

Interactive Learning: Technology in the Classroom



Symposium on Education and Technology
Harvard University
Cambridge, MA, 17 June 2013



Interactive Learning: Technology in the Classroom



@eric_mazur
#lectyr

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EDUCACION



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



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Think of something you are good at

EDUCACION

Think of something you are good at

How did you become good at this?

EDUCACION

Became good at it by:

- 1. trial and error**
- 2. lectures**
- 3. practicing**
- 4. apprenticeship**
- 5. other**









1 lecture

2 PI



1 lecture

2 PI

3 PI 2.0




**EXCITING
stuff!**

1 lecture

2 PI

3 PI 2.0

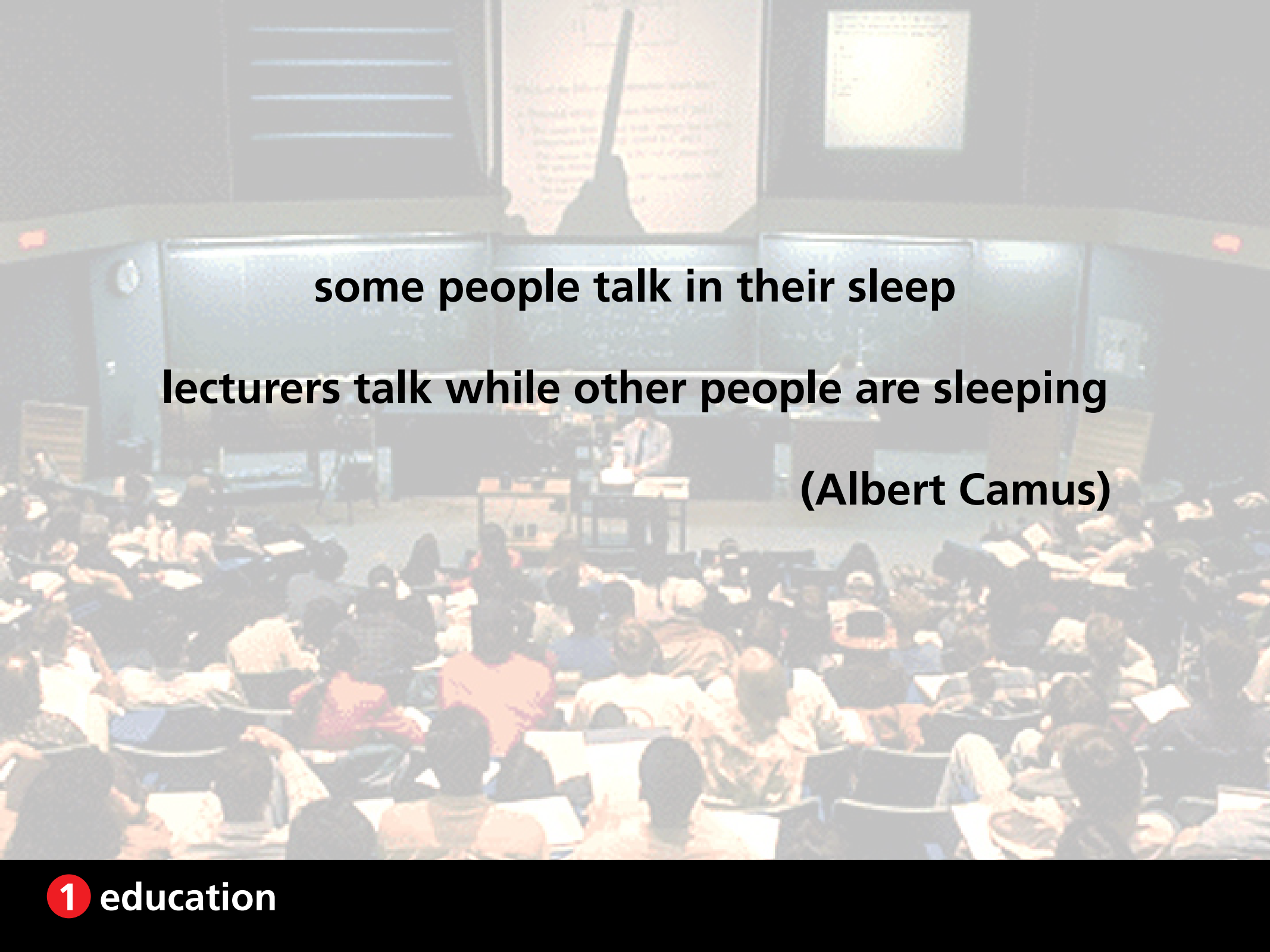


**What happens
in a lecture?**



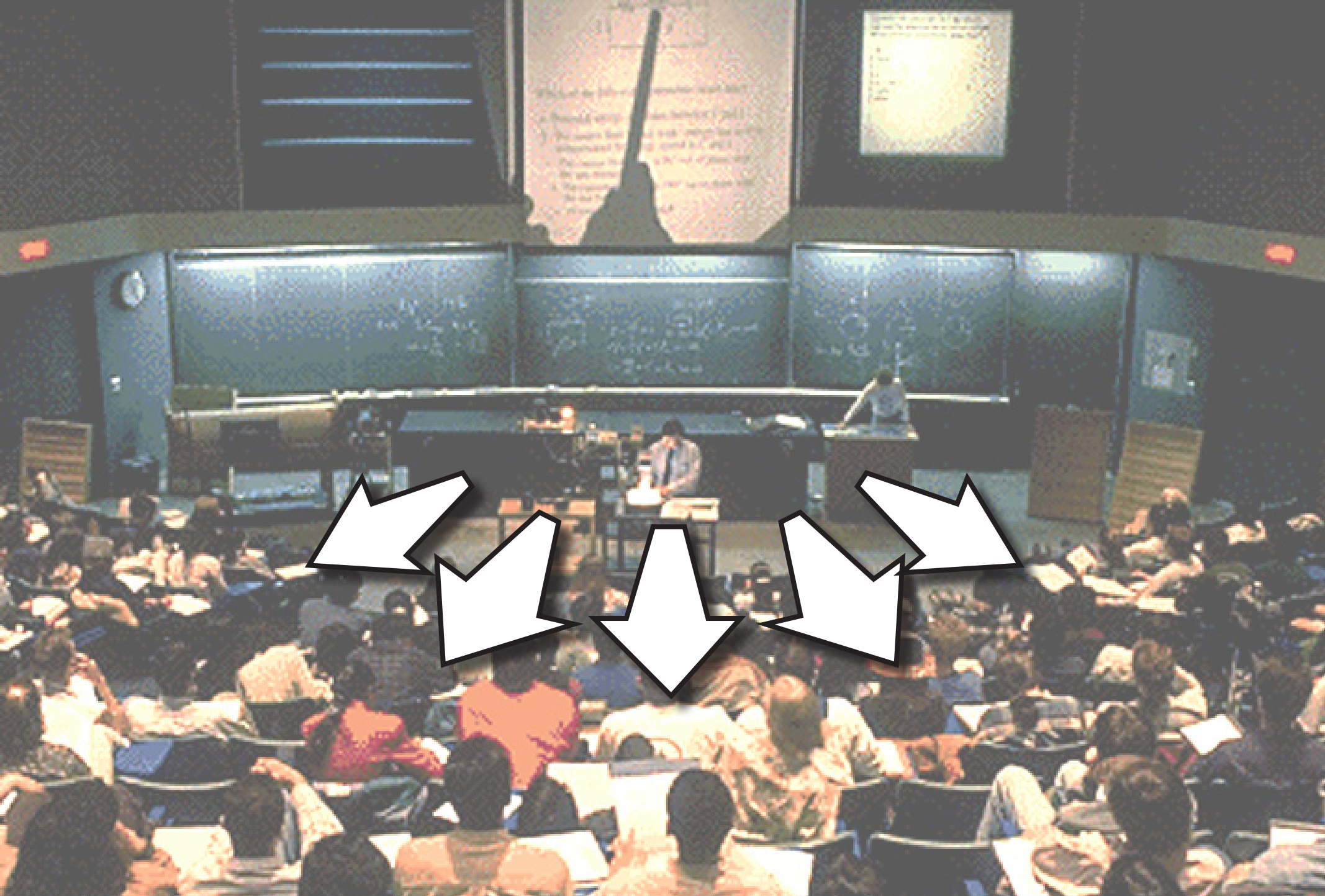


some people talk in their sleep

A large lecture hall filled with students. Many students are sleeping, with their heads resting on their desks or hands. The room has a curved front wall with a large screen displaying text. The lighting is dim, and the overall atmosphere is one of a lecture where many students are not paying attention.

some people talk in their sleep
lecturers talk while other people are sleeping
(Albert Camus)

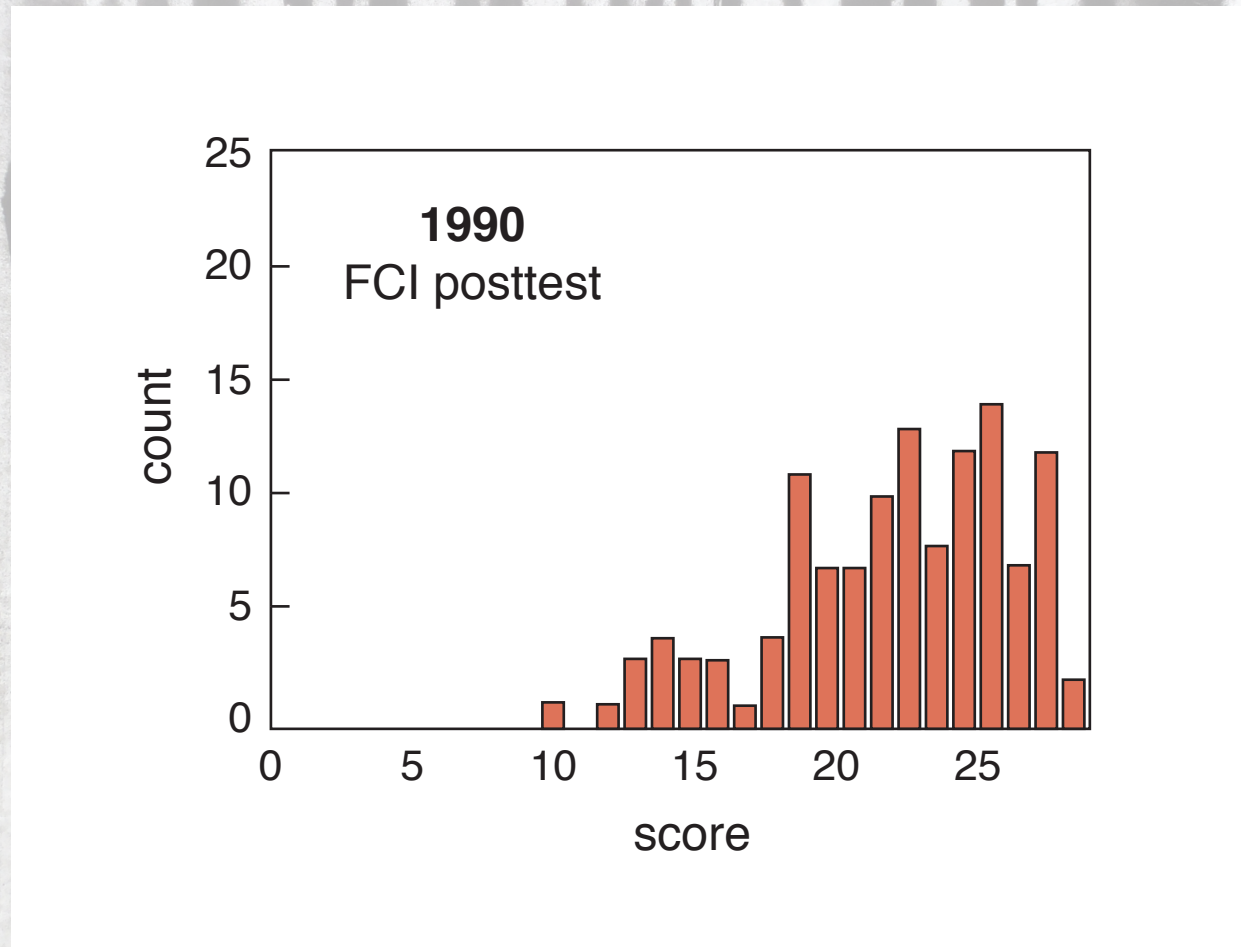




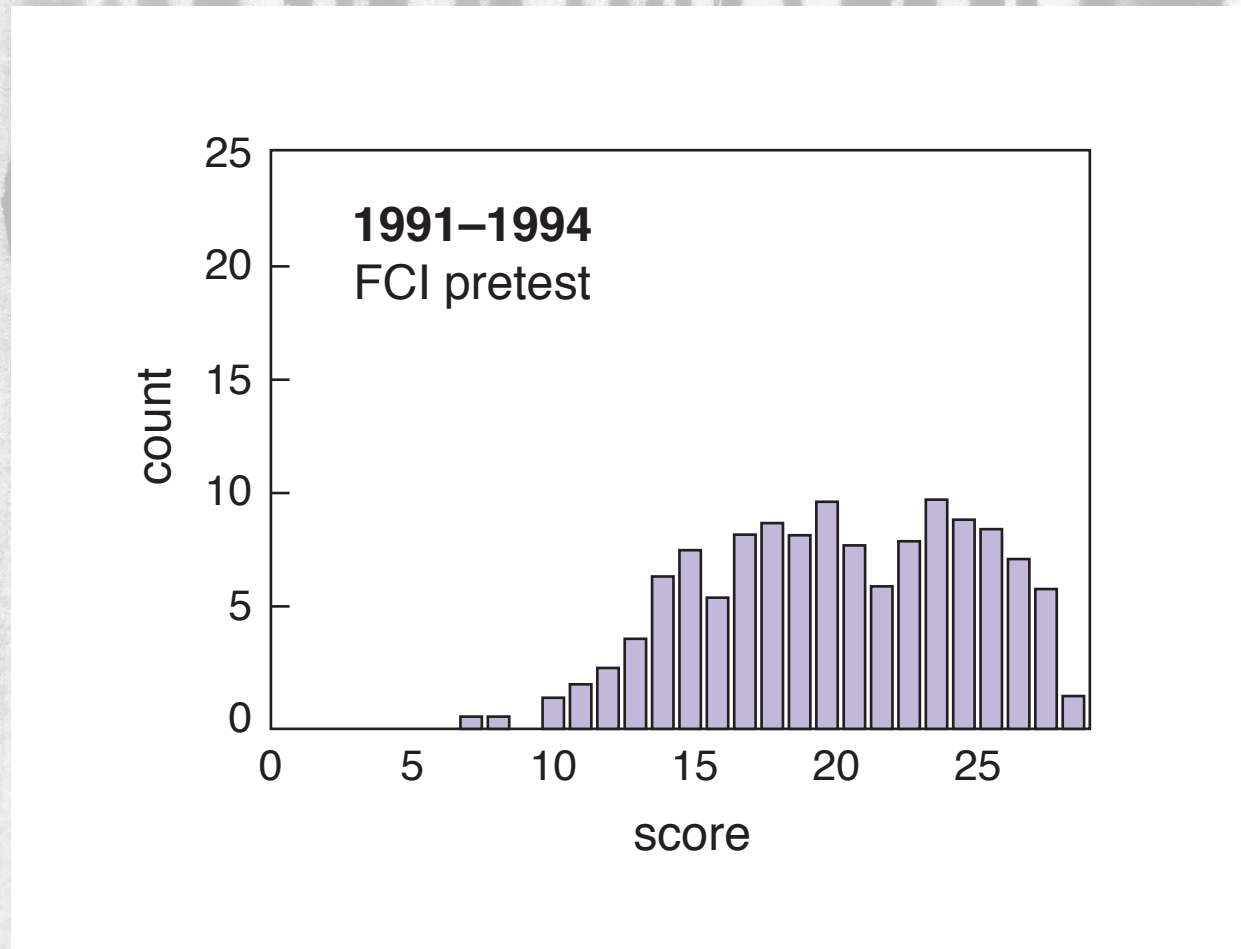
The result?

