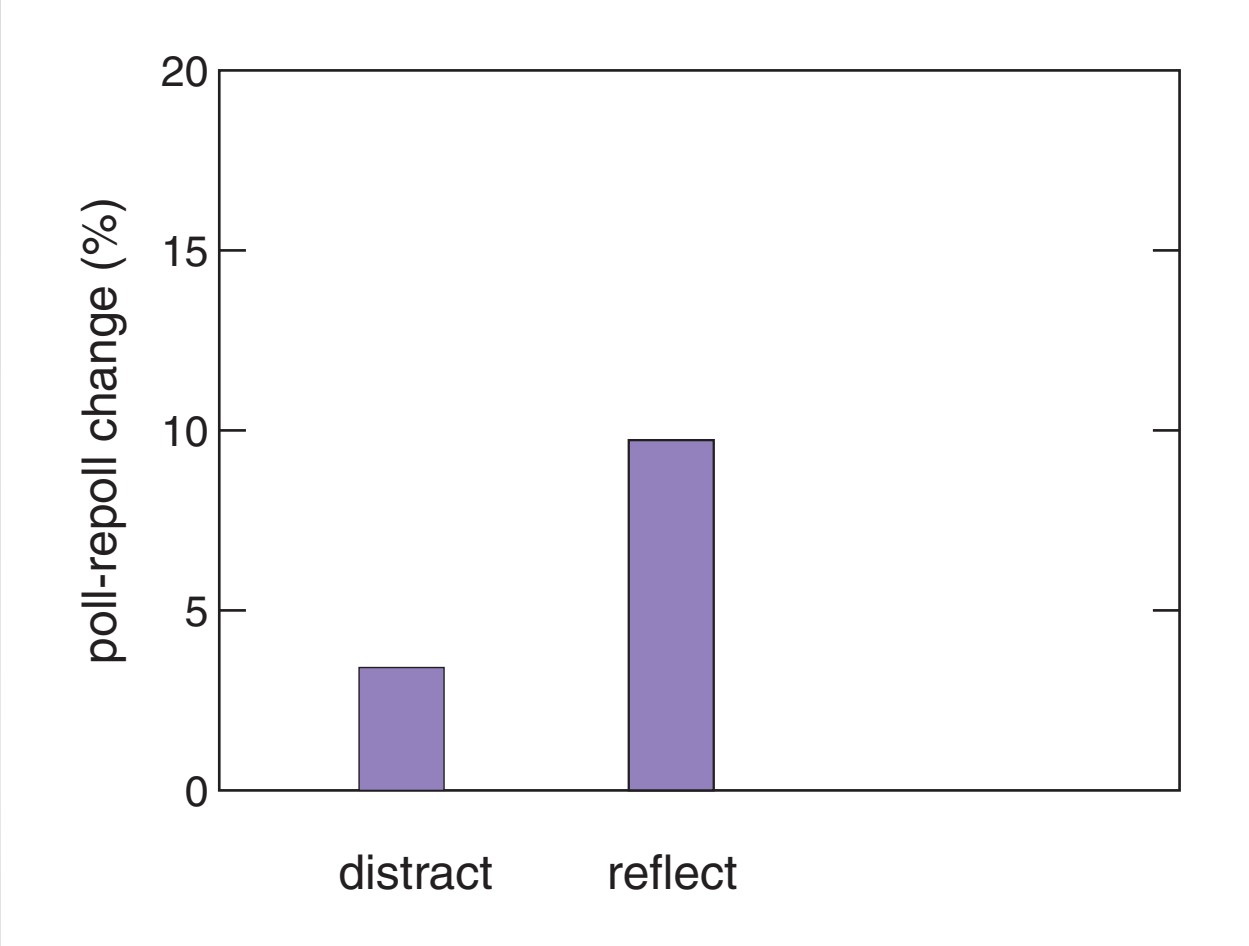
ConcepTest management

importance of peer discussion



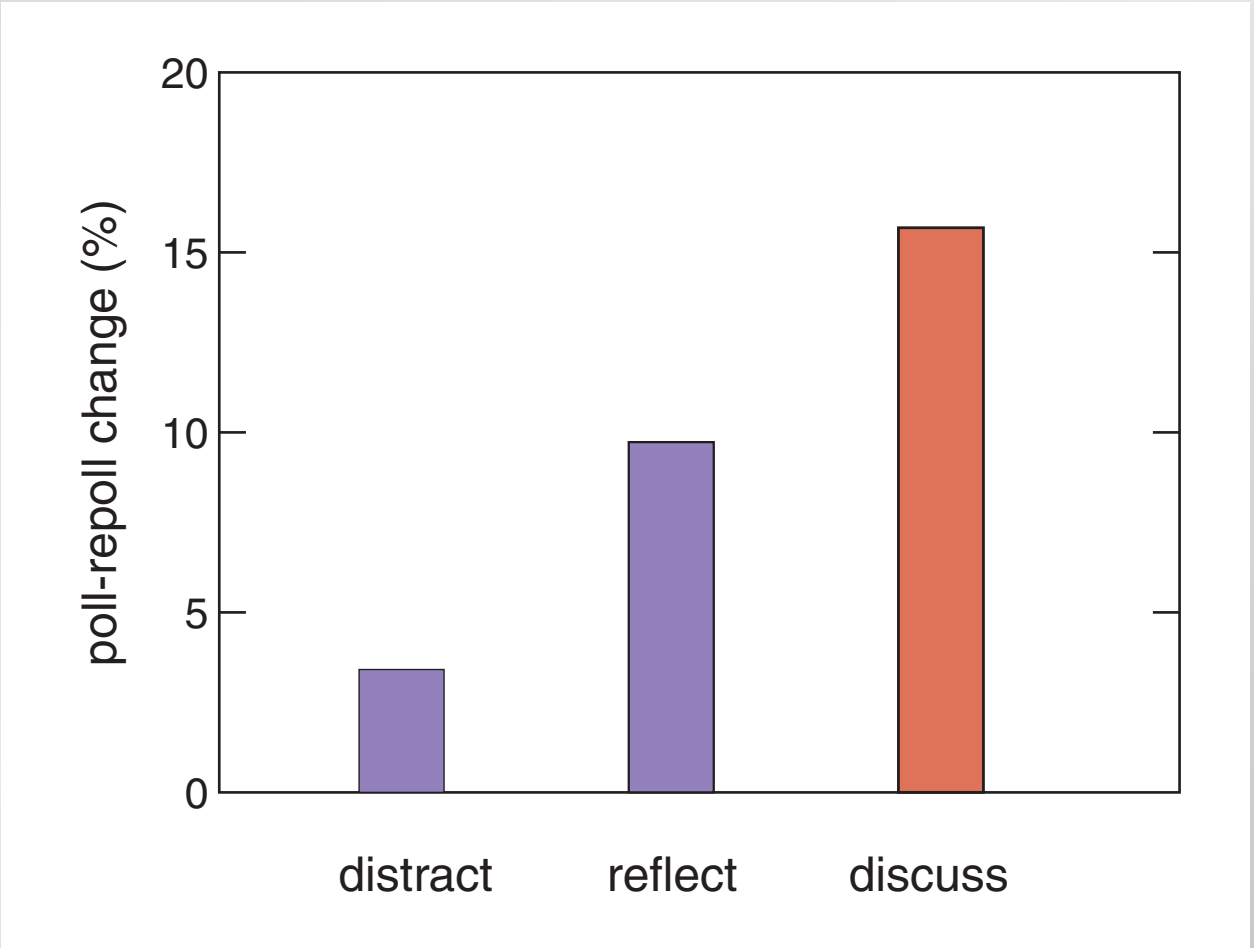
ConcepTest management

importance of peer discussion



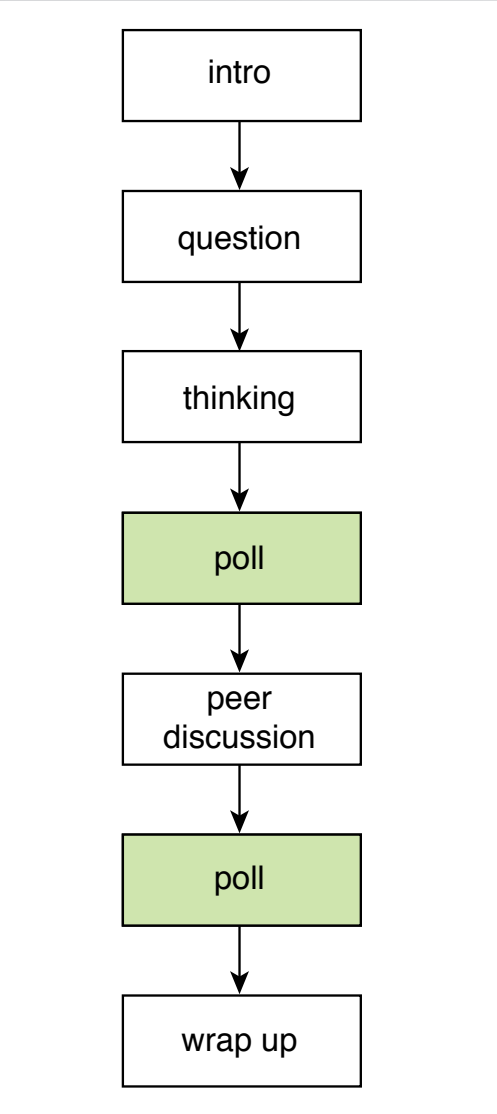
ConcepTest management

importance of peer discussion



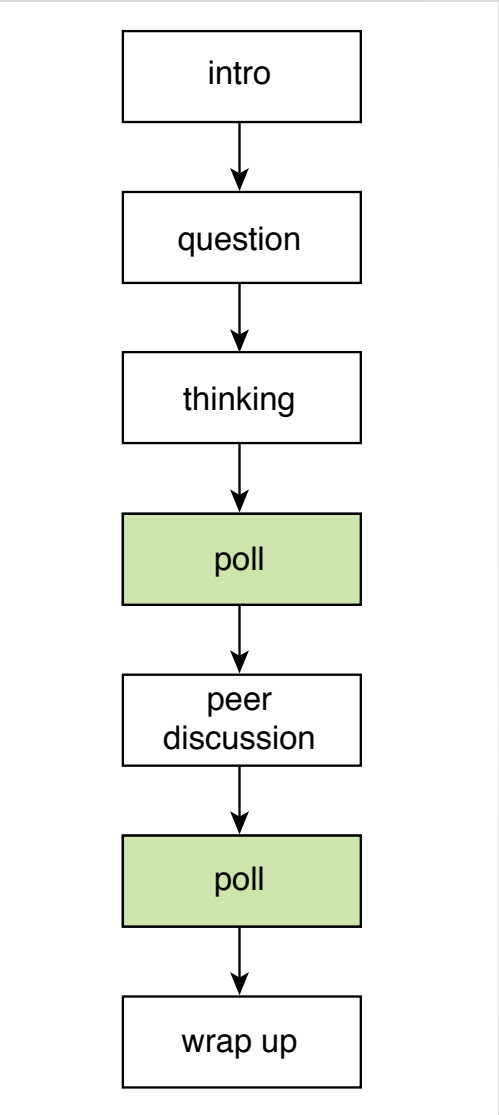
ConcepTest management

technology important?



ConcepTest management

technology important?



normalized FCI gain:

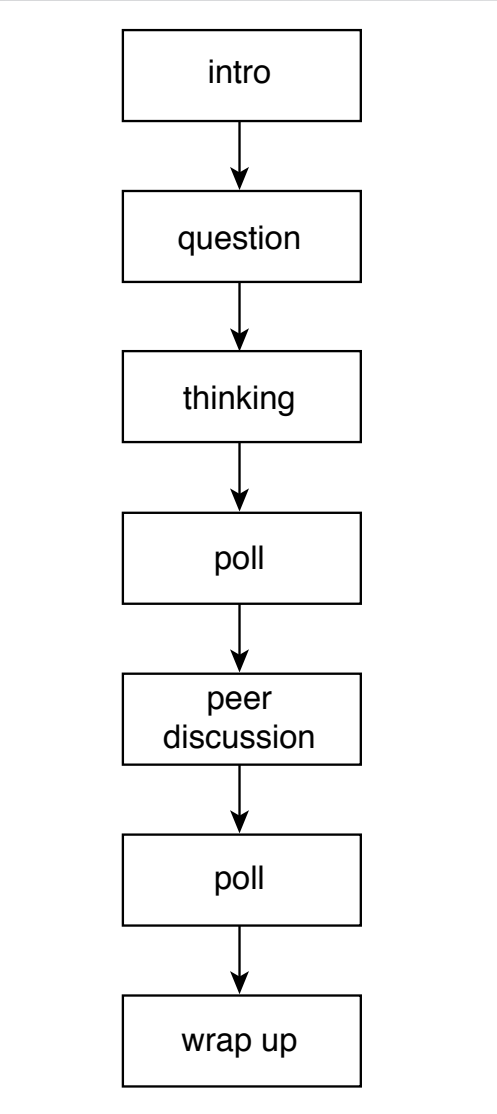
flashcards: 0.47

clickers: 0.44

Phys. Teacher, **46**, 242-244 (2008)

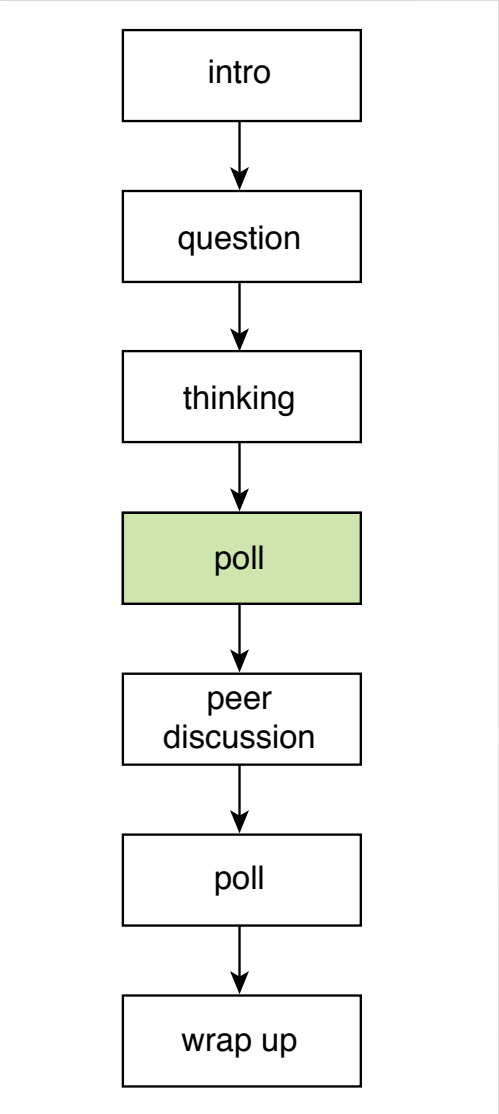
ConcepTest management

show histograms?



ConcepTest management

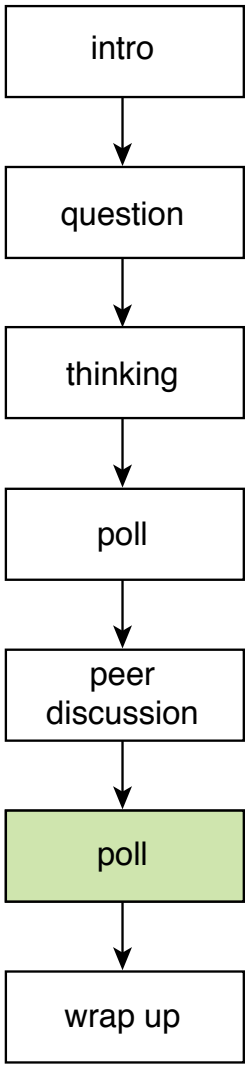
show histograms?



no — biases discussion

ConcepTest management

show histograms?

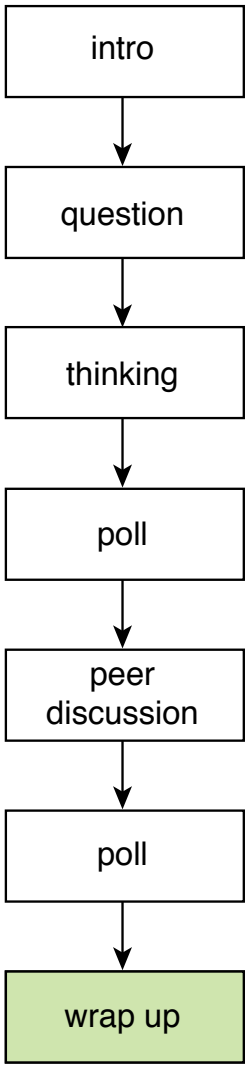


no — biases discussion

yes — helps bring closure

ConcepTest management

show histograms?