EDUCACION

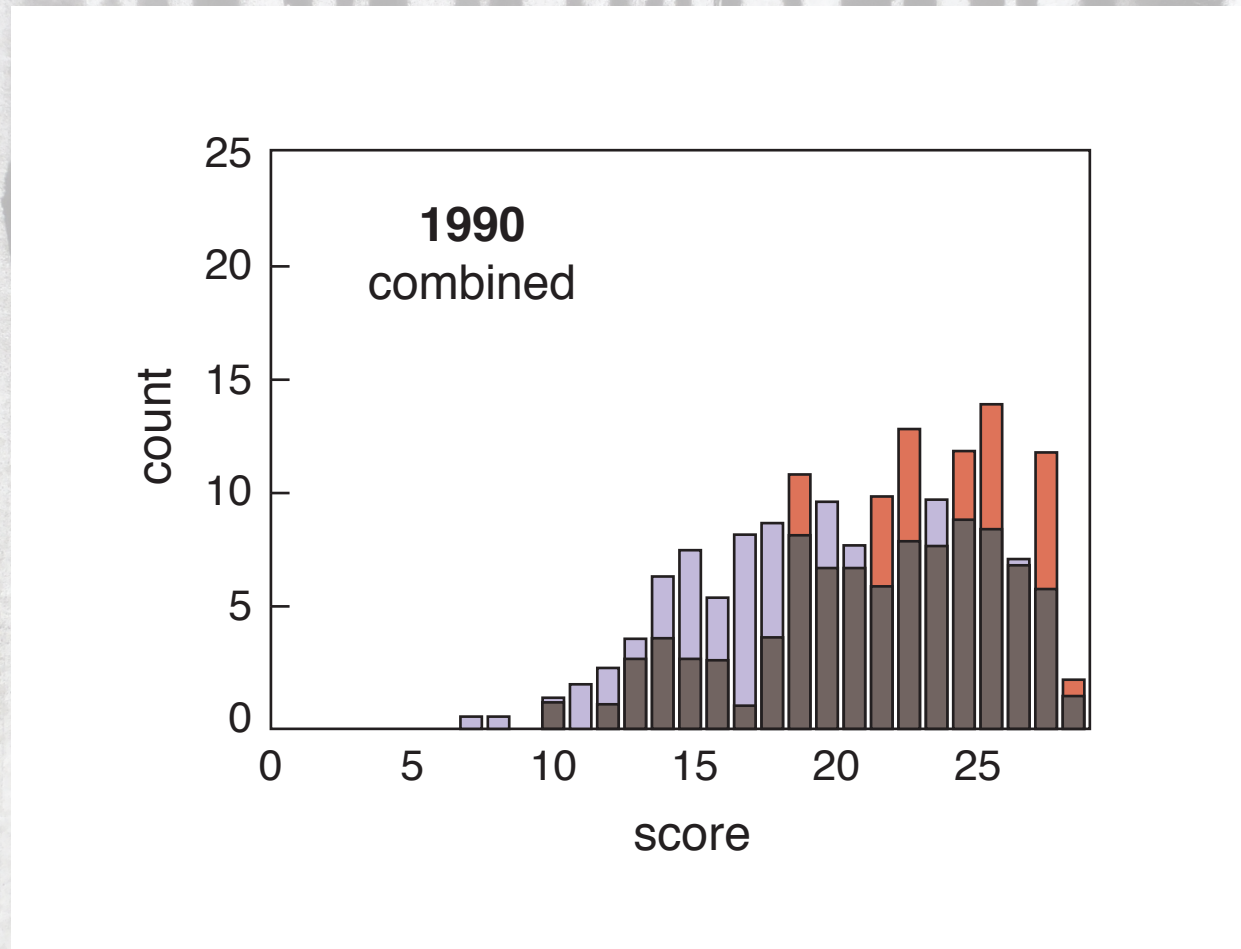
education is not just information transfer

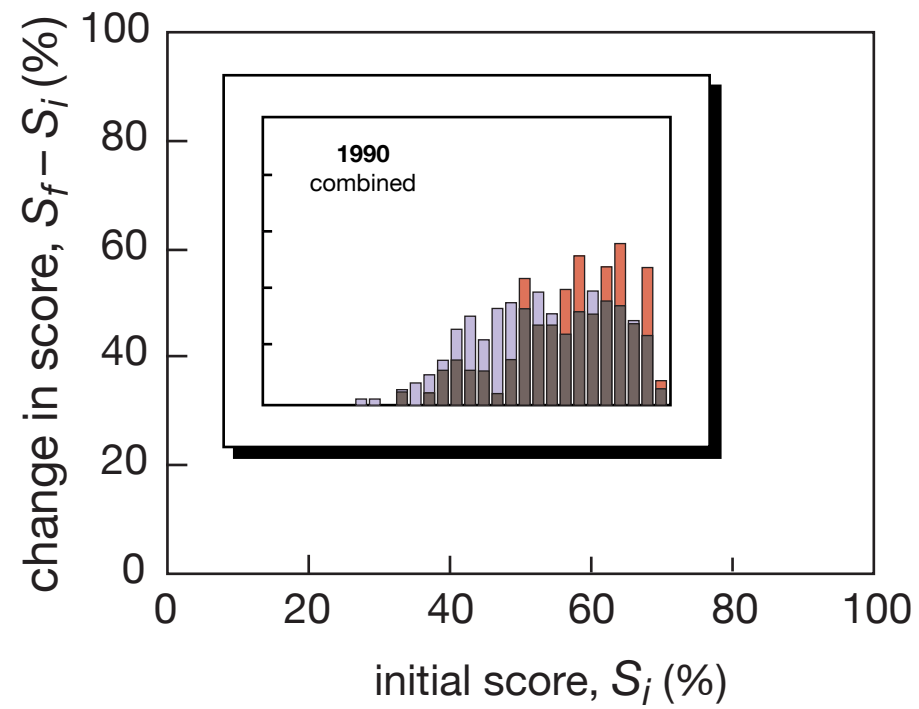


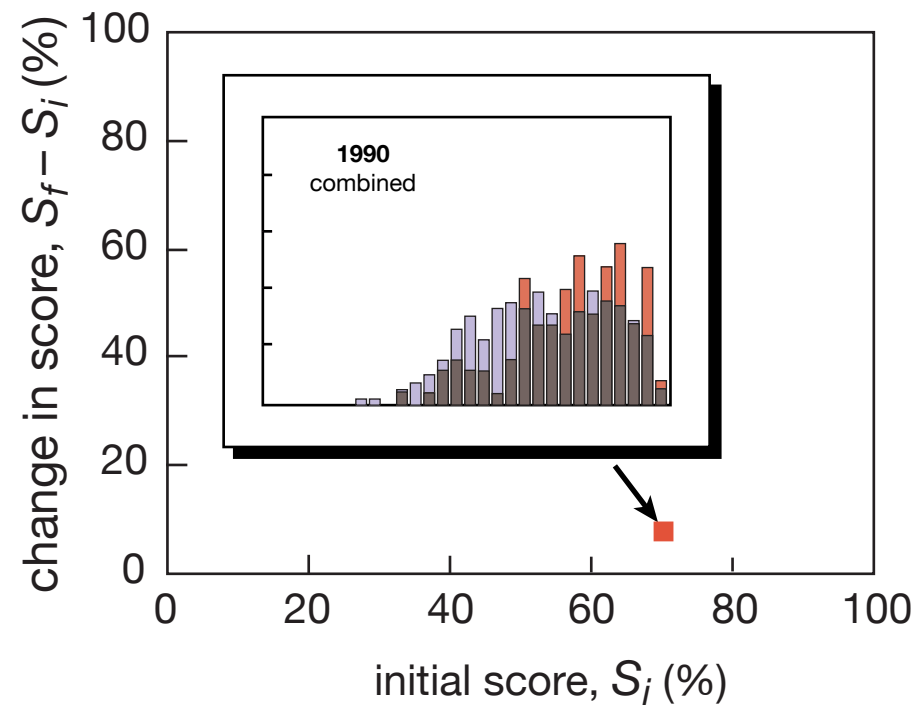
education is not just information transfer

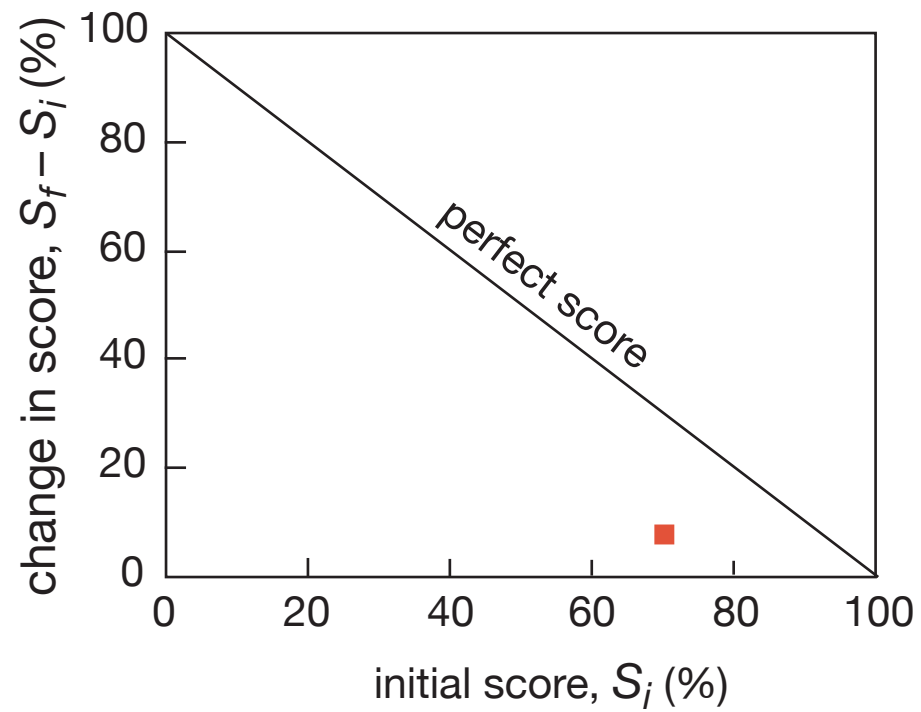


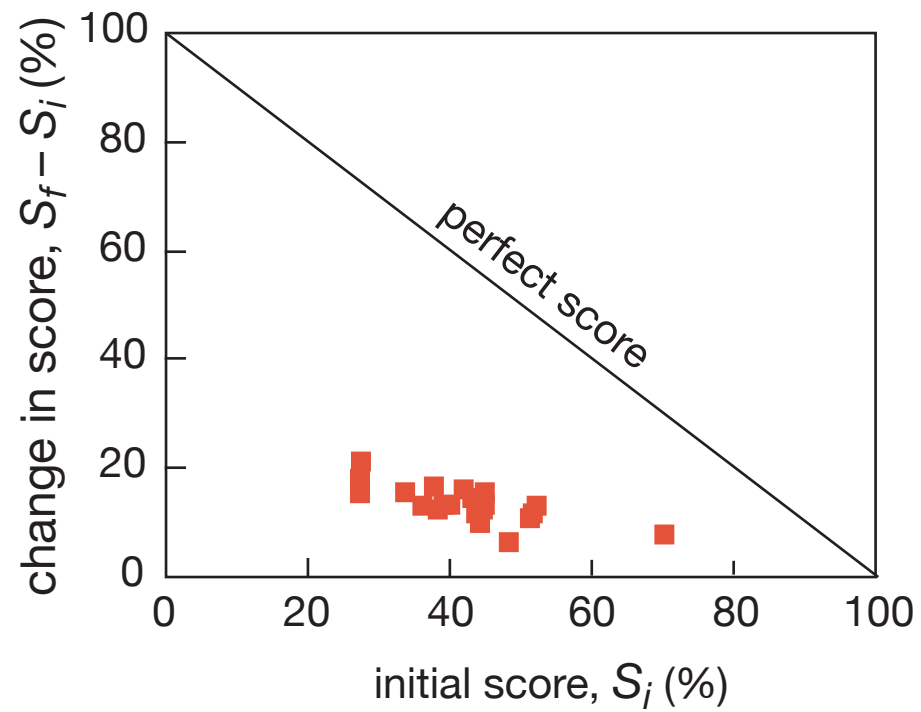
education is not just information transfer





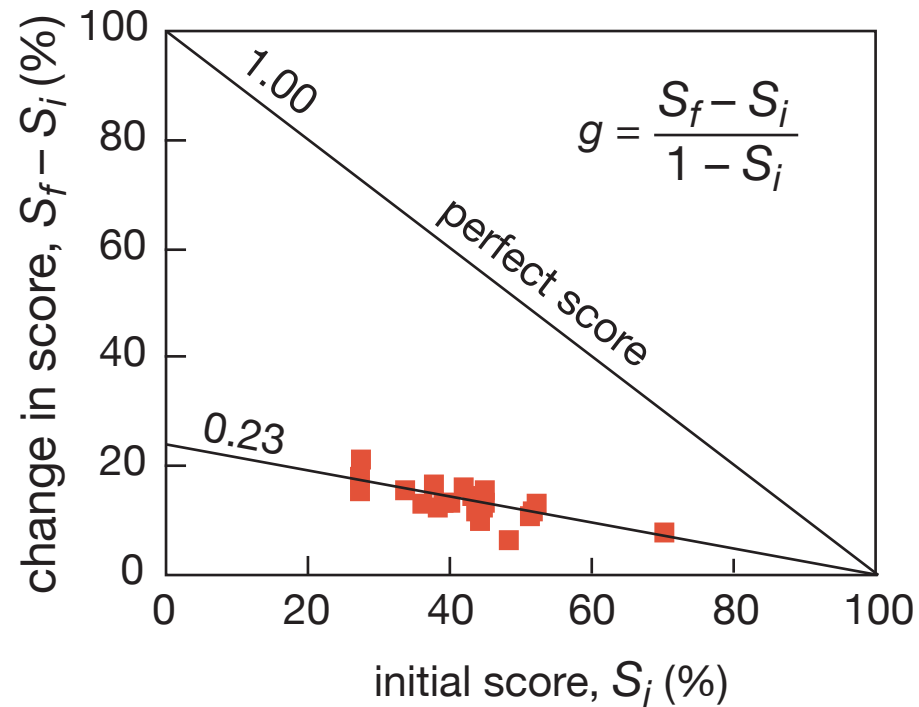






R.R. Hake, *Am. J. Phys.* 66, 64 (1998)

only one quarter of maximum gain realized



R.R. Hake, *Am. J. Phys.* 66, 64 (1998)

The background of the slide is a faded, high-contrast image of a book cover. The word 'EDUCACION' is visible in large, bold, capital letters at the bottom of the cover. The overall image is grainy and has a vintage feel.

not transfer but assimilation of information is key

Lack of learning

EDUCACION

Lack of learning

Lack of retention



1 lecture

2 PI



1. transfer of information



1. transfer of information

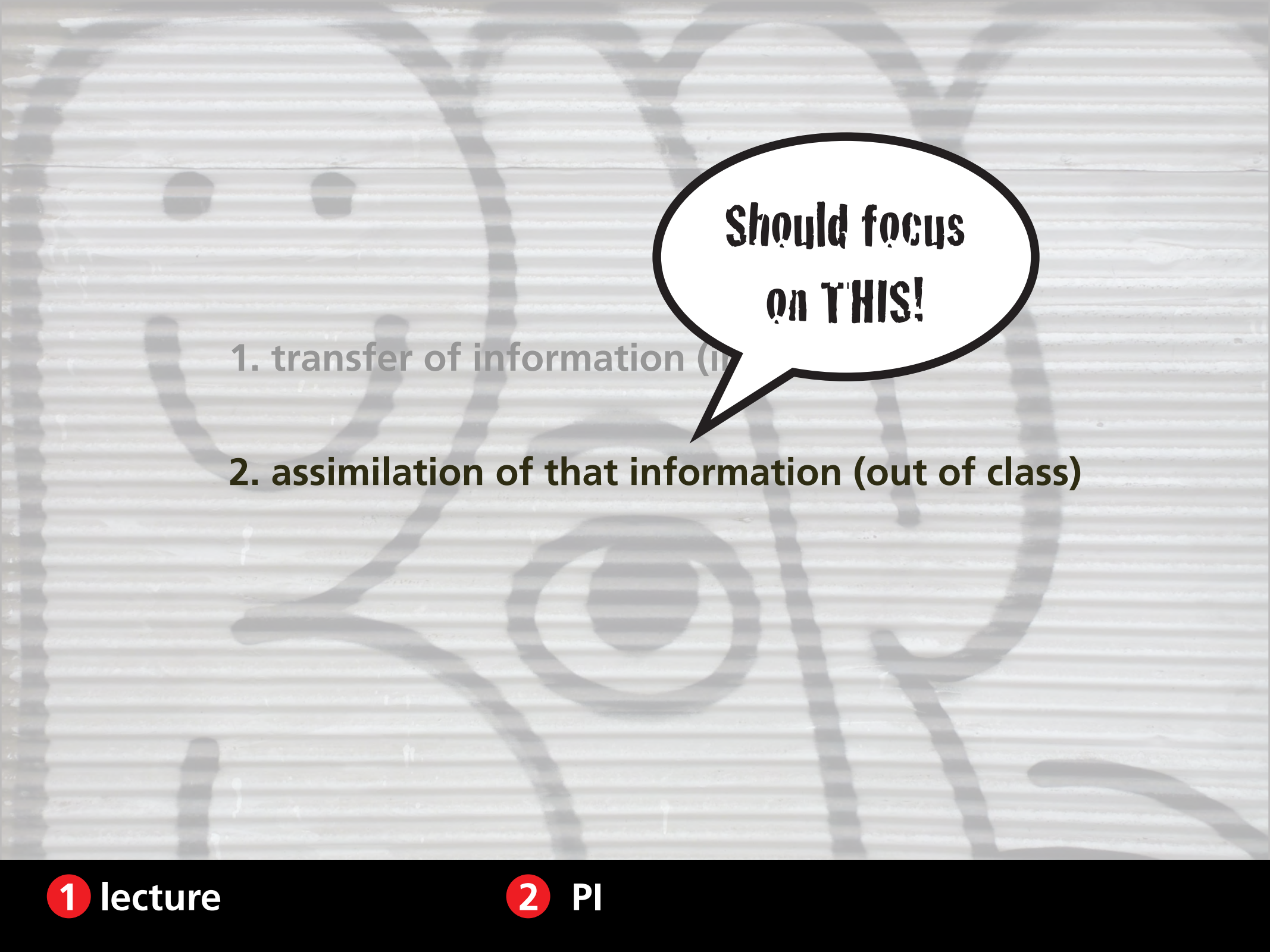
2. assimilation of that information



1. transfer of information (in class)

2. assimilation of that information

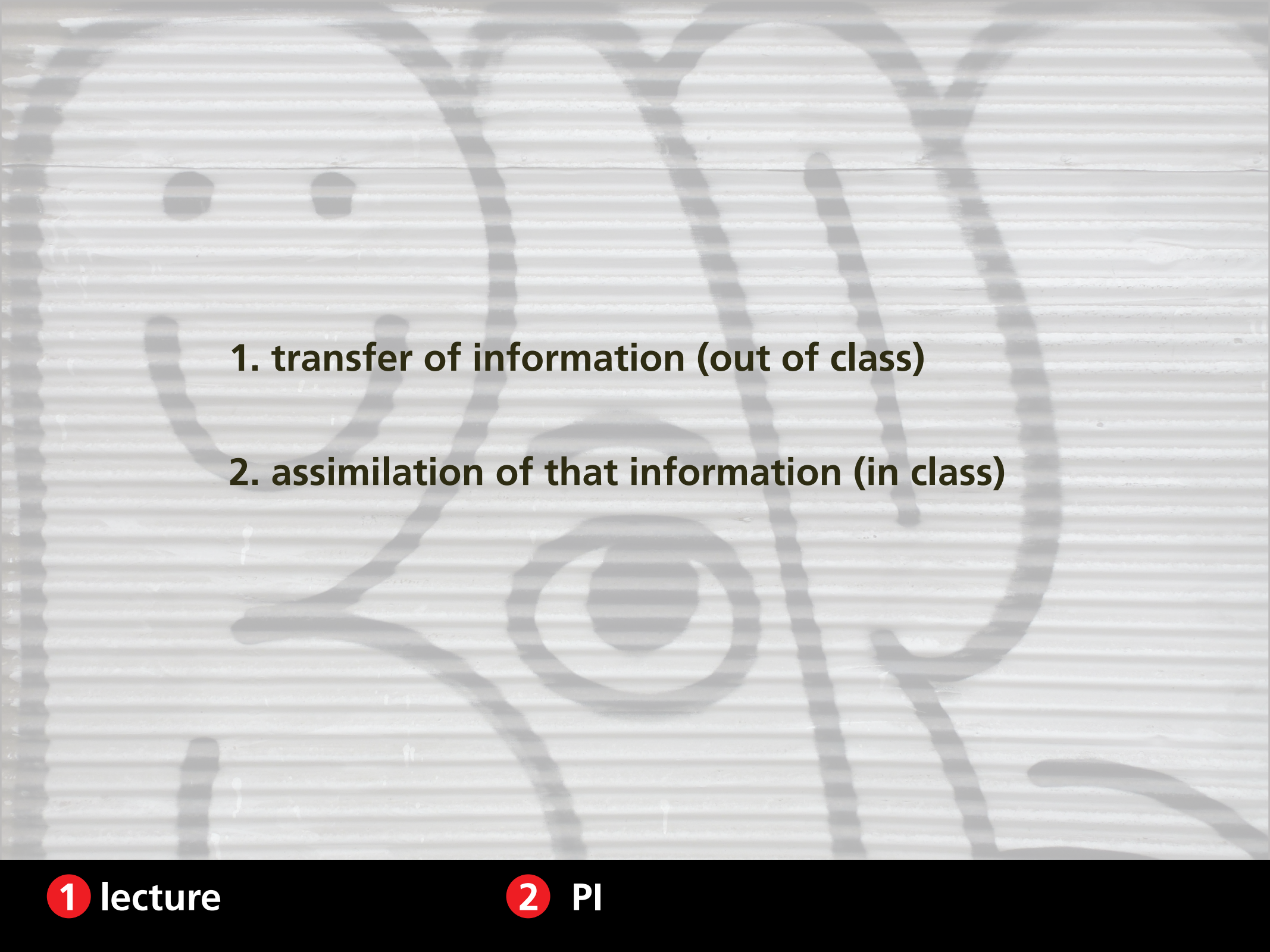
- 
1. transfer of information (in class)
 - 2. assimilation of that information (out of class)**



**Should focus
on THIS!**

1. transfer of information (in class)
- 2. assimilation of that information (out of class)**

- 
1. transfer of information (in class)
 2. assimilation of that information (out of class)

- 
1. transfer of information (out of class)
 2. assimilation of that information (in class)

A photograph of a lecture hall with green tiered seating. A man in a grey checkered suit and red tie is leaning over a group of students, interacting with them. The students are seated and looking towards him. The background shows other students and the curved wooden walls of the lecture hall.

1. transfer of information (out of class)

2. assimilation of that information (in class)

A photograph of a man in a plaid suit and red tie leaning over to assist a woman in a black jacket in a lecture hall. The man is looking down at something in his hands, and the woman is looking up at him. They are surrounded by other people seated in green chairs. A white box with the word "question" is overlaid on the right side of the image.

question



question



think



question



think



poll



question



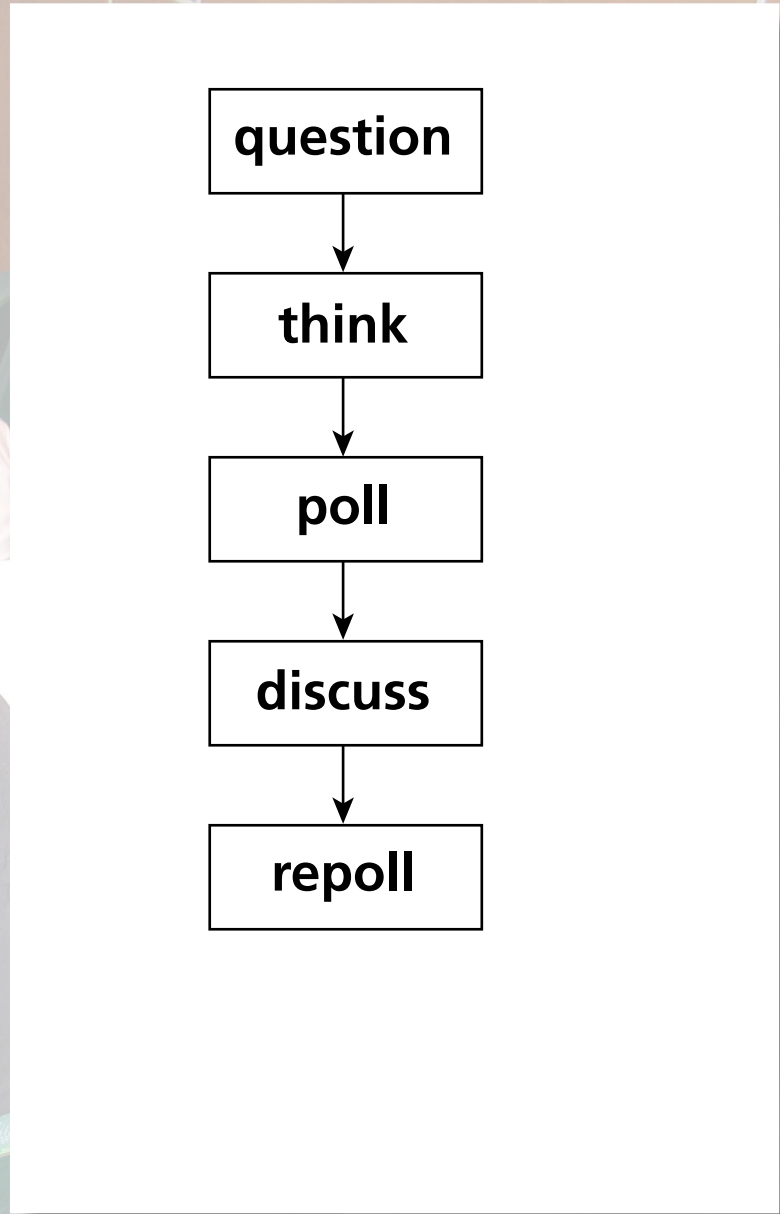
think

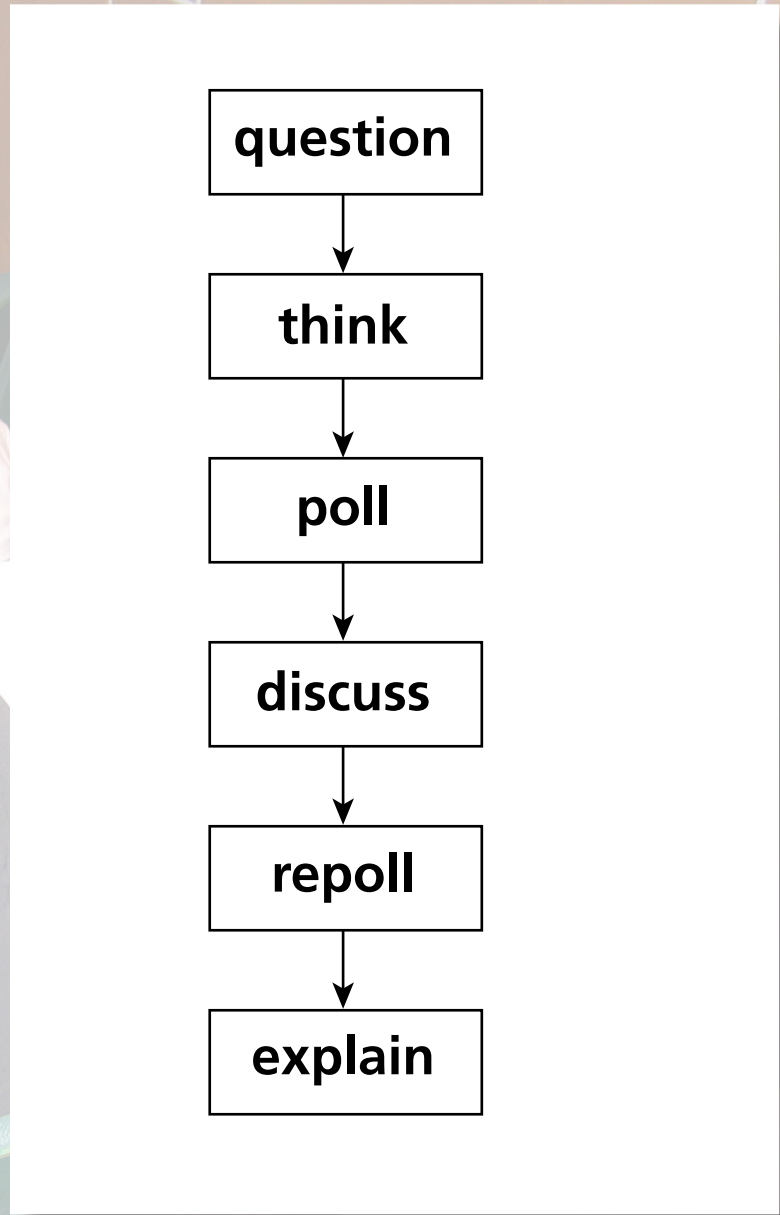


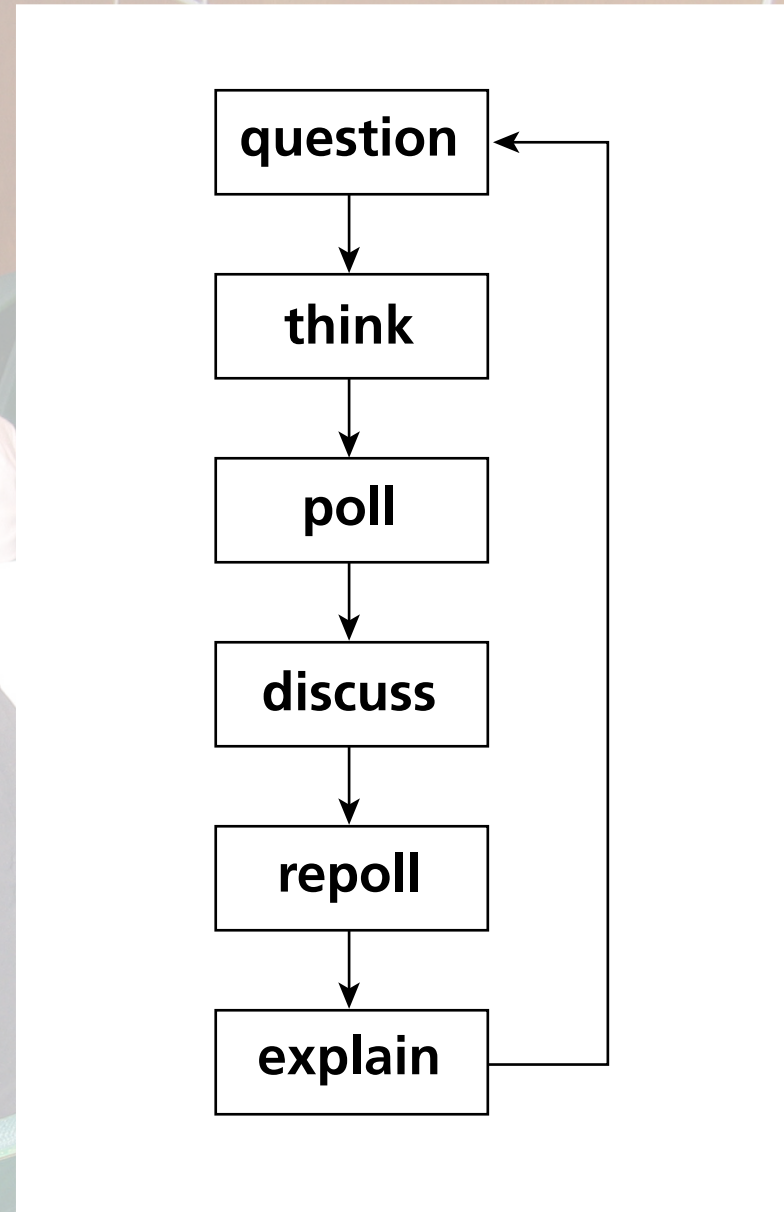
poll

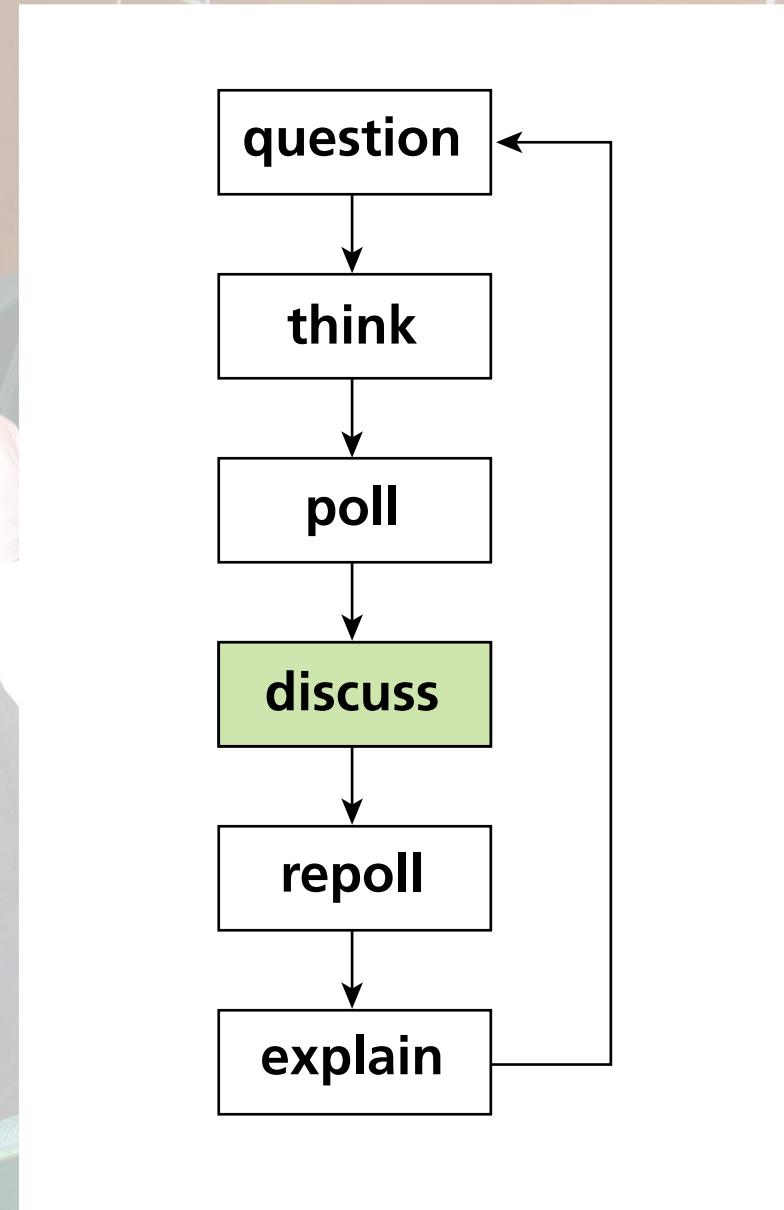


discuss









1 education

2 PI



Peer

INSTRUCTION

1 lecture

2 PI

Speak

speak



question

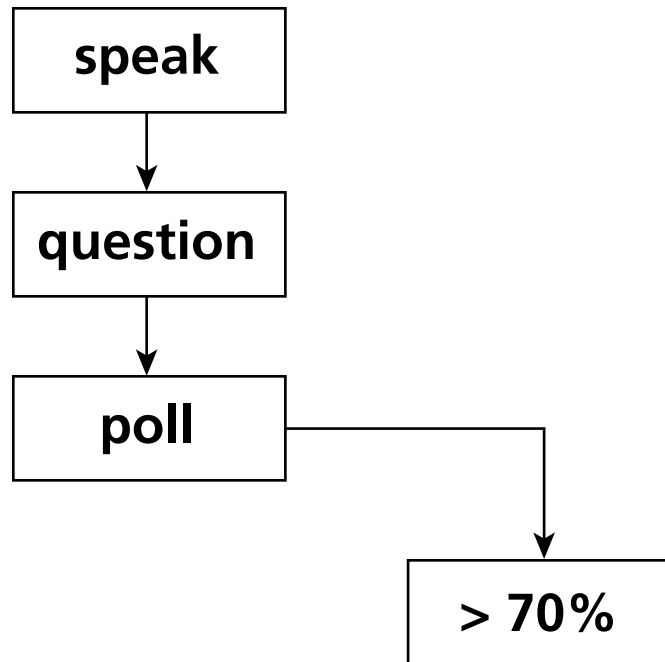
speak

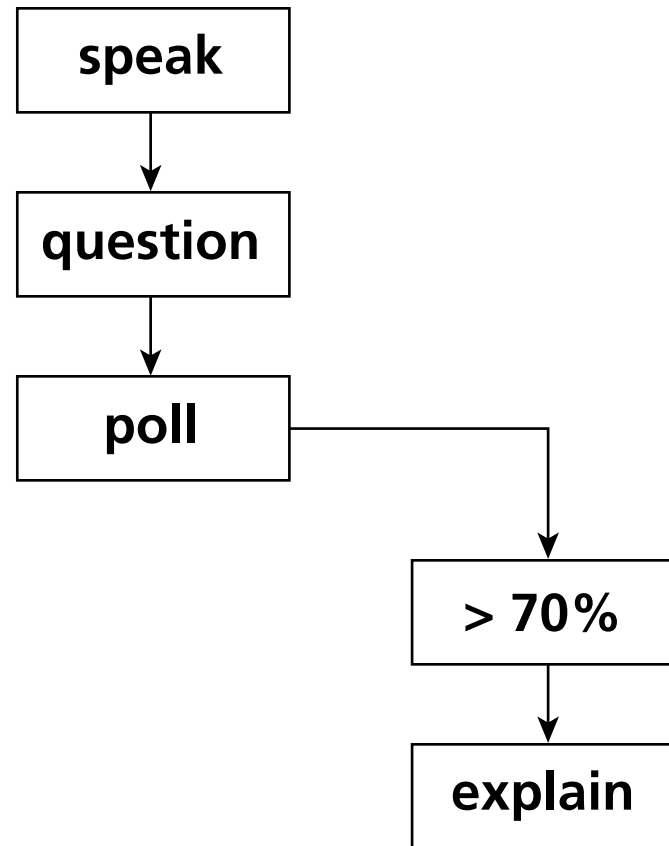


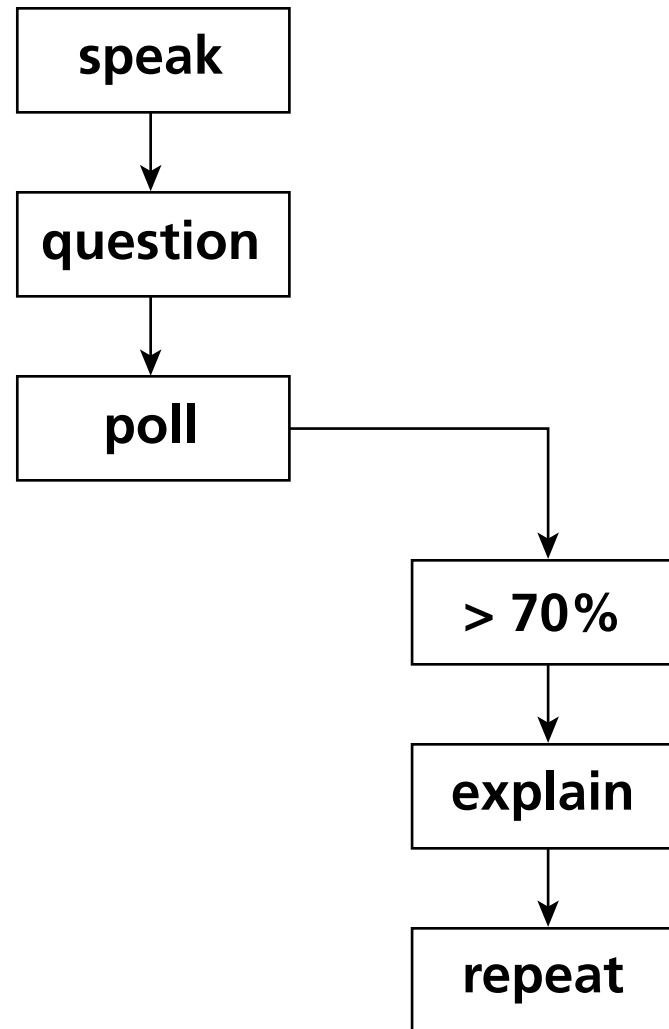
question

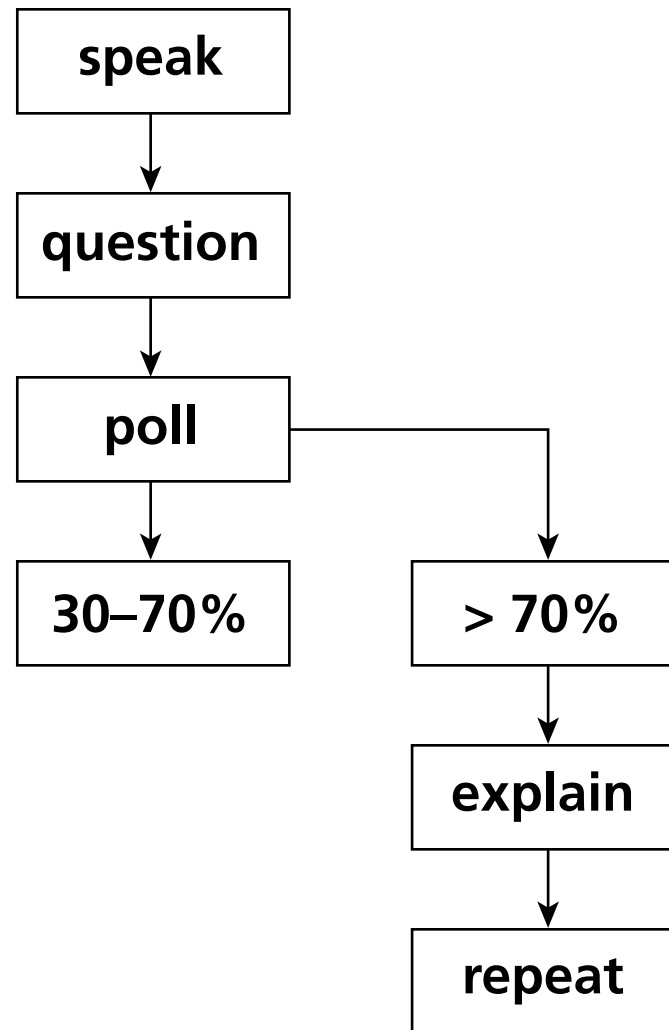


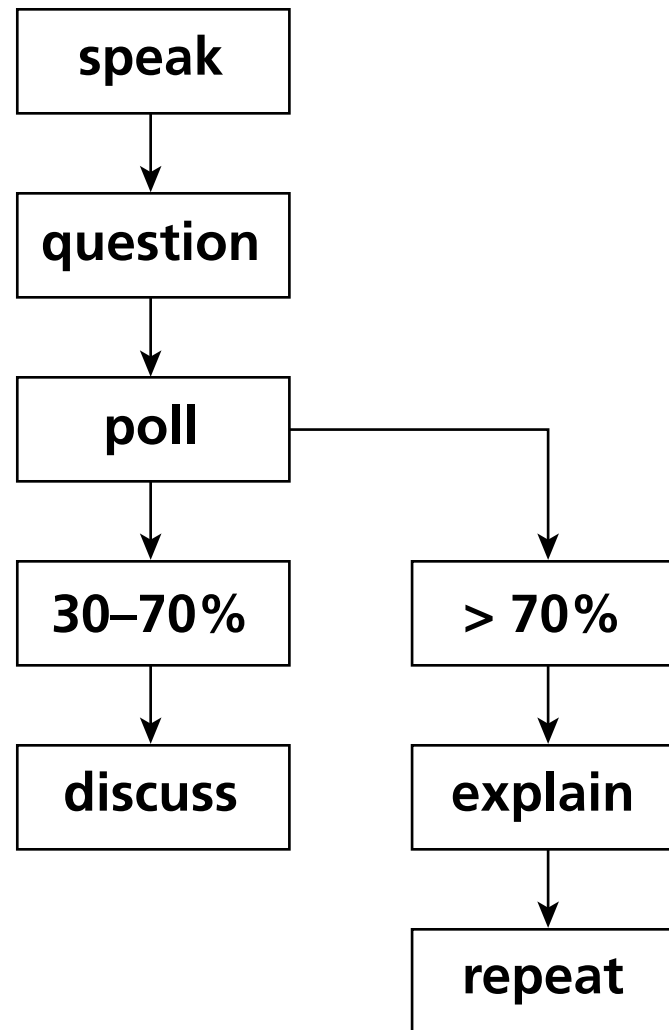
poll

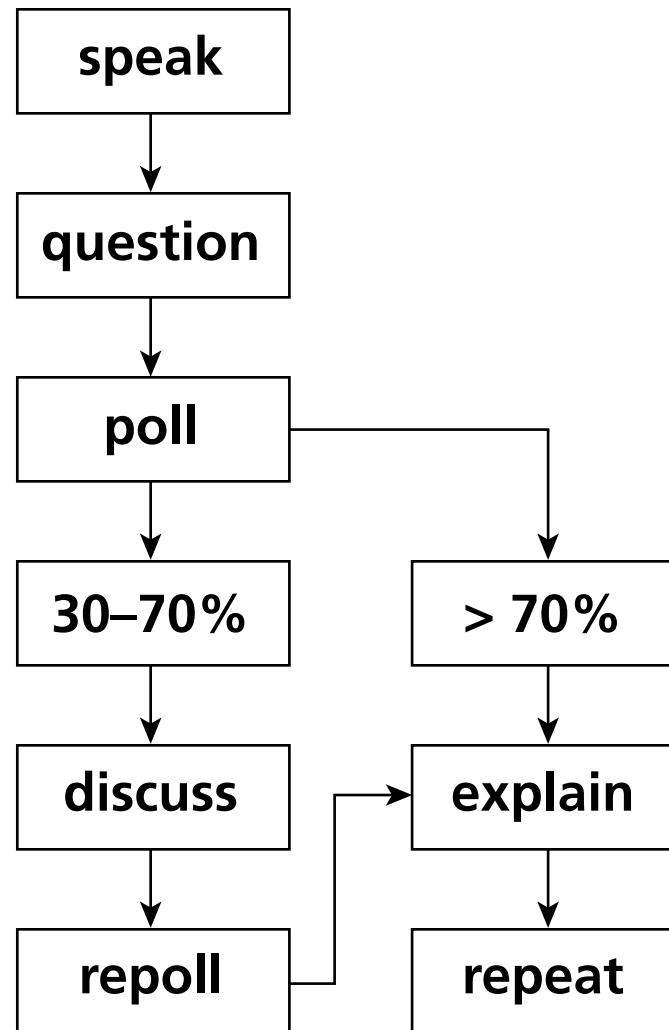


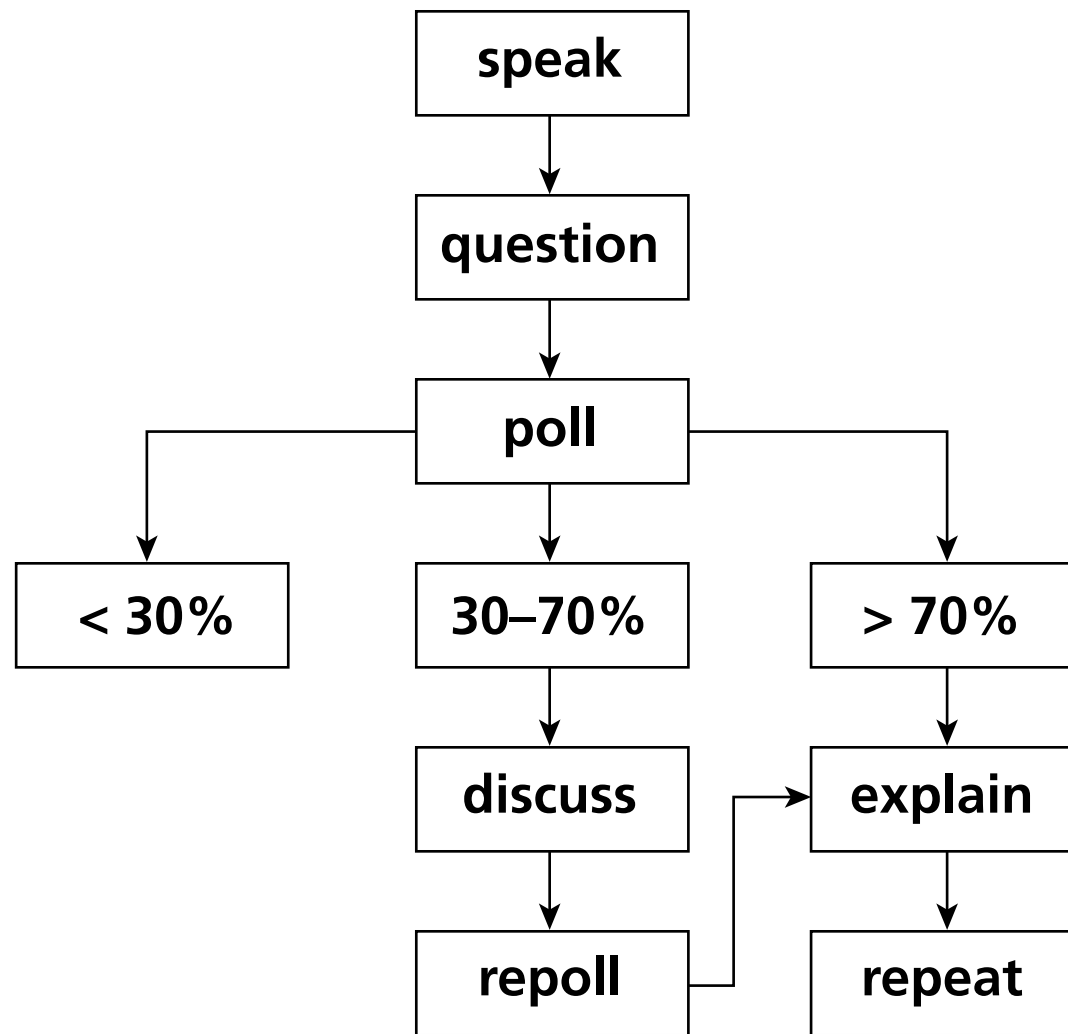


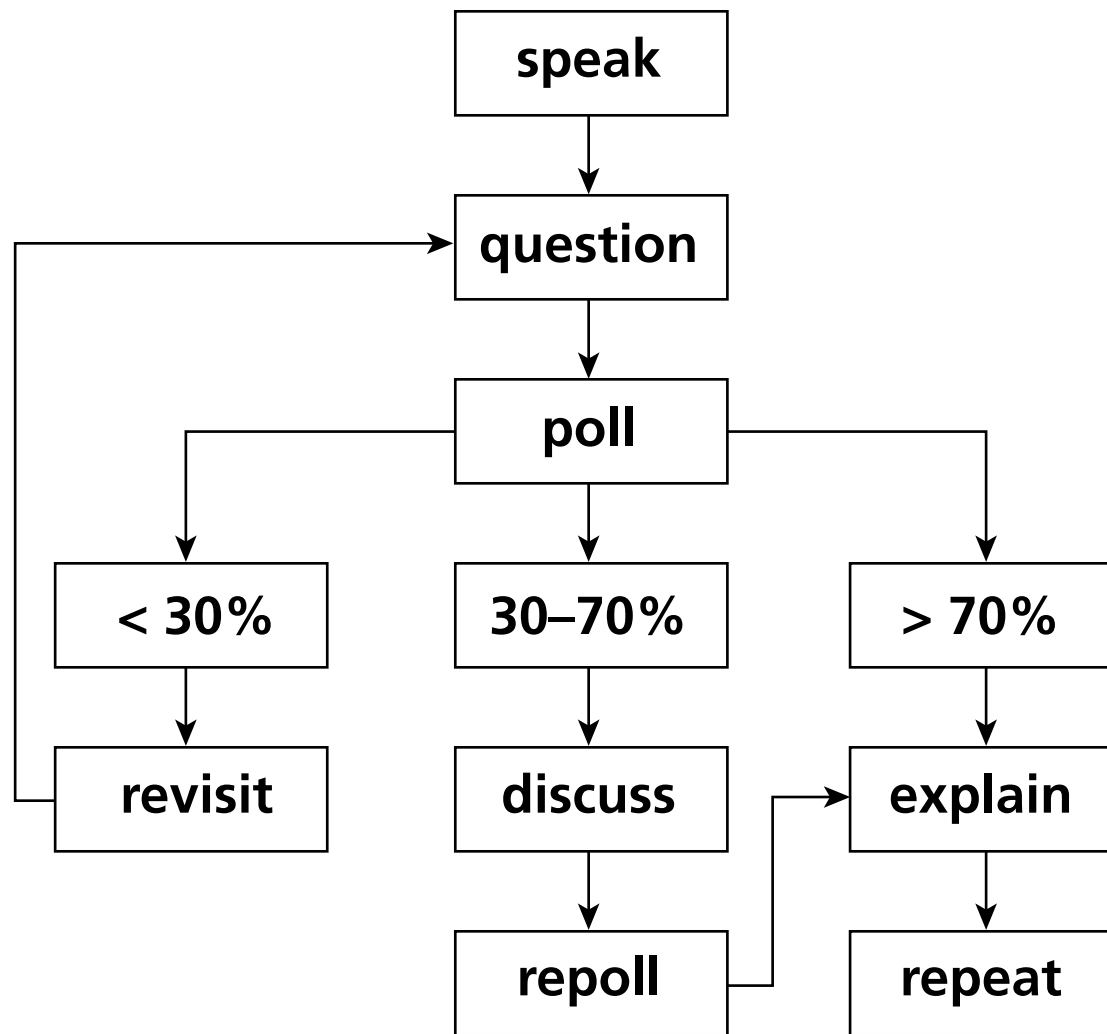


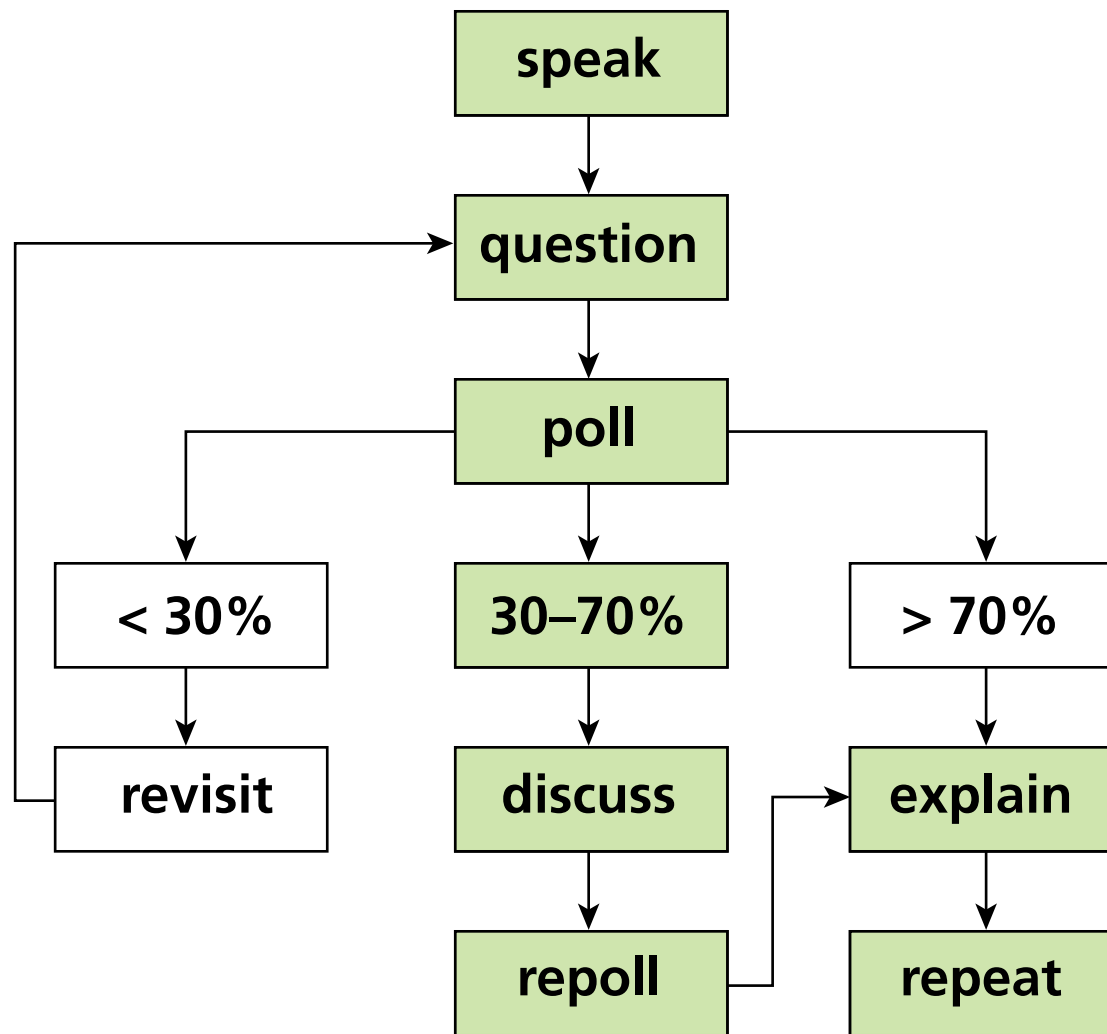










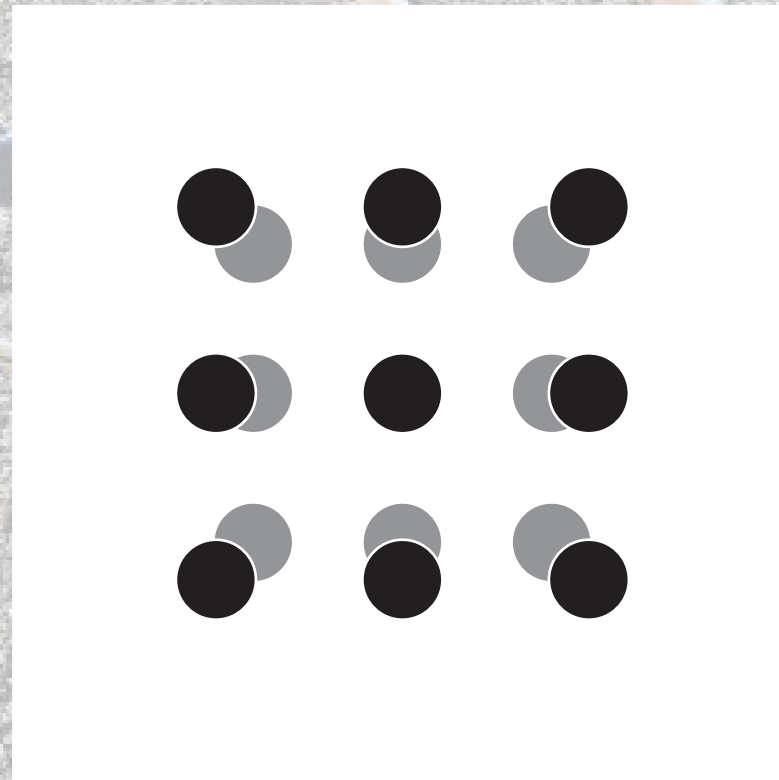




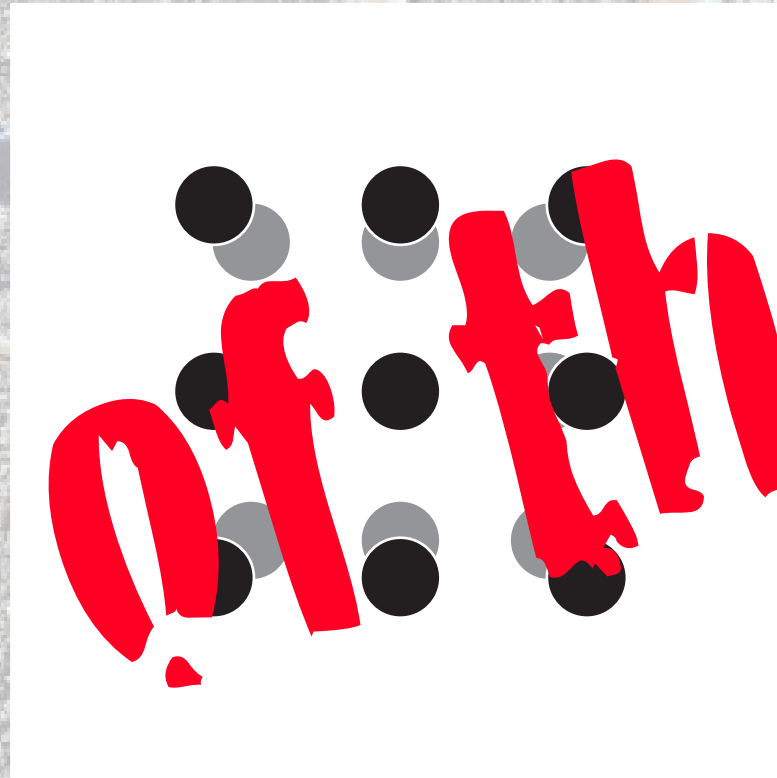
An aerial photograph of a railway track. The track is composed of two parallel steel rails on a bed of dark gravel. The track is not straight but follows a wavy, S-shaped path across the landscape. The surrounding area is covered in green grass. The text "thermal expansion" is written in a bold, black, sans-serif font, centered over the middle of the track.

thermal expansion

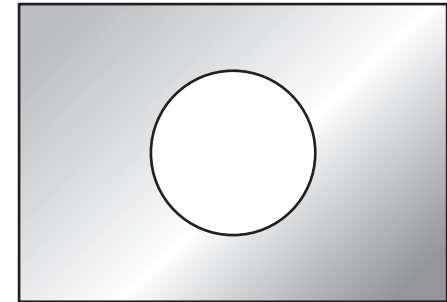




all of them



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



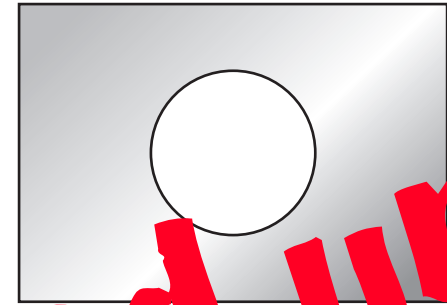
Consider a rectangular metal plate with a circular hole in it.



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

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

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.

you got all fired up!

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.**

Before I tell you the answer, let's analyze what happened.

Before I tell you the answer, let's analyze what happened.

You...

Before I tell you the answer, let's analyze what happened.

You...

1. made a commitment

Before I tell you the answer, let's analyze what happened.