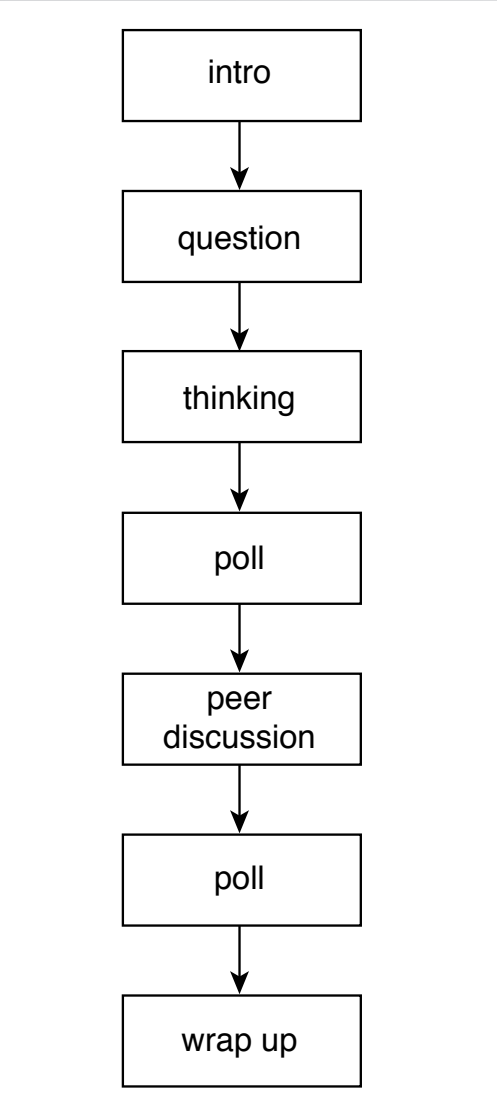
no — biases discussion

yes — helps bring closure

provide *your* answer

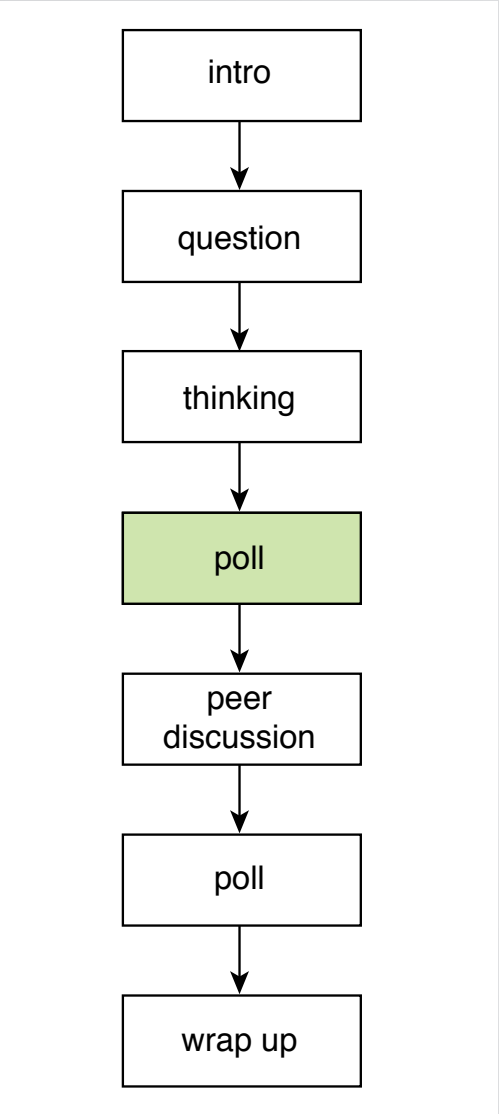
ConcepTest management

have individual students defend choices?



ConcepTest management

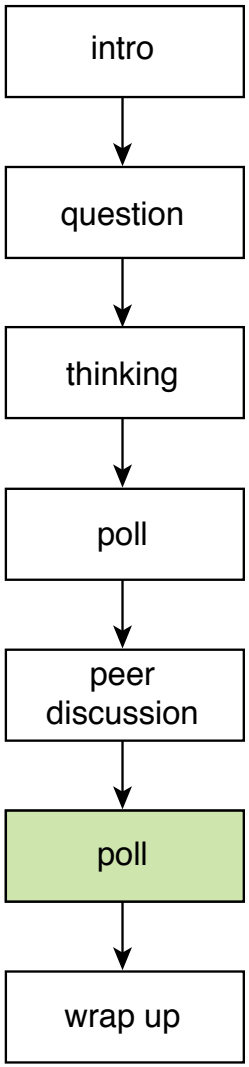
have individual students defend choices?



provides additional insights for discussion

ConcepTest management

have individual students defend choices?



involves students in wrap up

Outline

- anatomy of a ConcepTest
- ConcepTest management
- implementing PI & JiTT

Implementing PI & JiTT

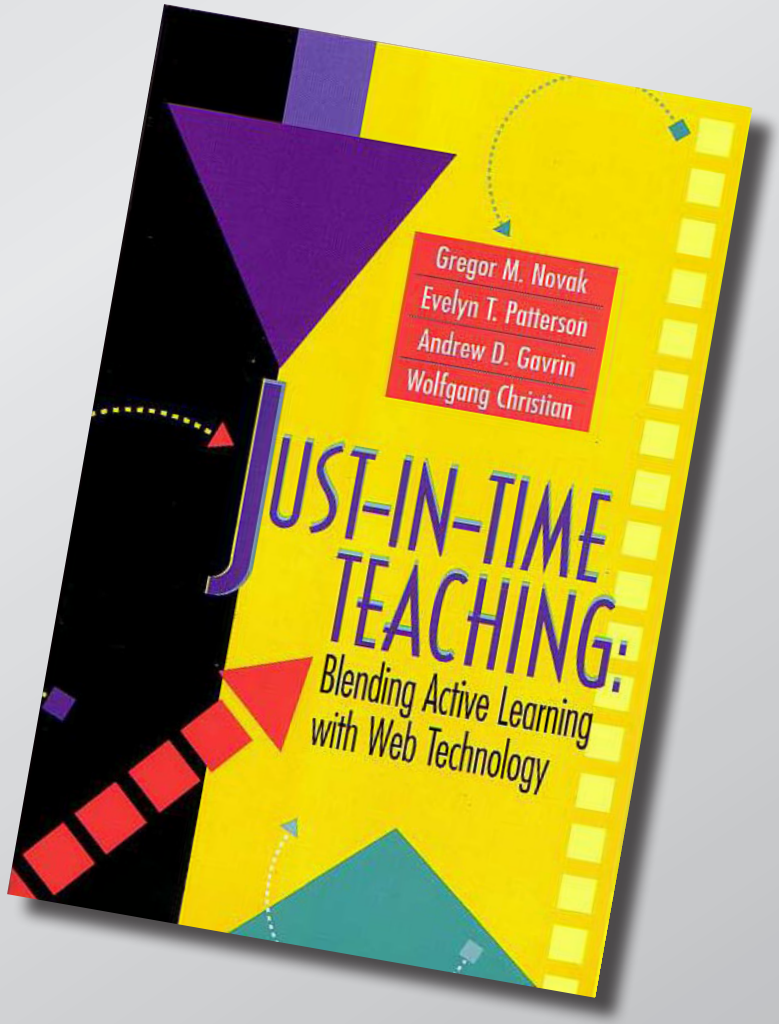
“How to encourage students to read materials before they come to class? If they don’t prepare, can this pedagogy still work?”

Will the students read before coming to class or will they simply stop coming to class?”

Implementing PI & JiTT

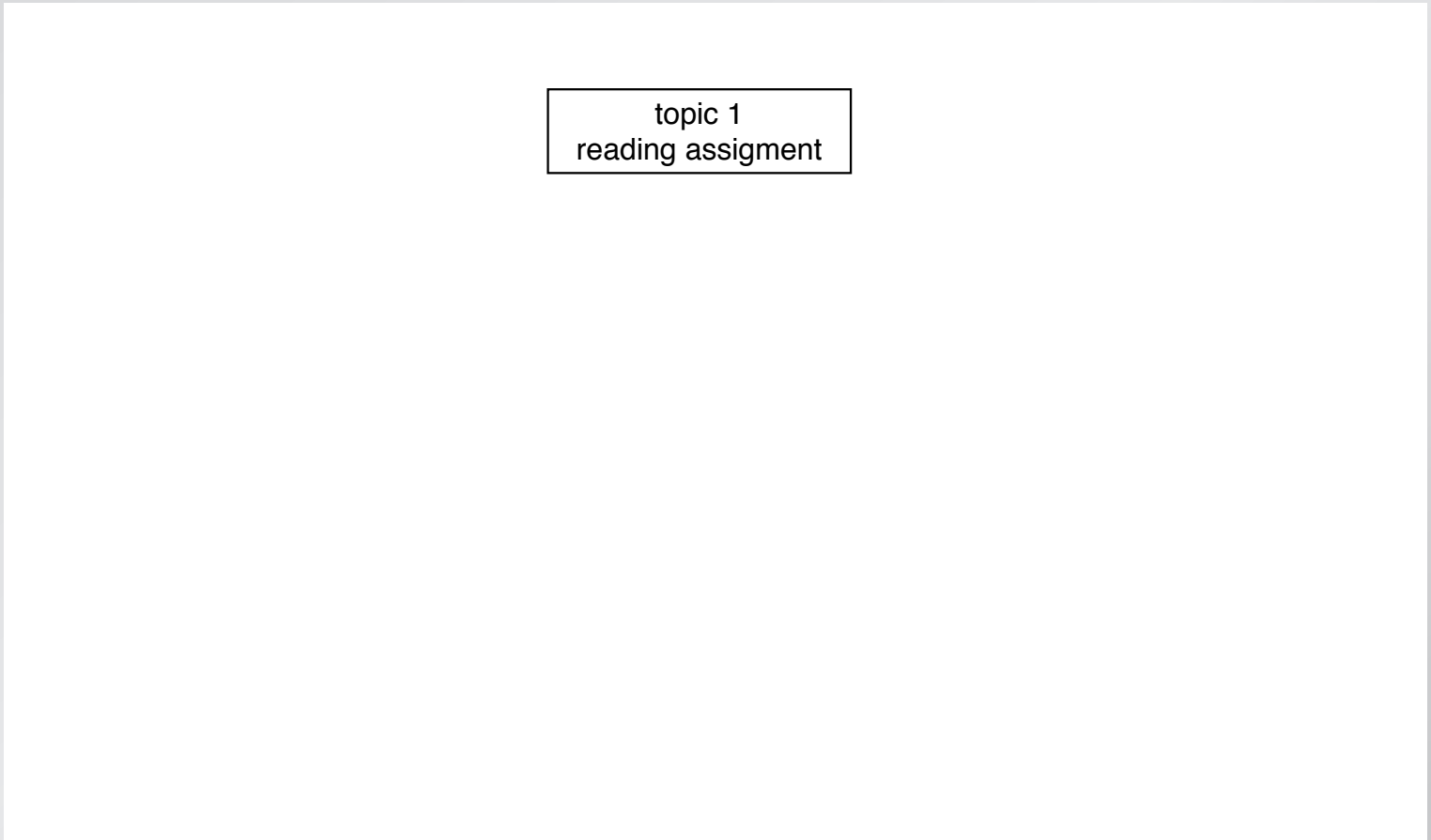
Just-in-time-Teaching (JiTT)