You...

- 1. made a commitment**
- 2. externalized your answer**

Before I tell you the answer, let's analyze what happened.

You...

- 1. made a commitment**
- 2. externalized your answer**
- 3. moved from the answer/fact to reasoning**

Before I tell you the answer, let's analyze what happened.

You...

- 1. made a commitment**
- 2. externalized your answer**
- 3. moved from the answer/fact to reasoning**
- 4. became emotionally invested in the learning process**

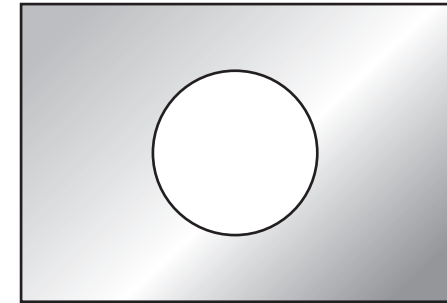
Consider a rectangular metal plate with a circular hole in it.



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

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

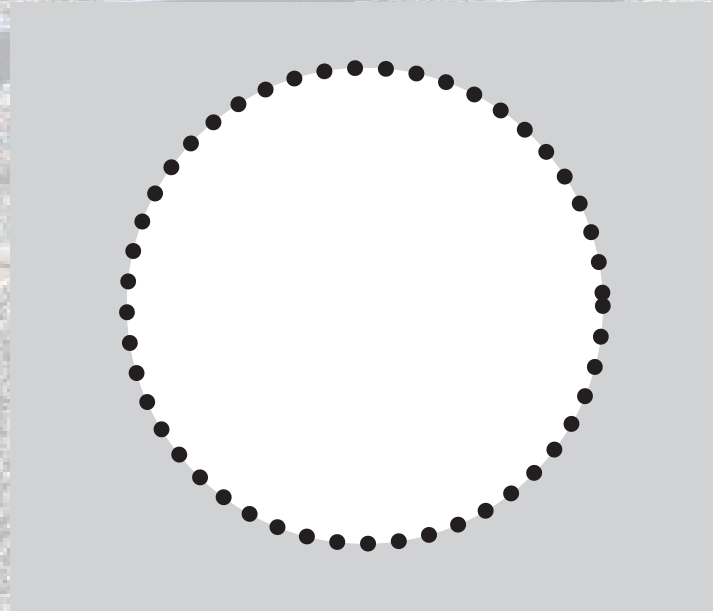
Consider a rectangular metal plate with a circular hole in it.



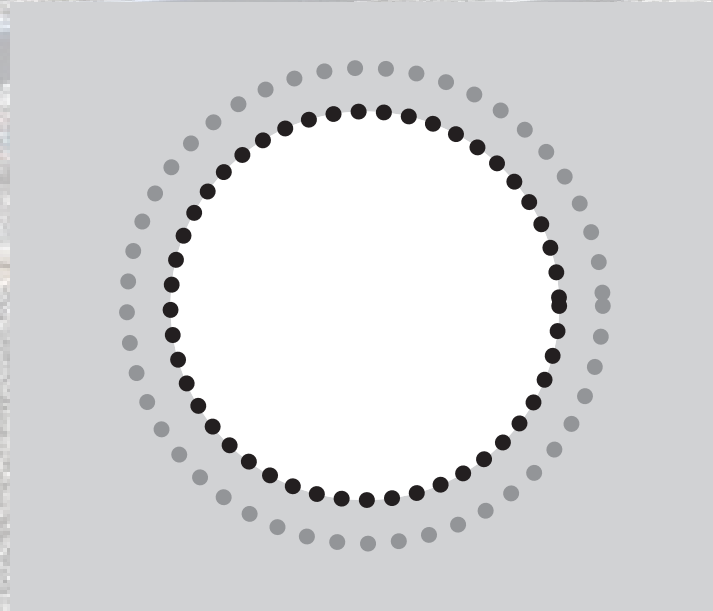
When the plate is uniformly heated, the diameter of the hole

- 1. increases. ✓**
- 2. stays the same.
- 3. decreases.

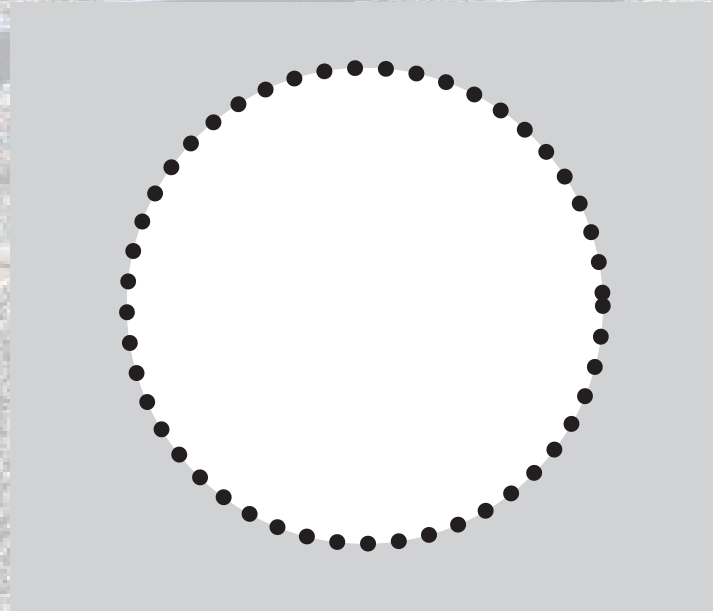
consider atoms at rim of hole



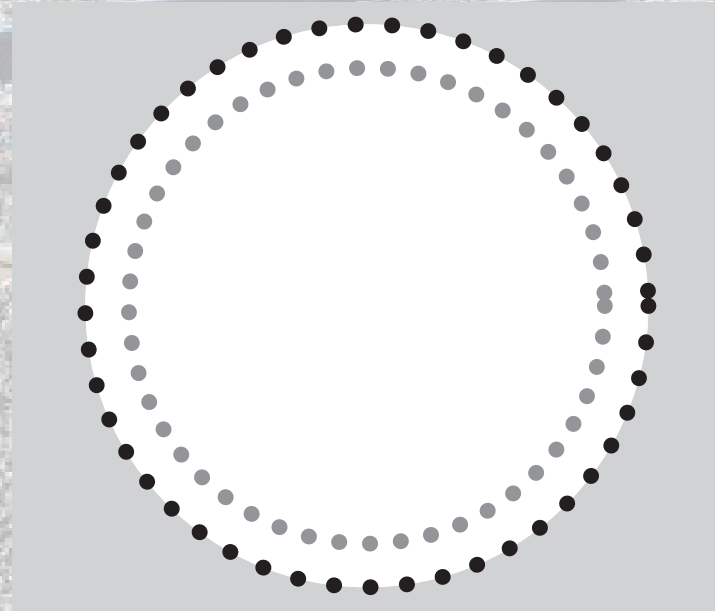
consider atoms at rim of hole



consider atoms at rim of hole



consider atoms at rim of hole



consider atoms at rim of hole

you won't forget this




Peer



back to PI

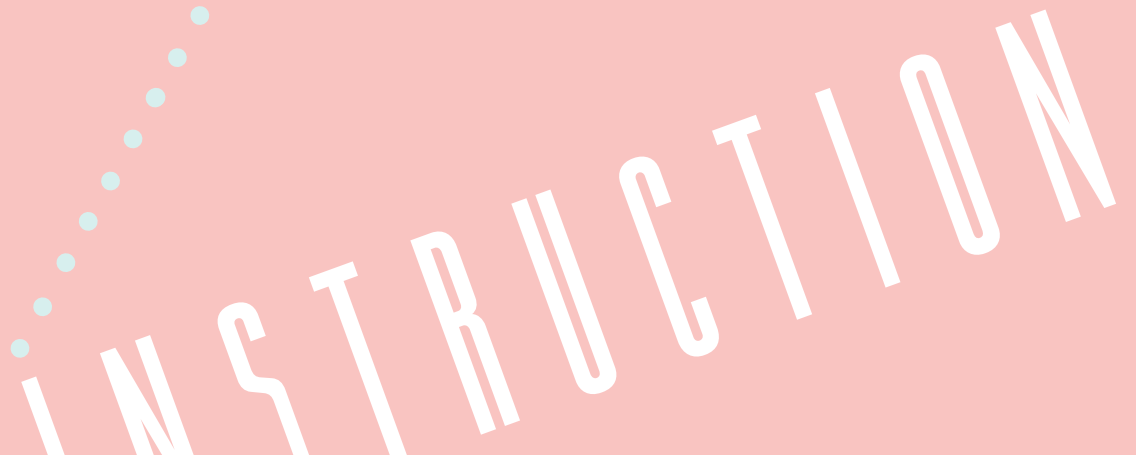


INSTRUCTION





Peer



INSTRUCTION

1 lecture

2 PI



Peer

Higher learning gains

INSTRUCTION

1 lecture

2 PI

The background features a large, light blue 'P' and 'I' on the left. The word 'Peer' is written in large, white, outlined letters across the top. The word 'INSTRUCTION' is written in white, outlined letters across the bottom. Two red, bold, italicized phrases, 'Higher learning gains' and 'Better retention', are positioned diagonally across the center. A dashed yellow line with arrows connects the 'P' to the 'I', passing through the red text. A dotted blue line with arrows also connects the 'P' to the 'I', passing through the red text.

Higher learning gains

Better retention

INSTRUCTION



Join now!

PeerInstruction.net



1 lecture

2 PI

3 PI 2.0

feedback

1 lecture

2 PI

3 PI 2.0



1991

① lecture

② PI

③ PI 2.0



1993



1998





1 lecture

2 PI

3 PI 2.0



How do I...

- design good questions?
- optimize the discussions?
- manage time?

learning | catalytics

1 lecture

2 PI

3 PI 2.0

learning | catalytics



Gary King



Brian Lukoff



Eric Mazur

1 lecture