www.jitt.org



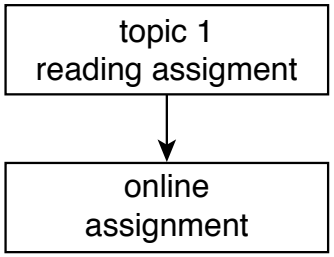
Implementing PI & JiTT

JiTT workflow



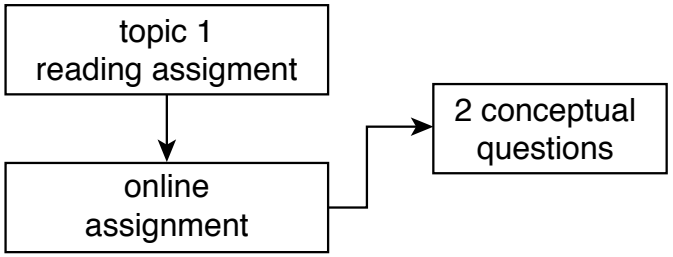
Implementing PI & JiTT

JiTT workflow



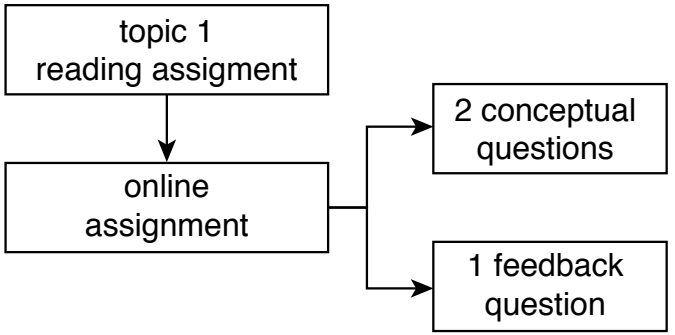
Implementing PI & JiTT

JiTT workflow



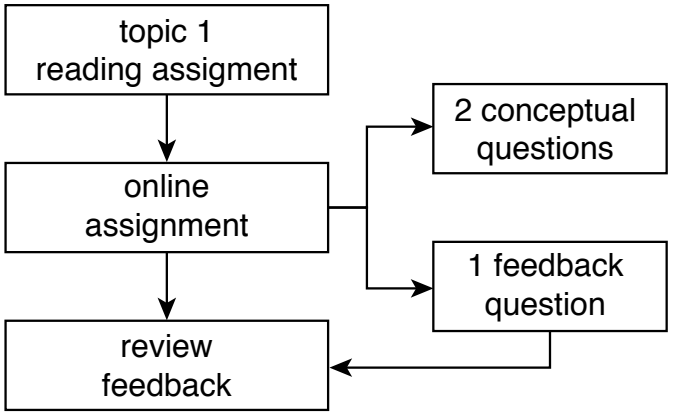
Implementing PI & JiTT

JiTT workflow



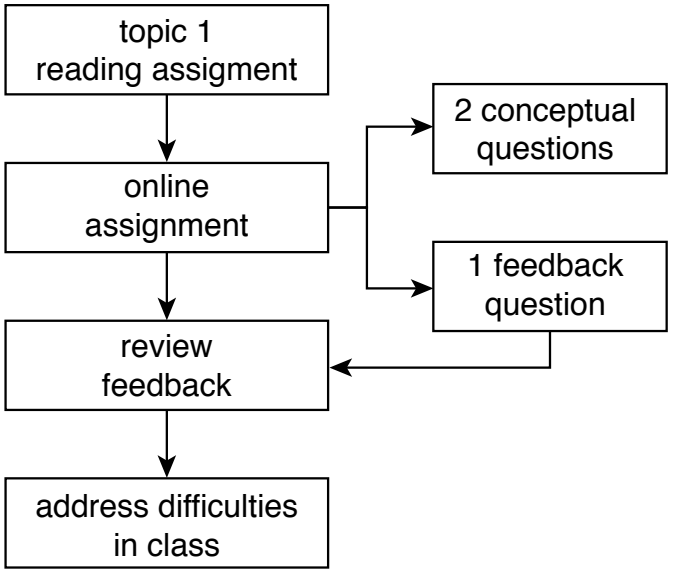
Implementing PI & JiTT

JiTT workflow



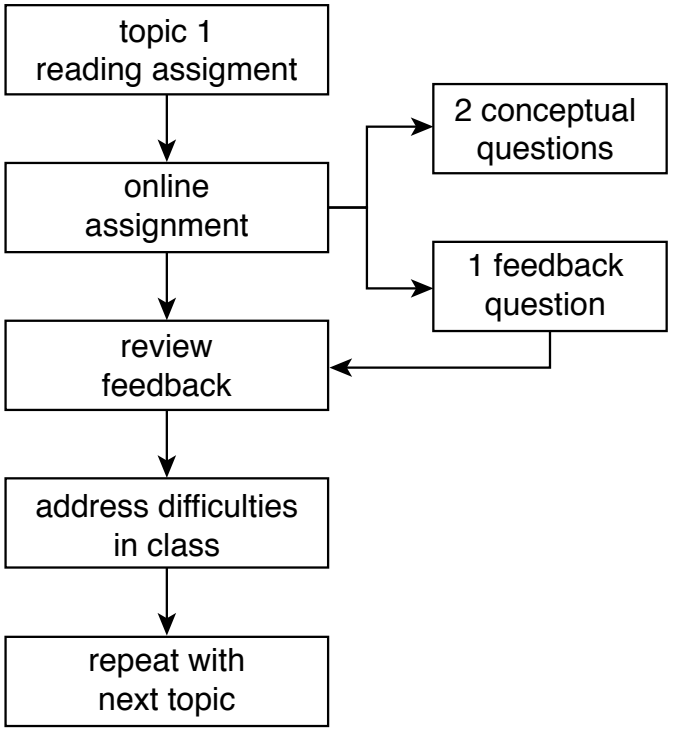
Implementing PI & JiTT

JiTT workflow



Implementing PI & JiTT

JiTT workflow



Implementing PI & JiTT

“I am not sure how much of the core traditional material I can cover given the amount of time it appears I will need to develop PI/JiTT ConcepTest questions. ”

Implementing PI & JiTT

JiTT:

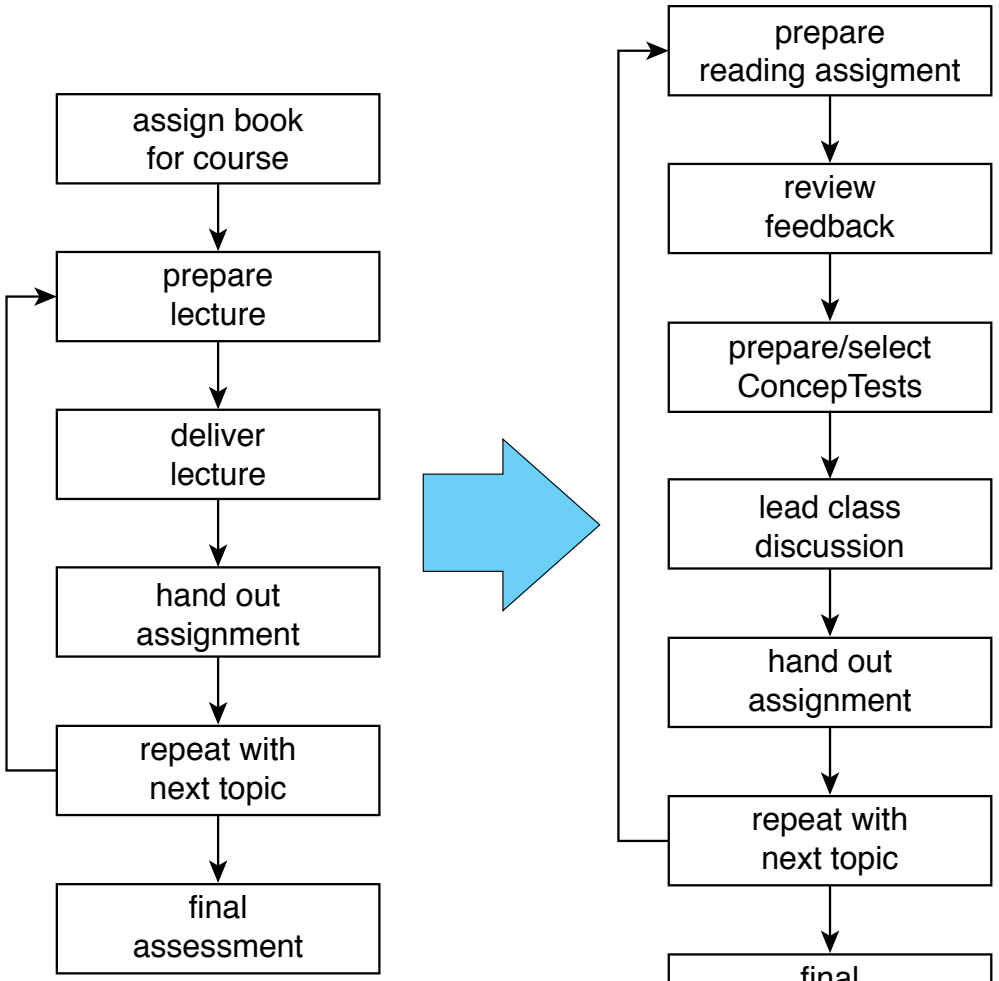
- **prepares you for class**
- **prepares students for class**
- **helps you address student difficulties**

Implementing PI & JiTT

“Reading responses from the students can be very time consuming, especially for large classes. Are there any ways that have been proved to make these methods more effective for large classes?”

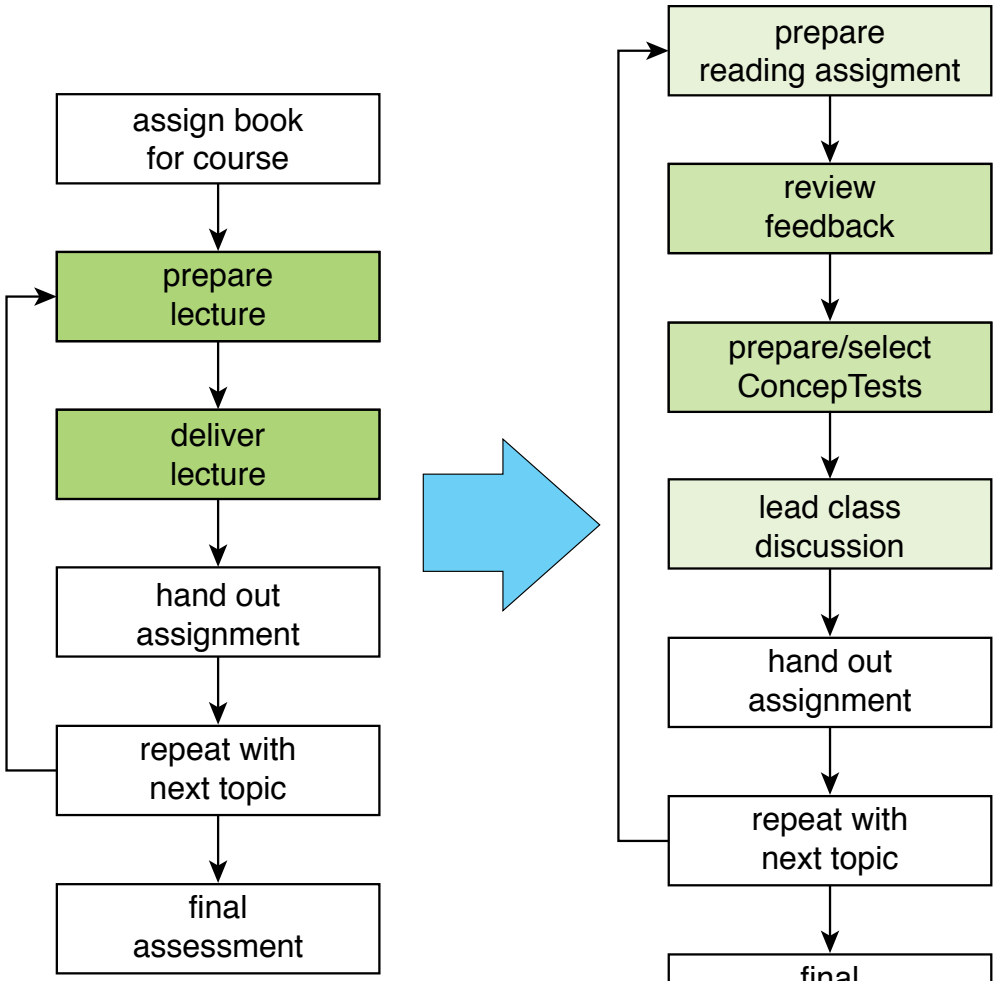
Implementing PI & JiTT

transitioning: where does the effort go?



Implementing PI & JiTT

transitioning: where does the effort go?



Implementing PI & JiTT

“Why not solve problems for students on the board? Why not show students how an ‘expert’ in the field tackles the problem?”

Also: many wondered about how to accurately assess student understanding

Implementing PI & JiTT

What constitutes a good problem?

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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.

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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?

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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?

Implementing PI & JiTT

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Developing a model
Applying that model

Implementing PI & JiTT

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

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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?

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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?

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

Implementing PI & JiTT

On a Saturday afternoon, you pull into a parking lot with unmetered 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

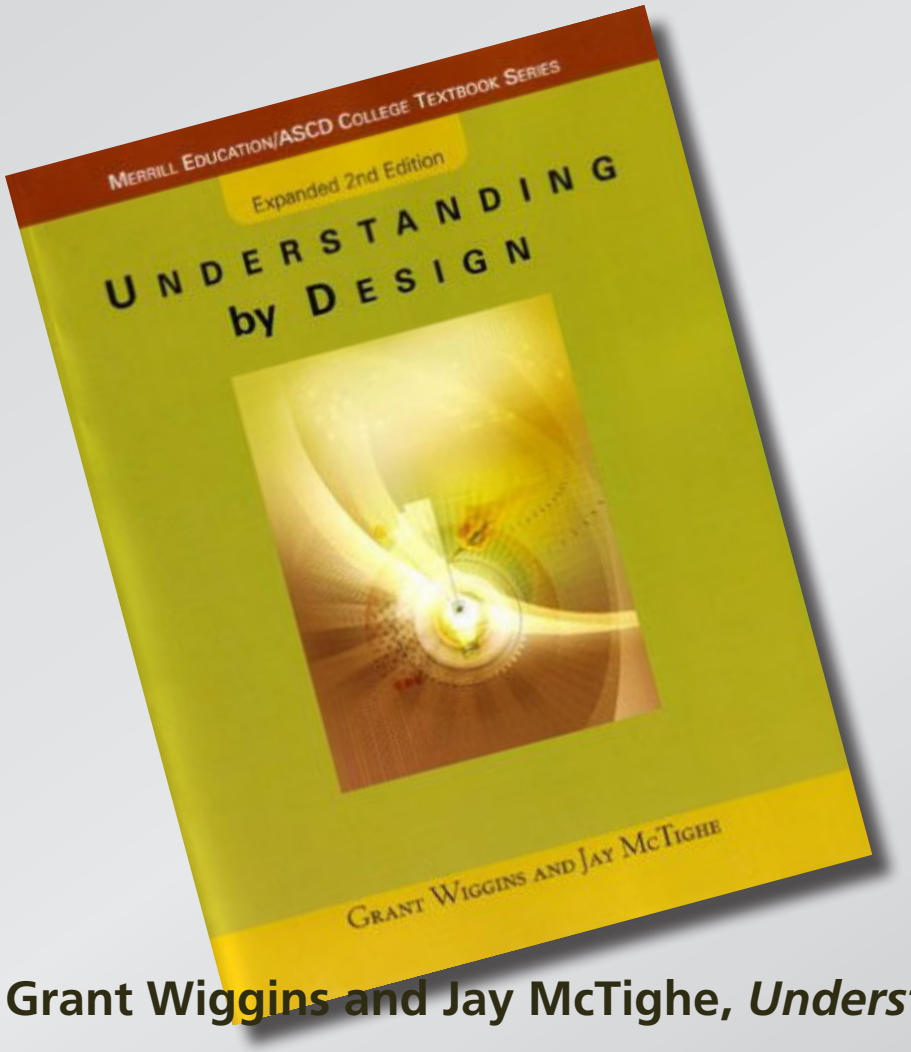
$$t_{wait} = \frac{T_{shop}}{N_{spaces}}$$

Implementing PI & JiTT

set learning goals to facilitate assessment!