2 PI

3 PI 2.0

Use intelligent algorithms and data analytics to...

- **improve questioning**
 - **manage discussions**
 - **facilitate time management/flow**
- learning | catalytics

- lowest
- a. A 30-year fixed rate mortgage at 12%
 - b. A 15-year fixed rate mortgage at 12%
 - c. A 30-year fixed rate mortgage at 12%
 - d. A 15-year fixed rate mortgage at 12%
2. The biggest factor that leads American companies to manufacture their products overseas in India is:
- a. Higher quality of craftsmanship
 - b. Lower labor costs
 - c. Decreased transportation costs
 - d. Effective legal systems
3. Which of the following correctly summarizes the accounting equation for a sole proprietorship?
- a. $\text{Assets} = \text{Liabilities} + \text{Owners' equity}$
 - b. $\text{Liabilities} = \text{Assets} + \text{Owners' equity}$
 - c. $\text{Owner's equity} = \text{Assets} + \text{Liabilities}$
 - d. $\text{Revenue} = \text{Assets} - \text{Liabilities}$
4. In order to present a business plan to a group of potential investors, a businessperson would most likely use which of the following?
- a. Powerpoint
 - b. Quickbooks
 - c. Peoplesoft
 - d. Excel
5. In order to start an online business, and individual would need all but which of the following:
- a. business model
 - b. depreciation?

extensible plug-in architecture for question types

Sample question types:

- direction
- mathematical expression
- long answer, short answer, word cloud
- numerical, data collection
- ranking, priority
- region (select point on image)
- sketch, composite sketch
- highlight passage



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optics i

current session: **766079** | 69 students[Back to all lectures](#) [Stop session](#) [Review results](#) [Seat map](#) [Show floating session ID](#) [Edit](#) [Delete](#)

Jump to ▼

1

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12

13

14

15

**4.** direction Light enters horizontally into the combination of two perpendicular mirrors as shown below.[Deliver](#) [Show all results](#)

Indicate the direction of the incident light after it reflects off of both mirrors.



feedback & support

1 lecture**2** PI**3** PI 2.0

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optics i current session: **766079** | 69 students

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6 7 8 9 10 11 12 13 14 15

perpendicular mirrors as shown below.