Implementing PI & JiTT

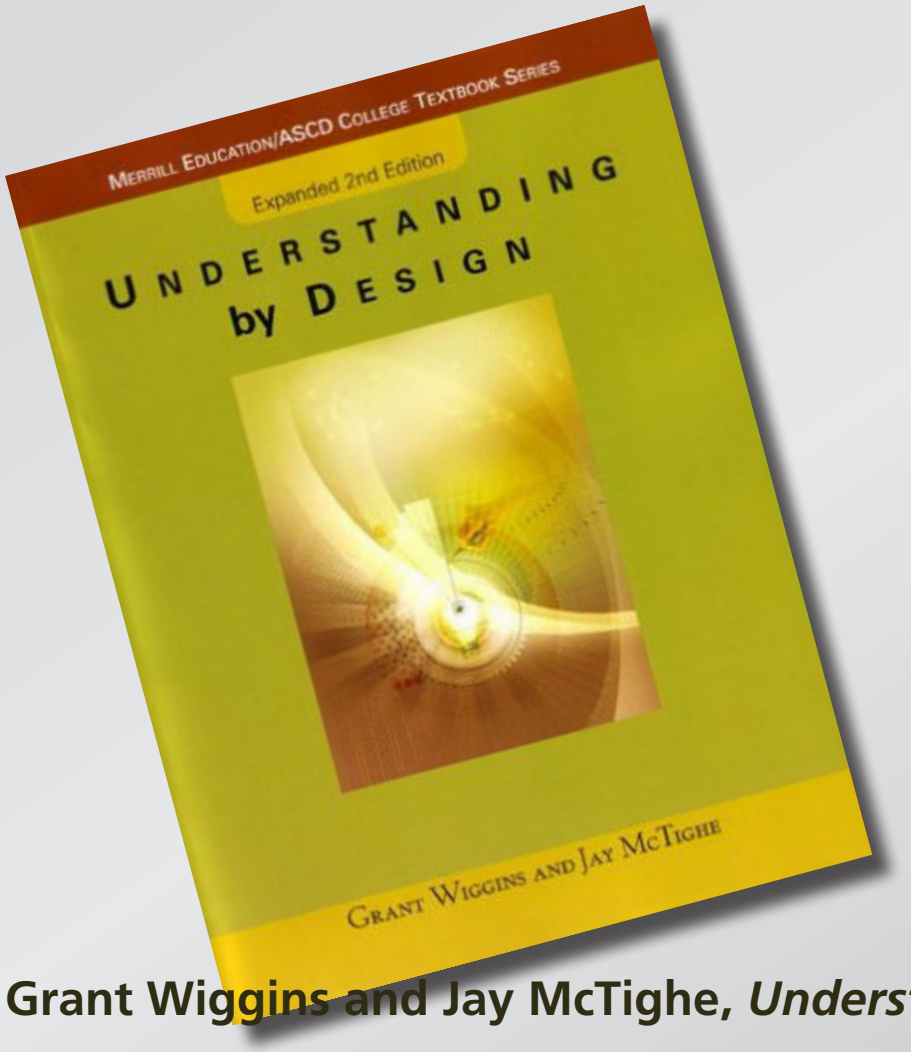
Setting learning goals



Grant Wiggins and Jay McTighe, *Understanding by Design* (Prentice Hall, 2001)

Implementing PI & JiTT

Setting learning goals

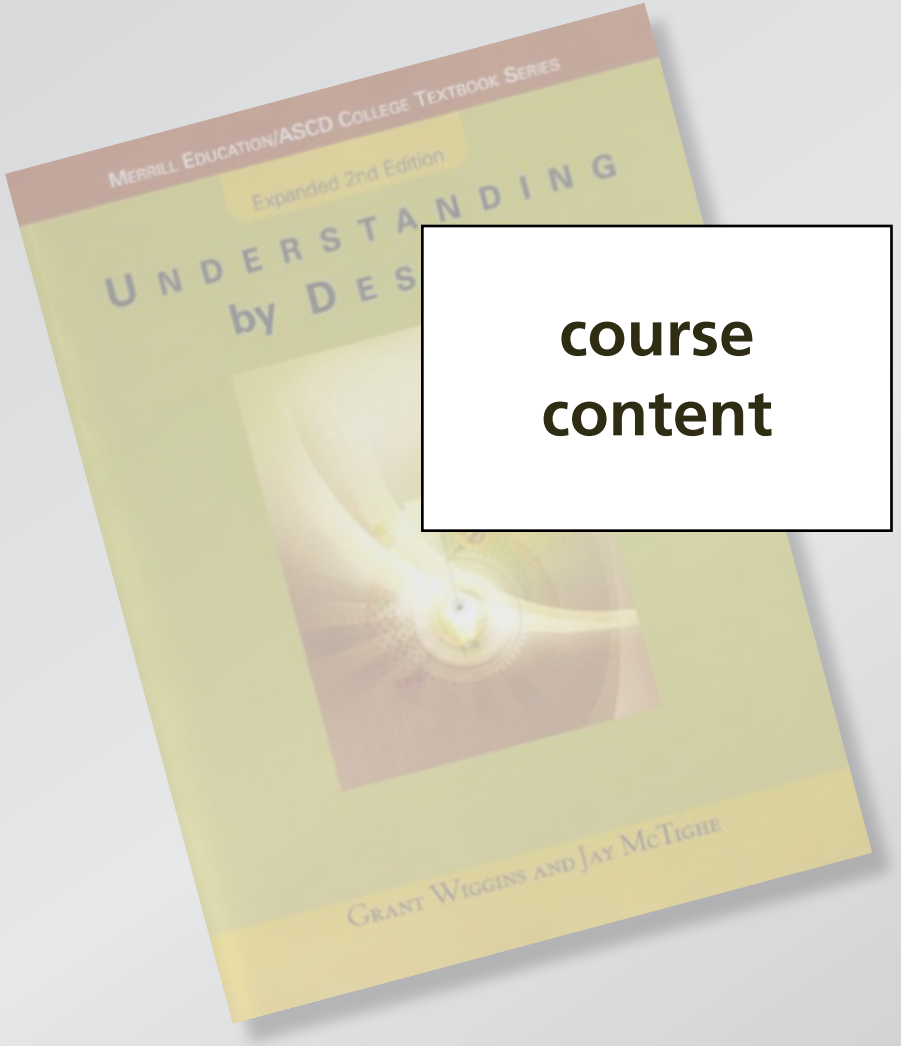


- approach, not content
- focus on understanding
- backward design

Grant Wiggins and Jay McTighe, *Understanding by Design* (Prentice Hall, 2001)

Implementing PI & JiTT

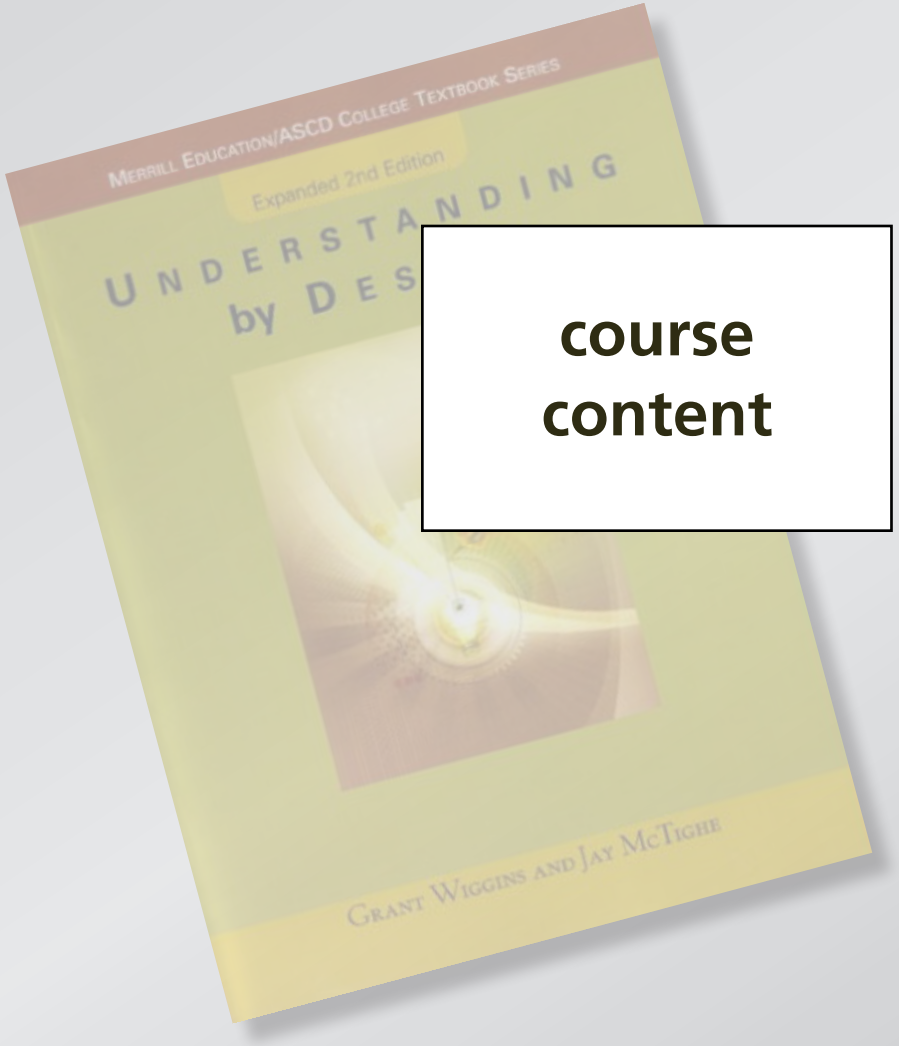
Traditional approach to course planning



course content

Implementing PI & JiTT

Traditional approach to course planning

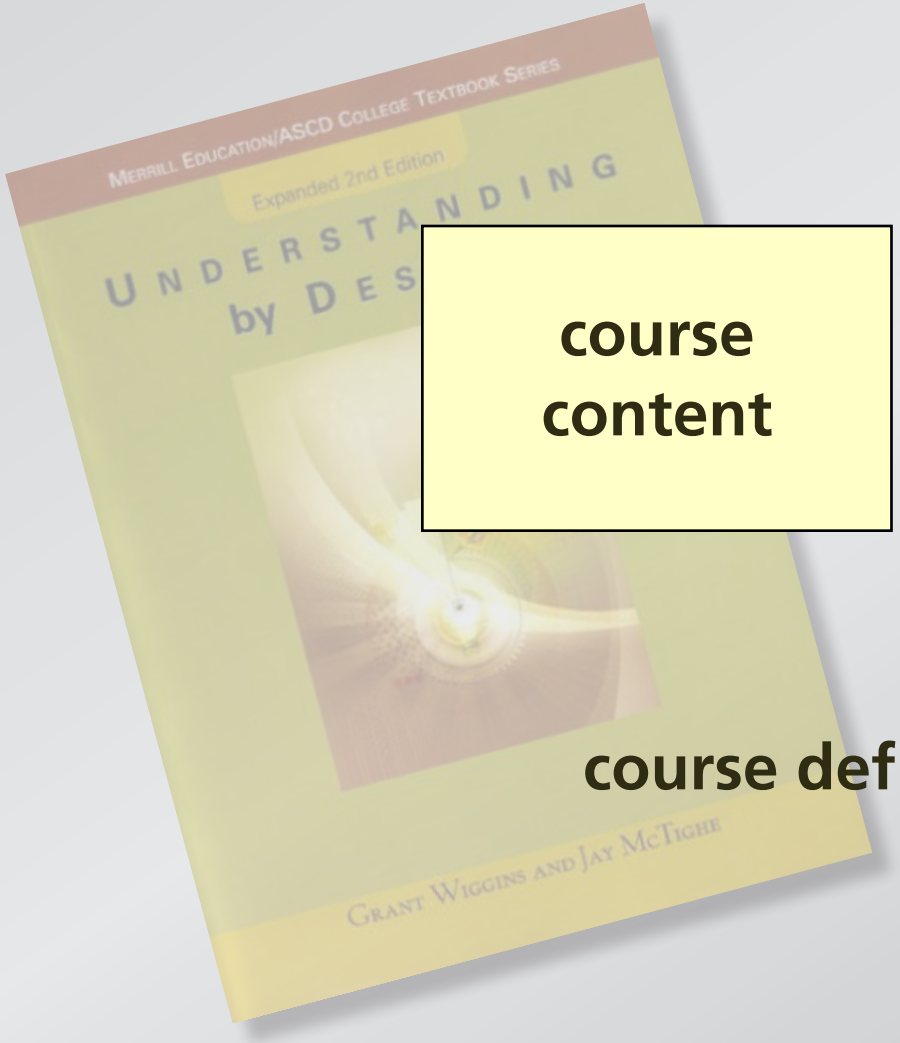


course content

assessment

Implementing PI & JiTT

Traditional approach to course planning

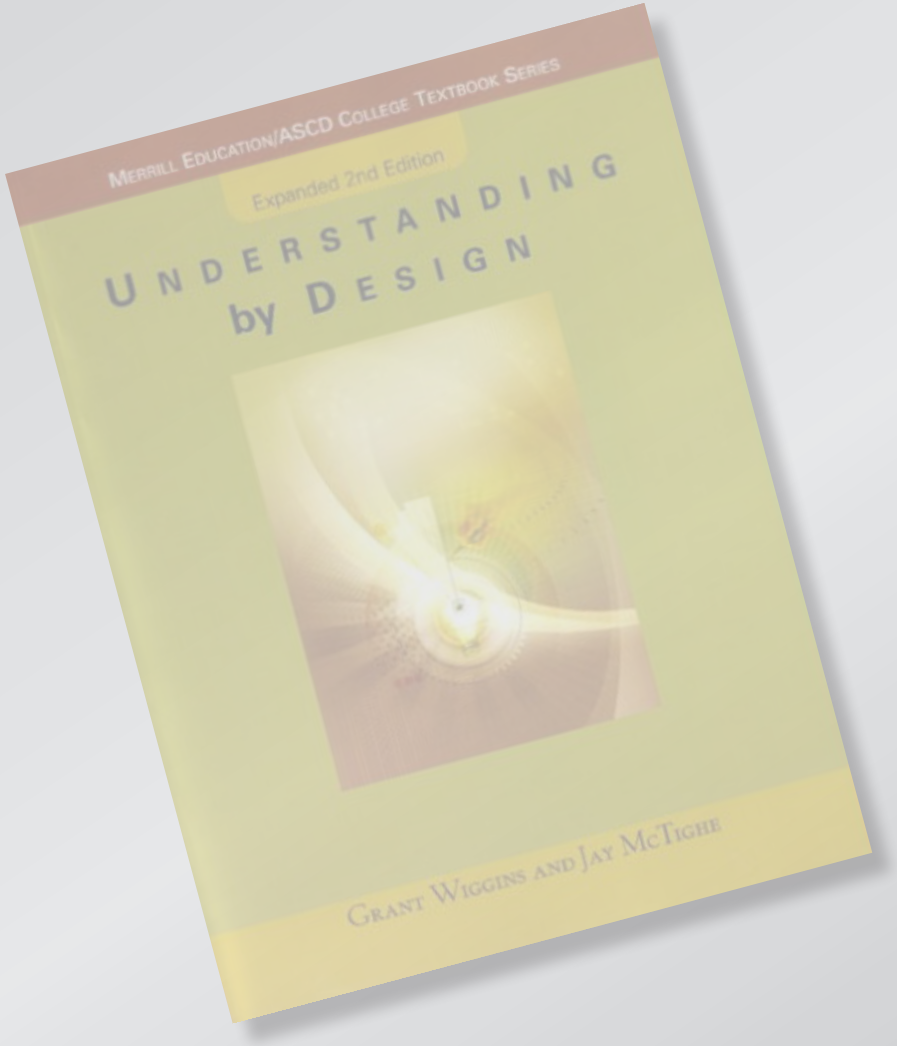


course content → assessment

course defined by content

Implementing PI & JiTT

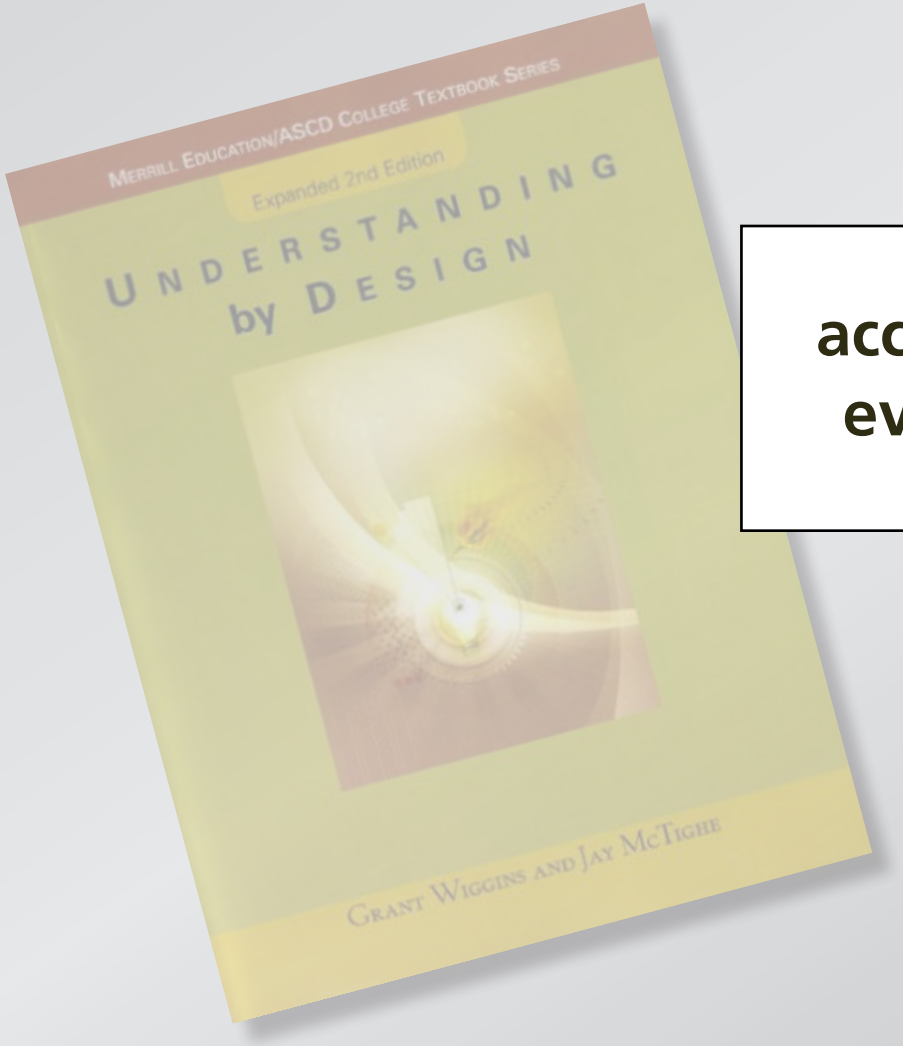
Backward design



desired outcomes

Implementing PI & JiTT