[Deliver](#) [Show all results](#)

Light enters horizontally into the combination of two perpendicular mirrors as shown below. Indicate the direction of the incident light after it reflects off of both mirrors.



Submit response

[Switch to text response](#)

[feedback & support](#)

1 lecture

3 PI 2.0

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perpendicular mirrors as shown below.

[Deliver](#) [Show all results](#)[feedback & support](#)

Indicate the d

1 lecture**3** PI 2.0

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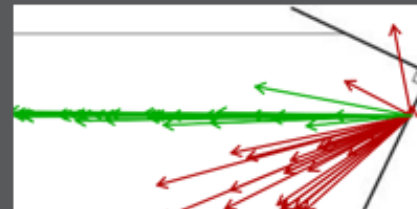
6 7 8 9 10 11 12 13 14 15

pendicular mirrors as shown below.

[Deliver](#) [Show all results](#)

Round 1

57 responses, 58% correct

[feedback & support](#)

1 lecture

3 PI 2.0

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6 7 8 9 10 11 12 13 14 15



perpendicular mirrors as shown below.

[Deliver](#) [Show all results](#)

Round 1

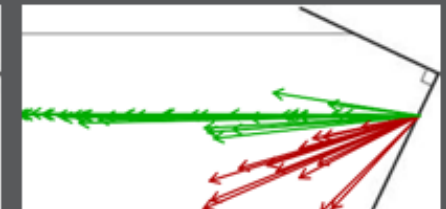
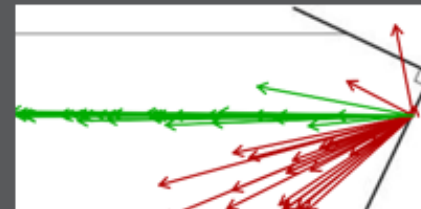


57 responses, 58% correct

Round 2



51 responses, 73% correct



✓ 8 get it now

✗ 0 still don't get it



feedback & support

1 lecture

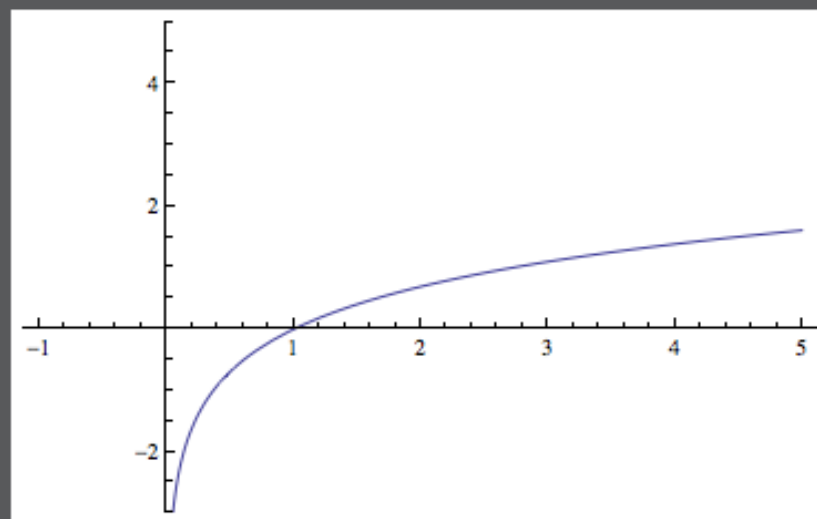
3 PI 2.0

If $2x - y = 4$, then $x =$

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This is a graph of $f(x) = \ln x$. Sketch a graph of the derivative $f'(x)$.

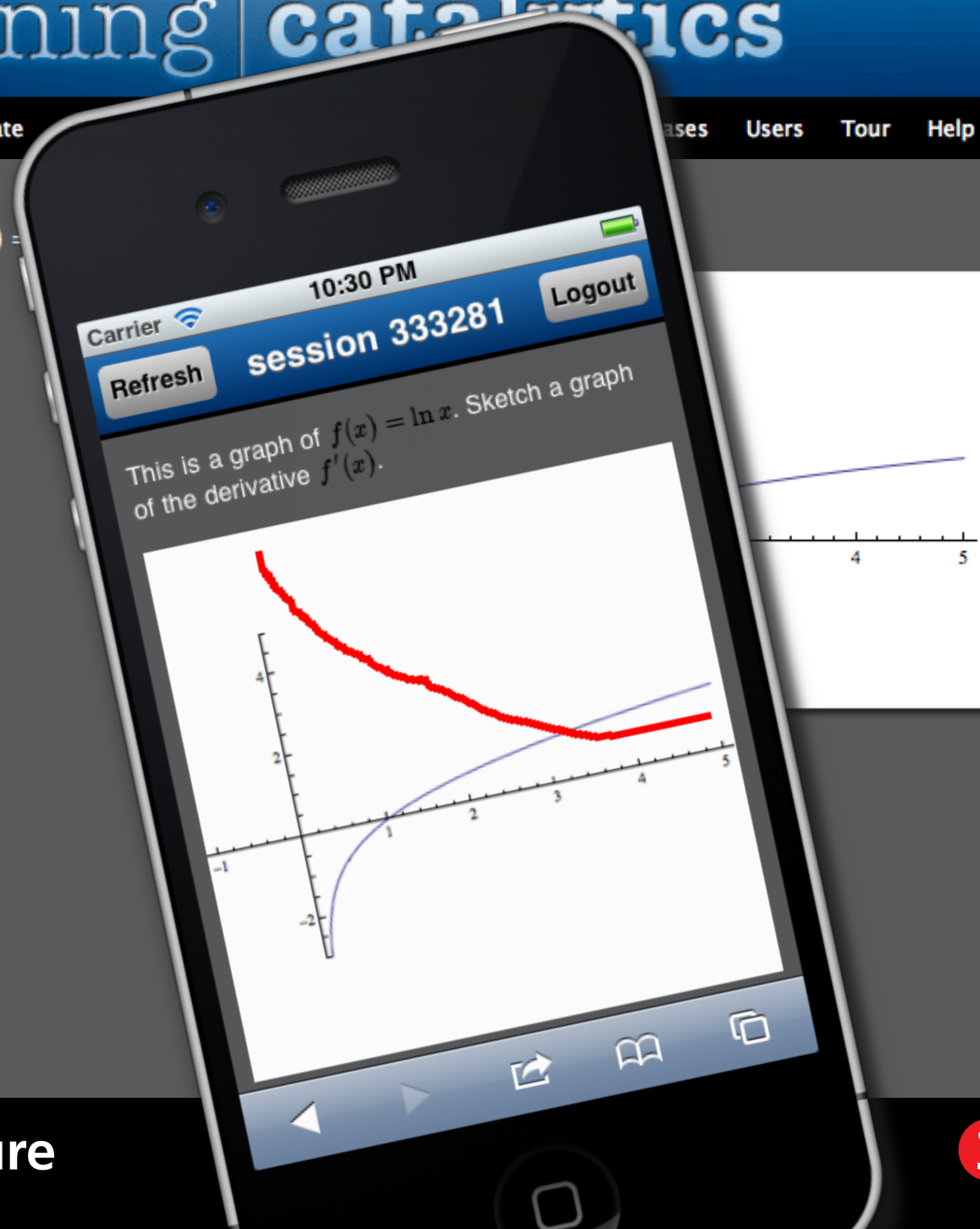


1 lecture

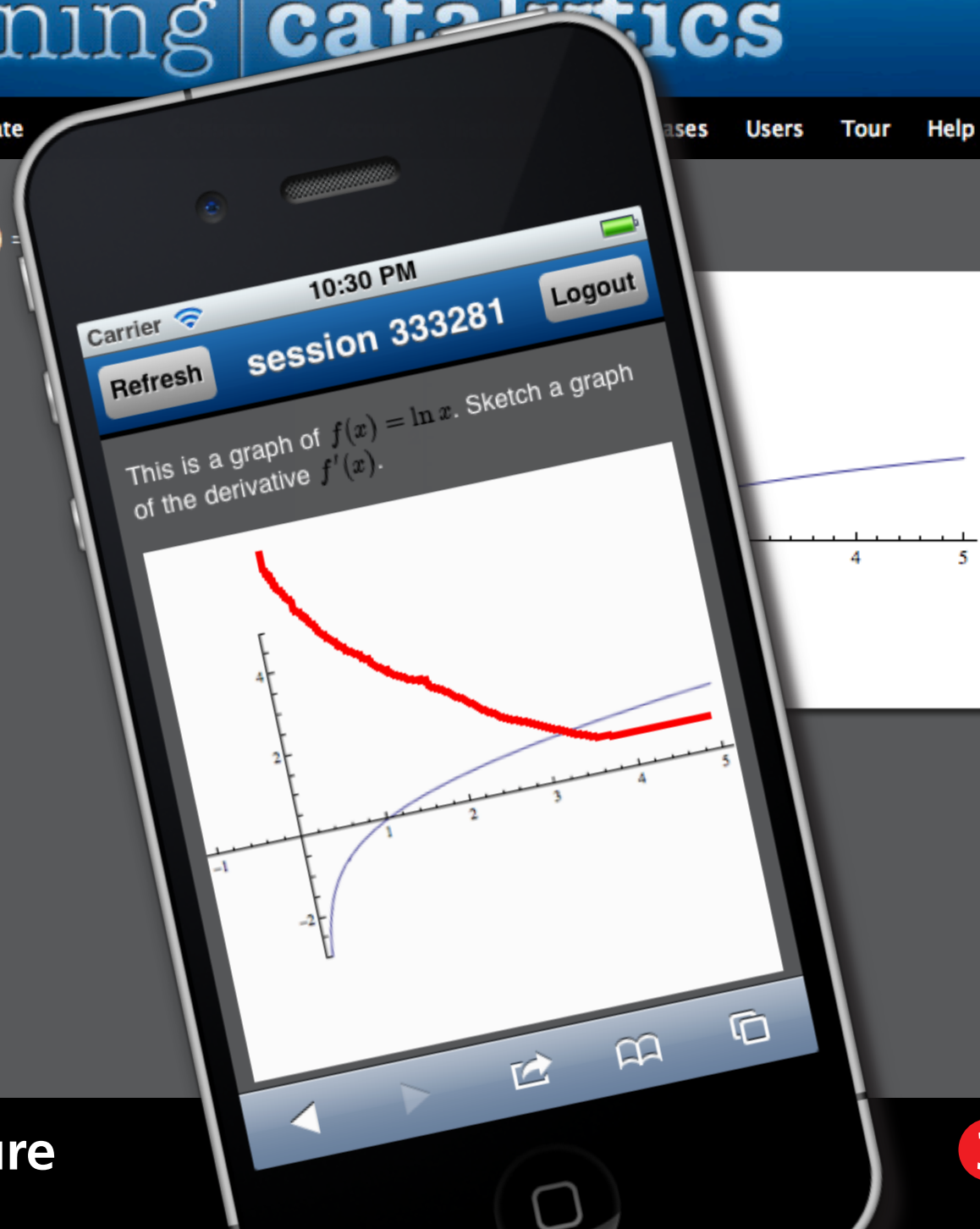
2 PI

3 PI 2.0

learning | catalytics

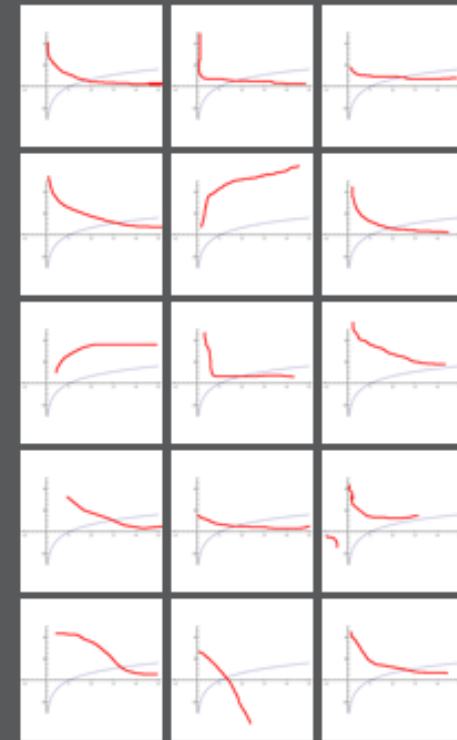
[Courses](#) [Participate](#)[ases](#) [Users](#) [Tour](#) [Help](#)This is a graph of $f(x) =$ **1** lecture**3** PI 2.0

learning | catalytics

[Courses](#) [Participate](#)[ases](#) [Users](#) [Tour](#) [Help](#)This is a graph of $f(x) =$ 

Round 1

15 responses



✓ 6 get it now
✗ 0 still don't get it

1 lecture

3 PI 2.0

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transformations of parabolas

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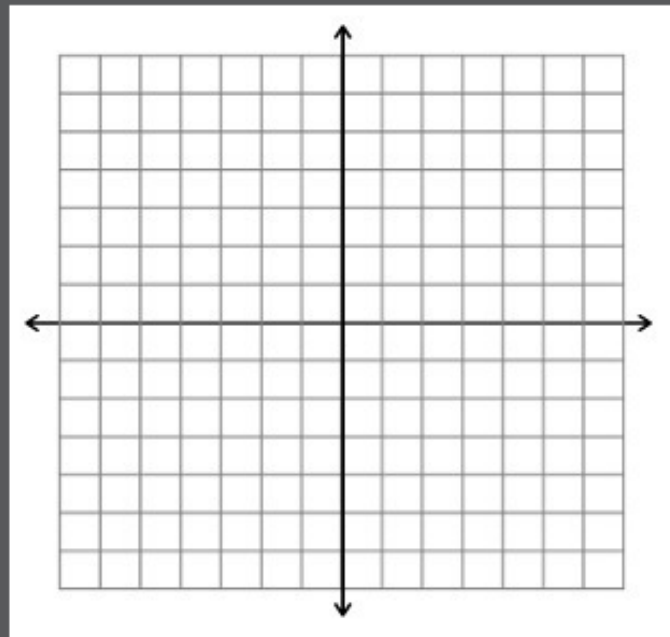
Jump to ▼

1

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3

4

**4.** sketch Sketch a graph of the function $f(x) = (x - 3)^2 + 2$.[✖ Stop delivery](#) [🔄 Deliver again](#) [👥 Assign groups](#) [📊 Show all results](#)**1** lecture**2** PI**3** PI 2.0

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transformations of parabolas

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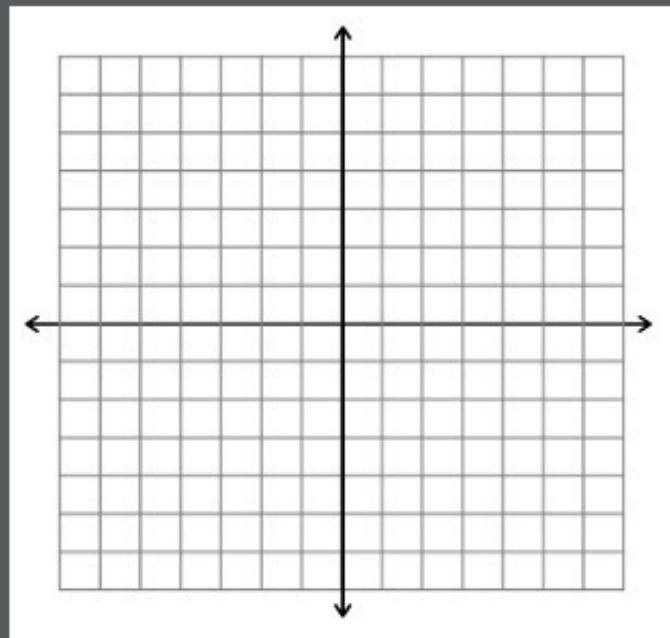
Jump to ▼

1

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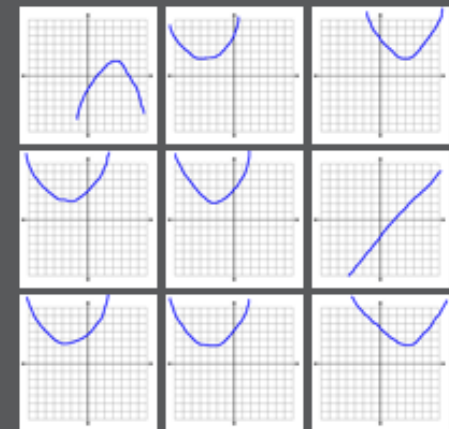
3

4

**4. sketch** Sketch a graph of the function $f(x) = (x - 3)^2 + 2$.[Stop delivery](#) [Deliver again](#) [Assign groups](#) [Show all results](#)

Round 1

9 responses

**1** lecture**2** PI**3** PI 2.0



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1. highlighting What do you see as the most important part of this Shakespeare sonnet? [Stop delivery](#) [Deliver again](#) [Assign groups](#) [Show all results](#)

For shame! deny that thou bear'st love to any,
Who for thyself art so unprovident.
Grant, if thou wilt, thou art beloved of many,
But that thou none lovest is most evident;
For thou art so possess'd with murderous hate
That 'gainst thyself thou stick'st not to conspire.
Seeking that beauteous roof to ruinate
Which to repair should be thy chief desire.
O, change thy thought, that I may change my mind!
Shall hate be fairer lodged than gentle love?
Be, as thy presence is, gracious and kind,
Or to thyself at least kind-hearted prove:
Make thee another self, for love of me,
That beauty still may live in thine or thee.

1 lecture

2 PI

3 PI 2.0

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1. highlighting
sonnet?

this Shakespeare

[Stop delivery](#)

[Deliver again](#)

[Assign groups](#)

[Show all results](#)

For shame
Who for t
Grant, if t
But that th
For thou a
That 'gainst
Seeking tha
Which to rep
O, change th
Shall hate be
Be, as thy pres
Or to thyself a
Make thee ano
That beauty stil

Carrier 10:32 PM session 333281 Logout
Refresh

What do you see as the most important part of this Shakespeare sonnet?

Highlight the passage below by clicking or tapping once to set the beginning of your highlight, and then clicking or tapping again to set the end.

For shame! deny that thou bear'st love to any,
Who for thyself art so unprovident.
Grant, if thou wilt, thou art beloved of many,
But that thou none lovest is most evident;
For thou art so possess'd with murderous hate
That 'gainst thyself thou stick'st not to
conspire.