Backward design

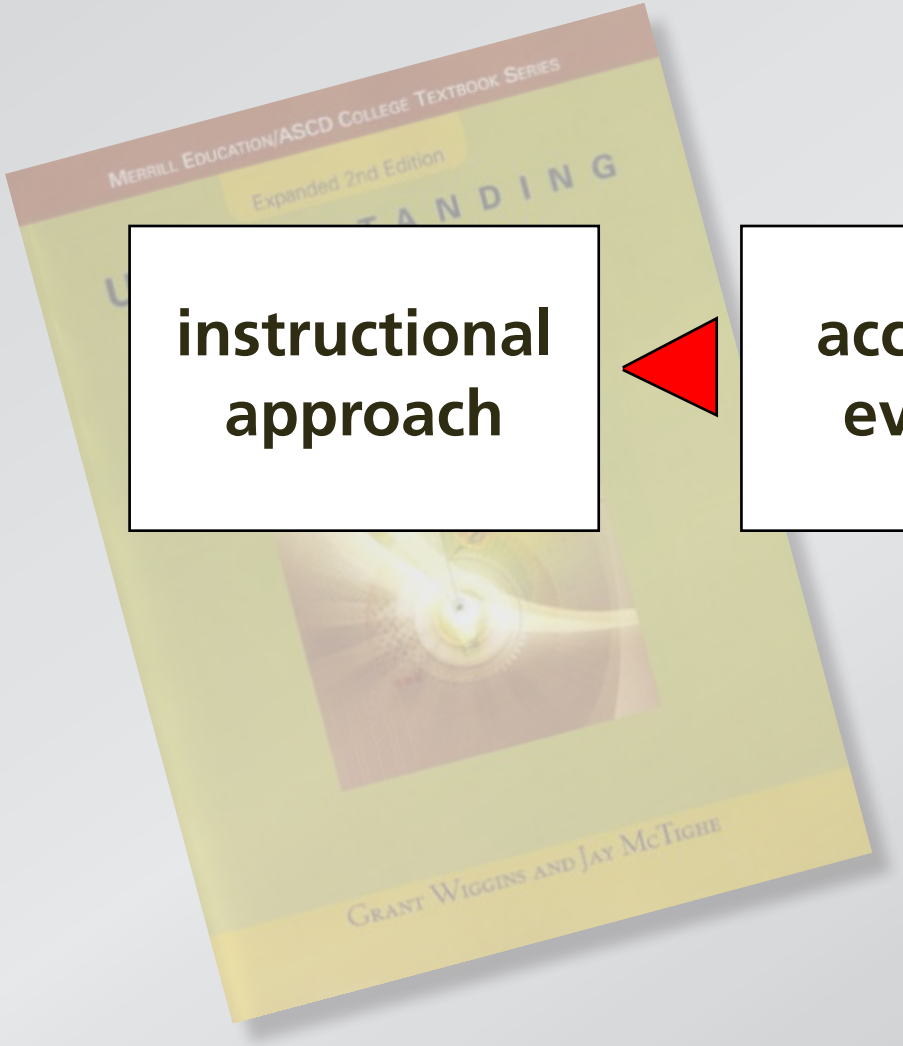


acceptable evidence

desired outcomes

Implementing PI & JiTT

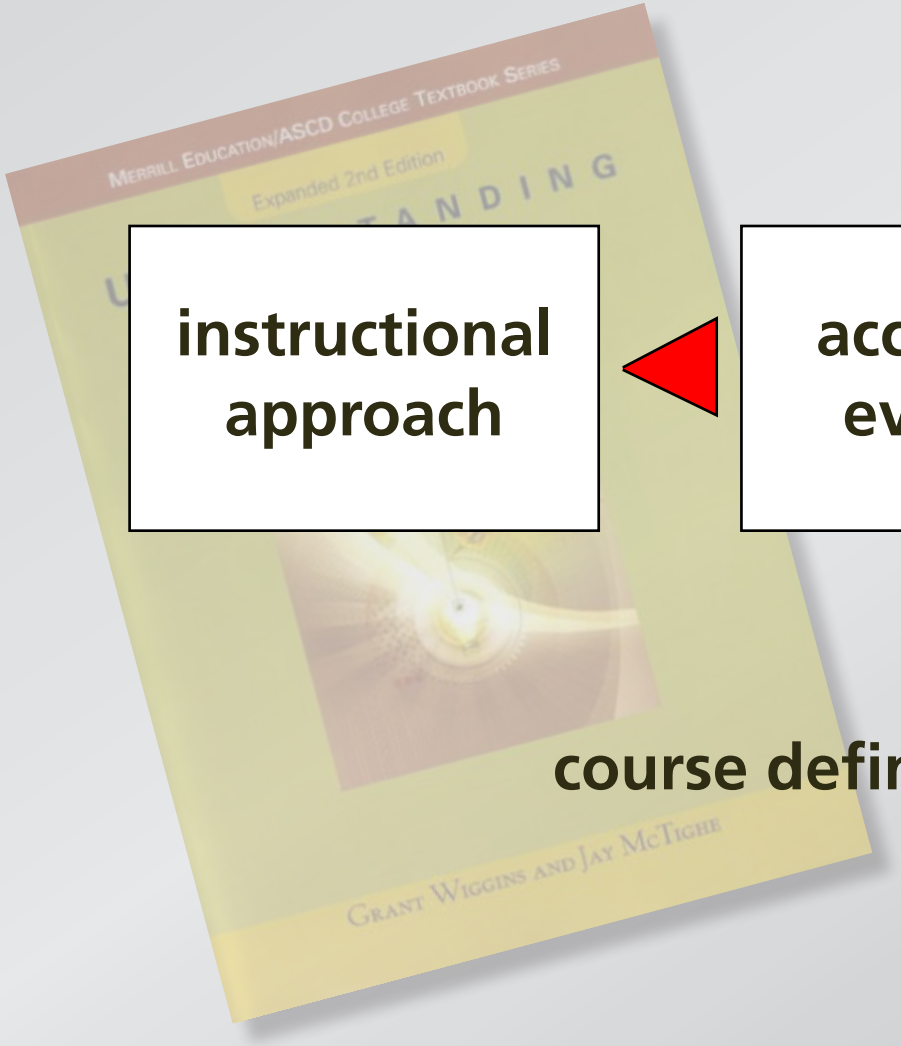
Backward design



instructional approach ◀ **acceptable evidence** ◀ **desired outcomes**

Implementing PI & JiTT

Backward design



instructional approach ◀ **acceptable evidence** ◀ **desired outcomes**

course defined by outcomes

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http://mazur.harvard.edu

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