Seeking that beauteous roof to ruinate
Which to repair should be thy chief desire.
O, change thy thought, that I may change my

1 lecture

3 PI 2.0

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1. highlighting
sonnet?

this Shakespeare

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Round 1

● 3 responses

For shame! deny that thou bear'st
love to any,
Who for thyself art so
unprovident.
Grant, if thou wilt, thou art
beloved of many,
But that thou none lovest is most
evident;
For thou art so possess'd with
murderous hate
That 'gainst thyself thou stick'st
not to conspire.
**Seeking that beauteous roof to
ruinate**
Which to repair should be thy
chief desire.
O, change thy thought, that I may
change my mind!
Shall hate be fairer lodged than
gentle love?
Be, as thy presence is, gracious
and kind,

What do you see as the most important part
of this Shakespeare sonnet?

**Highlight the passage below by clicking or
tapping once to set the beginning of your
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**Seeking that beauteous roof to ruinate
Which to repair should be thy chief desire.**
O, change thy thought, that I may change my
mind!

1 lecture

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Sample question types:

- direction
- mathematical expression
- long answer, short answer, word cloud
- numerical data collection
- ranking priority
- region (select point on image)
- sketch, composite sketch
- highlight passage



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human interaction

1 lecture

2 PI

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A positively charged rod is held near a neutral conducting sphere as illustrated below. A positively charged particle is moved from point A to point B



Round 1 74 responses, 61% correct

A. 61%
B. 4%
C. 35%
D. 0%
E. 0%

Round 2 75 responses, 83% correct

A. 83%
B. 0%
C. 17%
D. 0%
E. 0%

A. positive
B. zero
C. negative
D. depends on the path taken from A to B
E. cannot be determined without knowing more about the polarization induced in the sphere

Search:

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A positively charged rod is held near a neutral conducting sphere as illustrated below. A positively charged particle is moved from point A to point B at constant speed. The potential difference from A to B is

A. positive
B. zero
C. negative
D. depends on the path taken from A to B
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Round 1
74 responses, 61% correct

A. 61%
B. 4%
C. 35%
D. 0%
E. 0%

Round 2
75 responses, 83% correct

A. 83%
B. 0%
C. 17%
D. 0%
E. 0%

Search: _____

Carrier 9:31 PM 100%

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Carrier 100%

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A positively charged rod is held near a neutral conducting sphere as illustrated below. A positively charged particle is moved from point A to point B at constant speed. The potential difference from A to B is

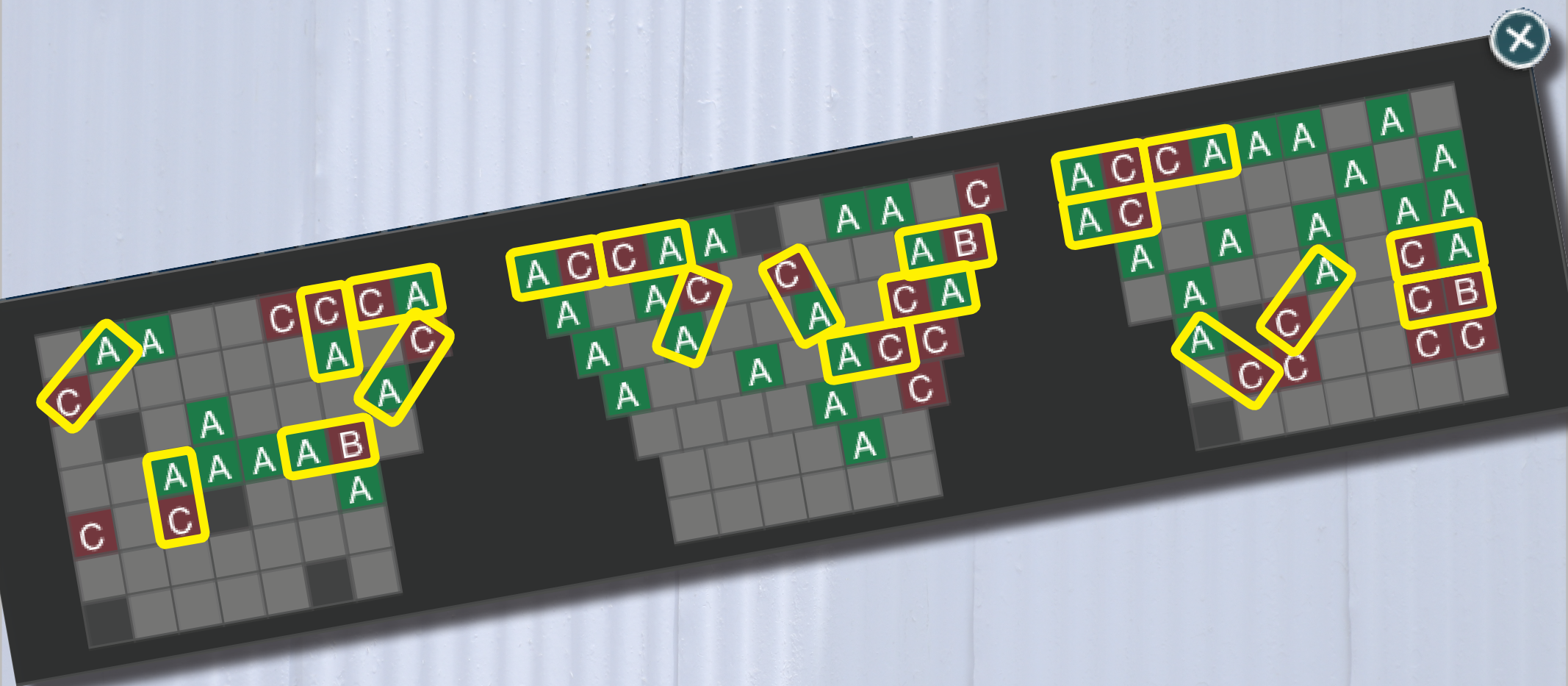
Round 1
74 responses, 61% correct

A. 61%	Round 2 75 responses, 83% correct
B. 4%	A. 83%
C. 35%	B. 0%
D. 0%	C. 17%
E. 0%	D. 0%
	E. 0%

Search:

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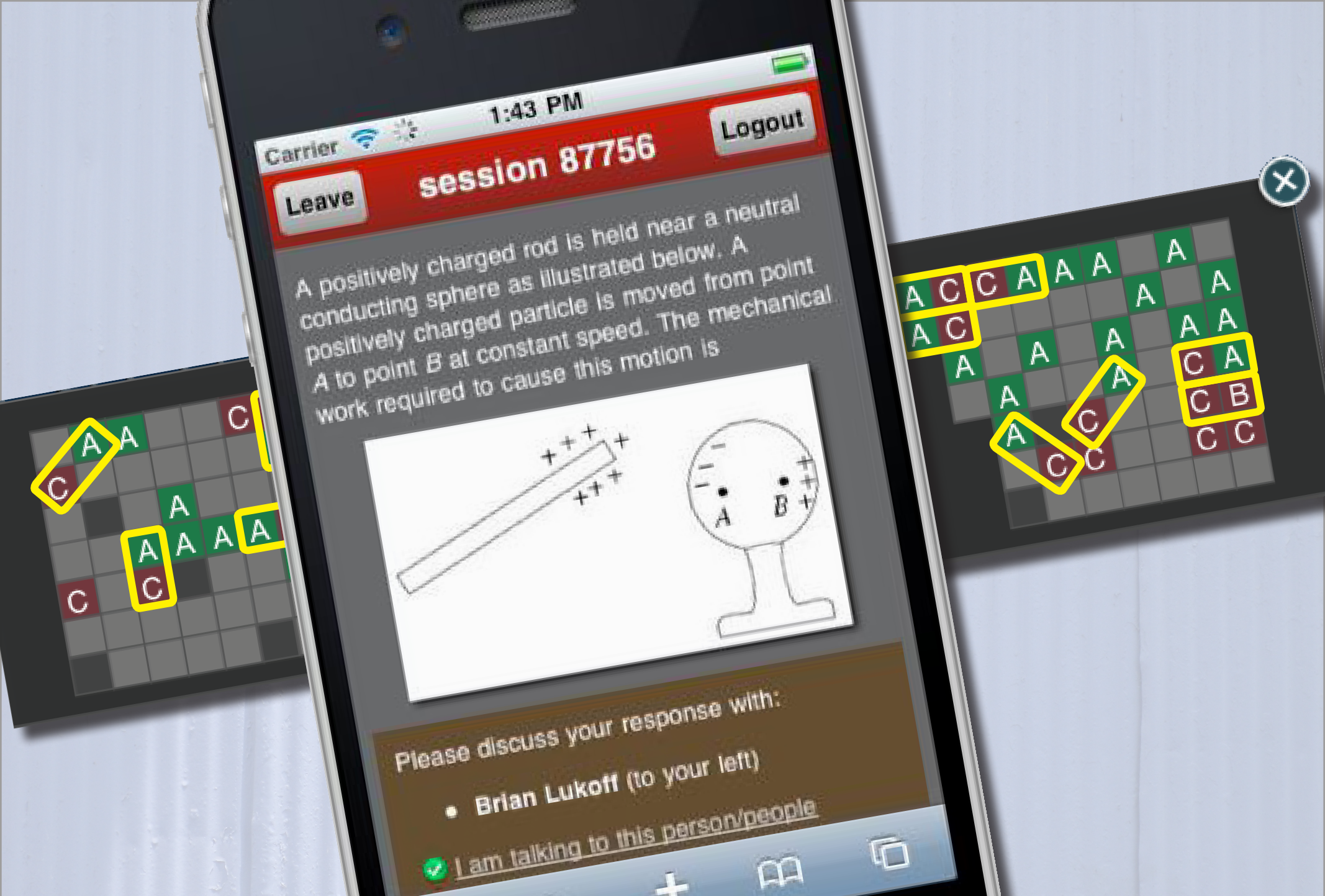
let system manage pairing



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2 PI

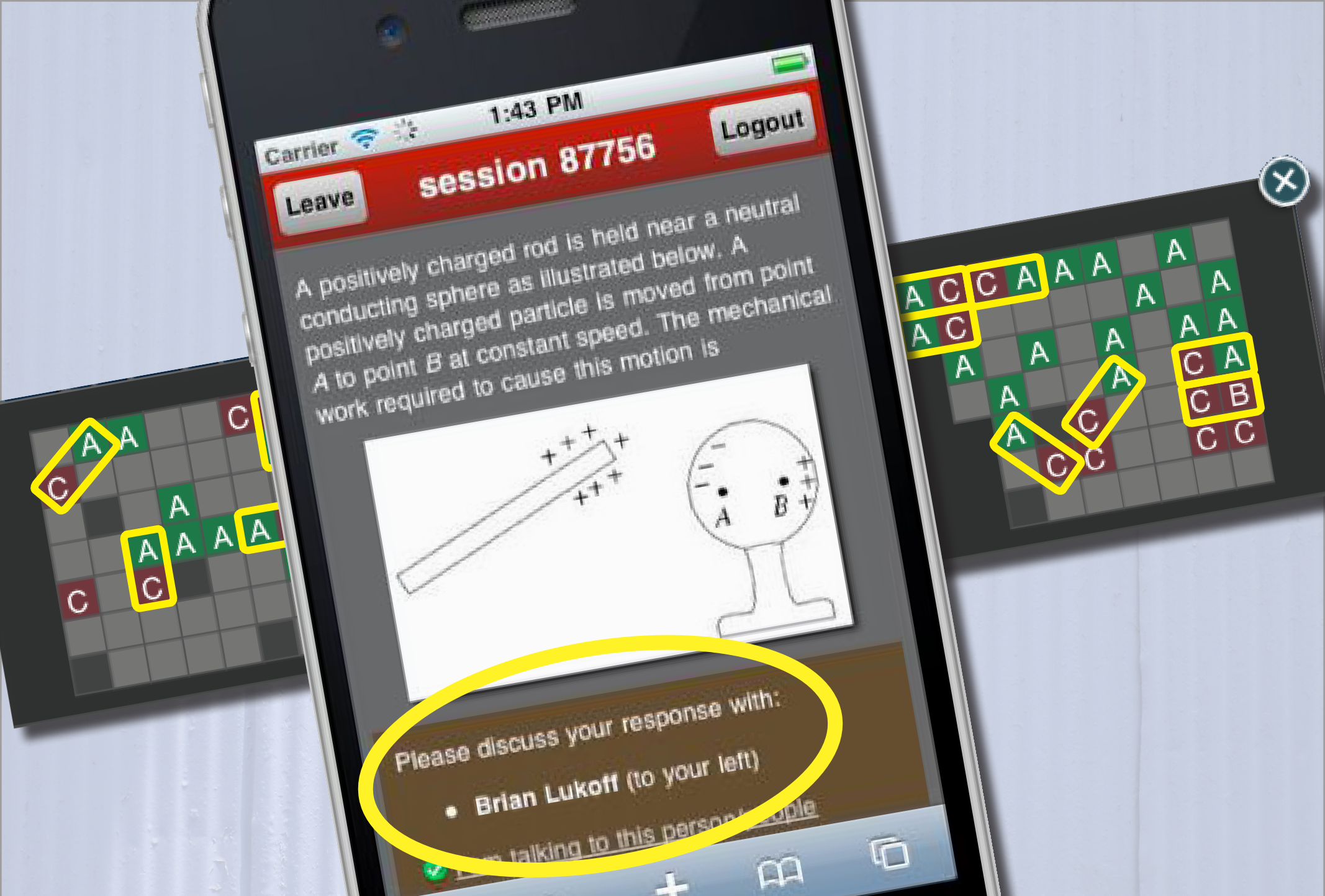
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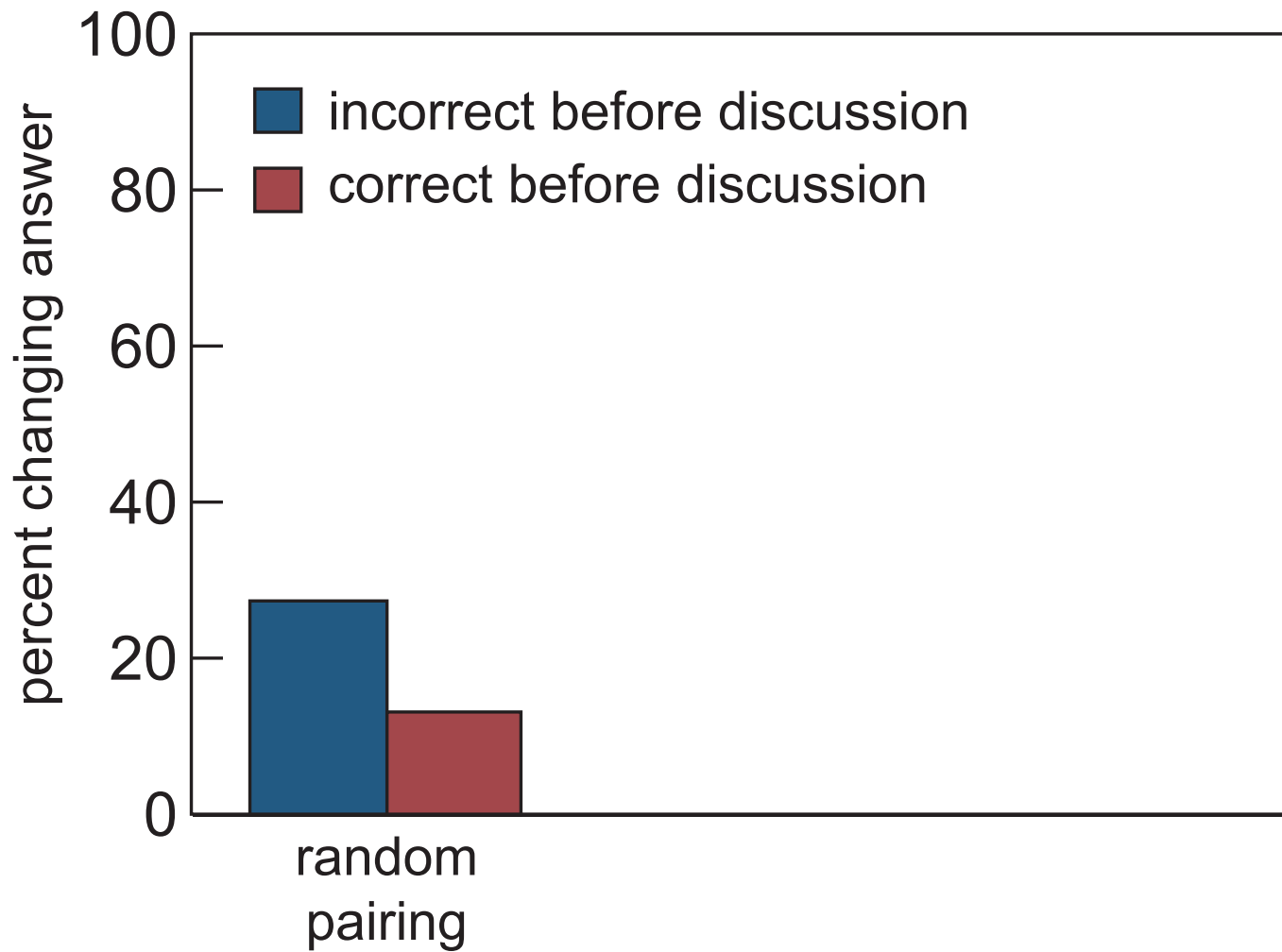
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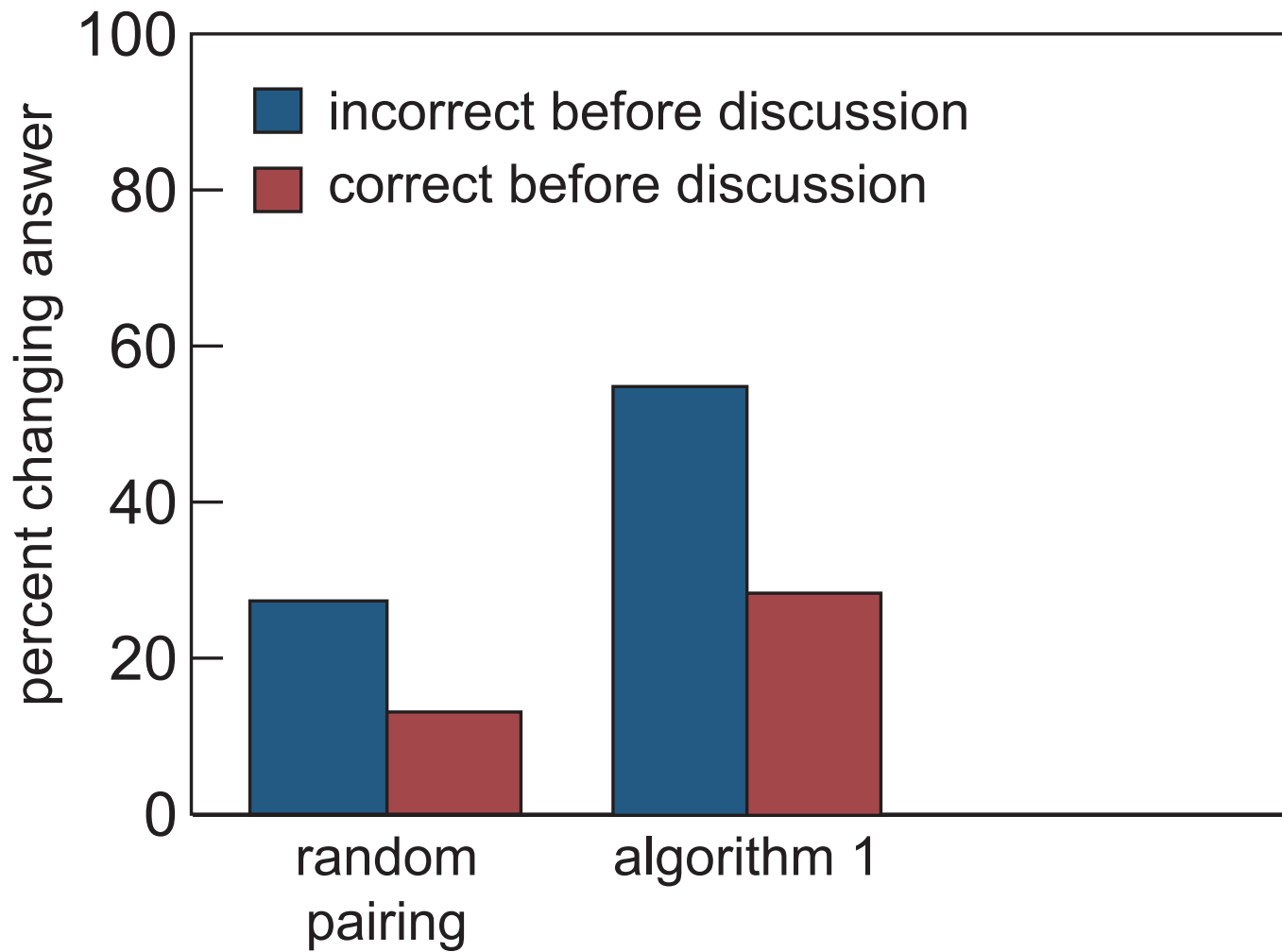


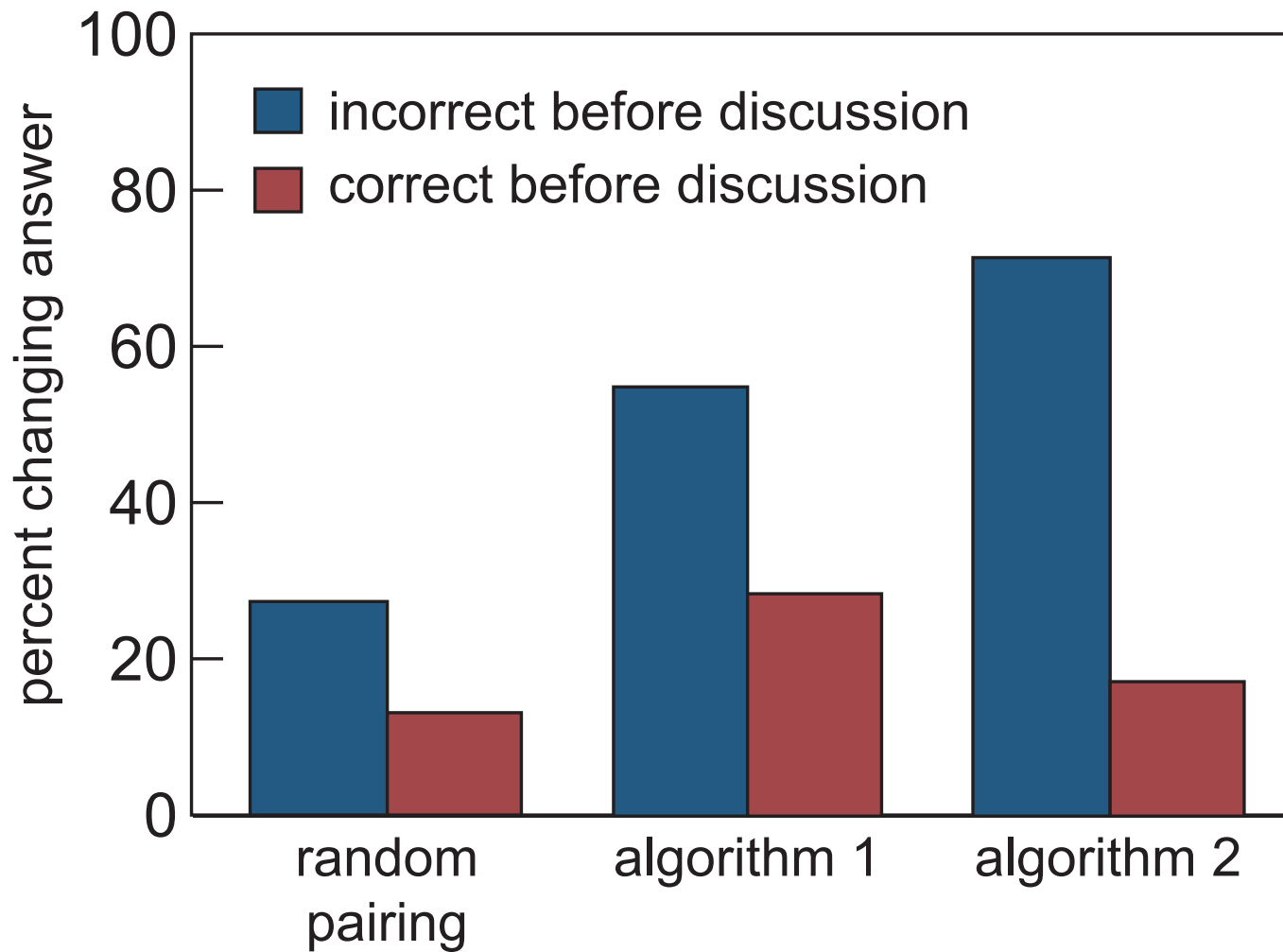
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2 PI

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1 lecture

2 PI

3 PI 2.0

in a lecture, students...

1 lecture

2 PI

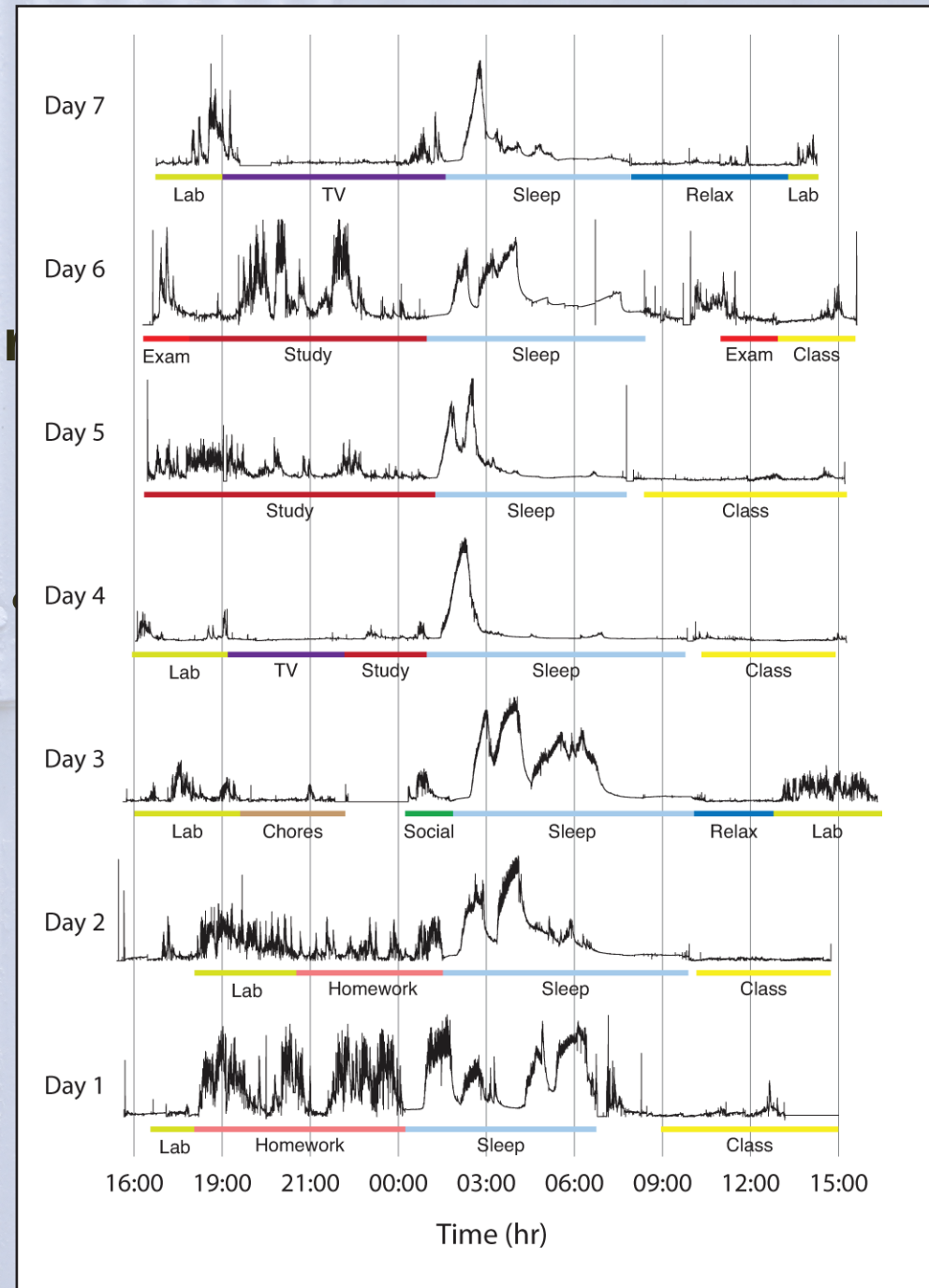
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in a lecture, students...

1. don't pay utmost attention

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

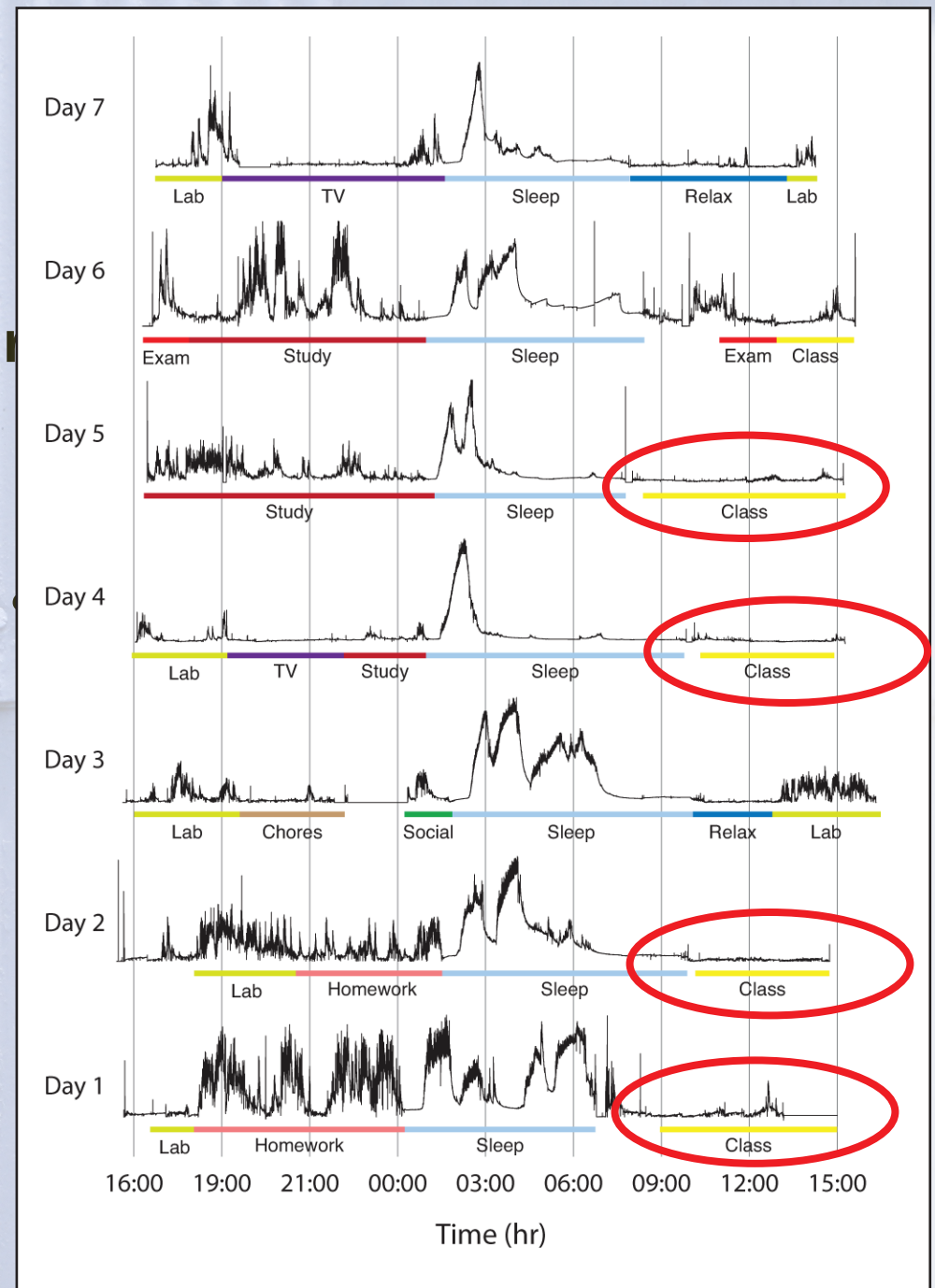
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2 PI

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in a lecture

1. don't pay utmost



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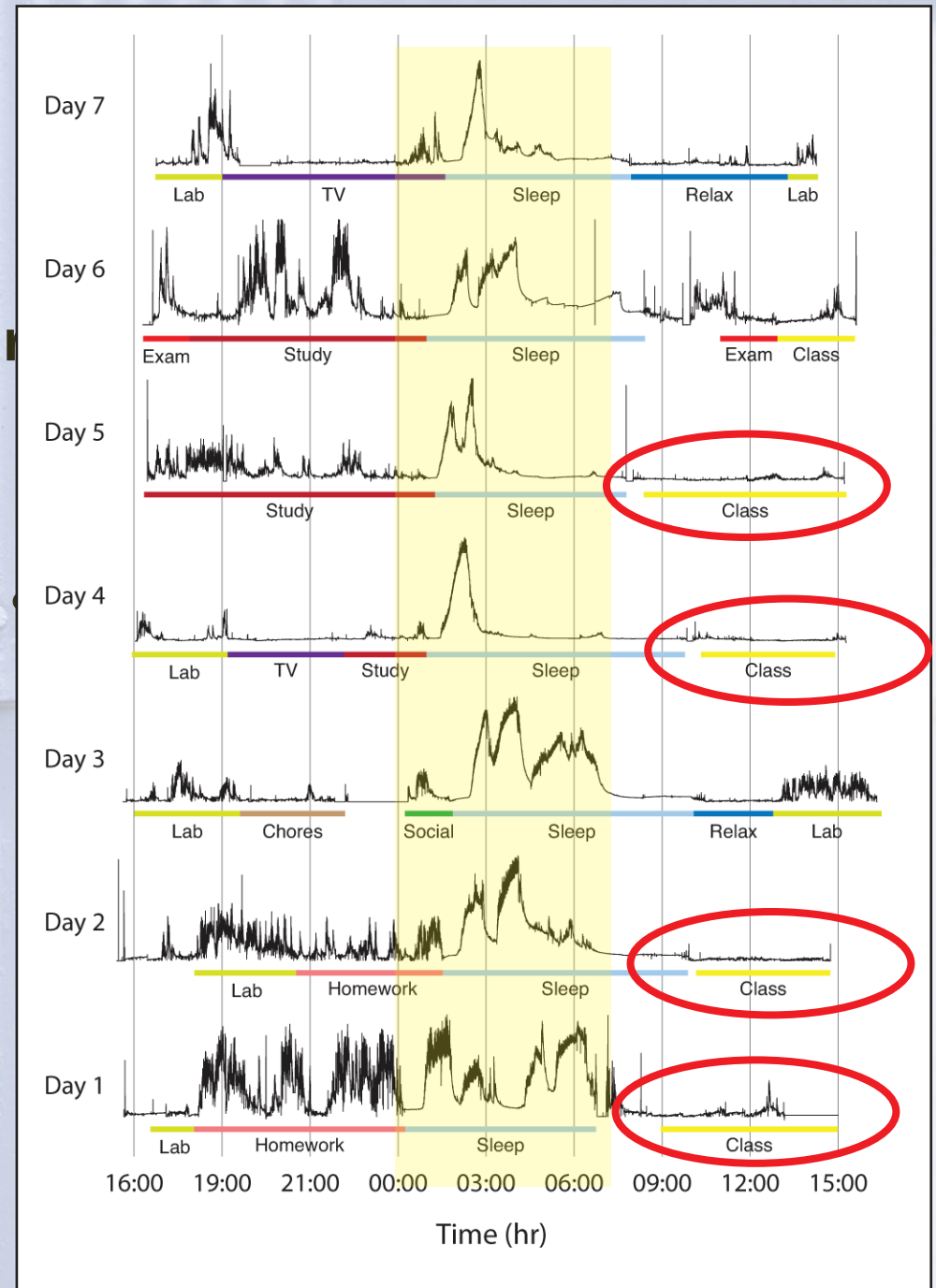
1 lecture

2 PI

3 PI 2.0

in a lecture

1. don't pay utmost



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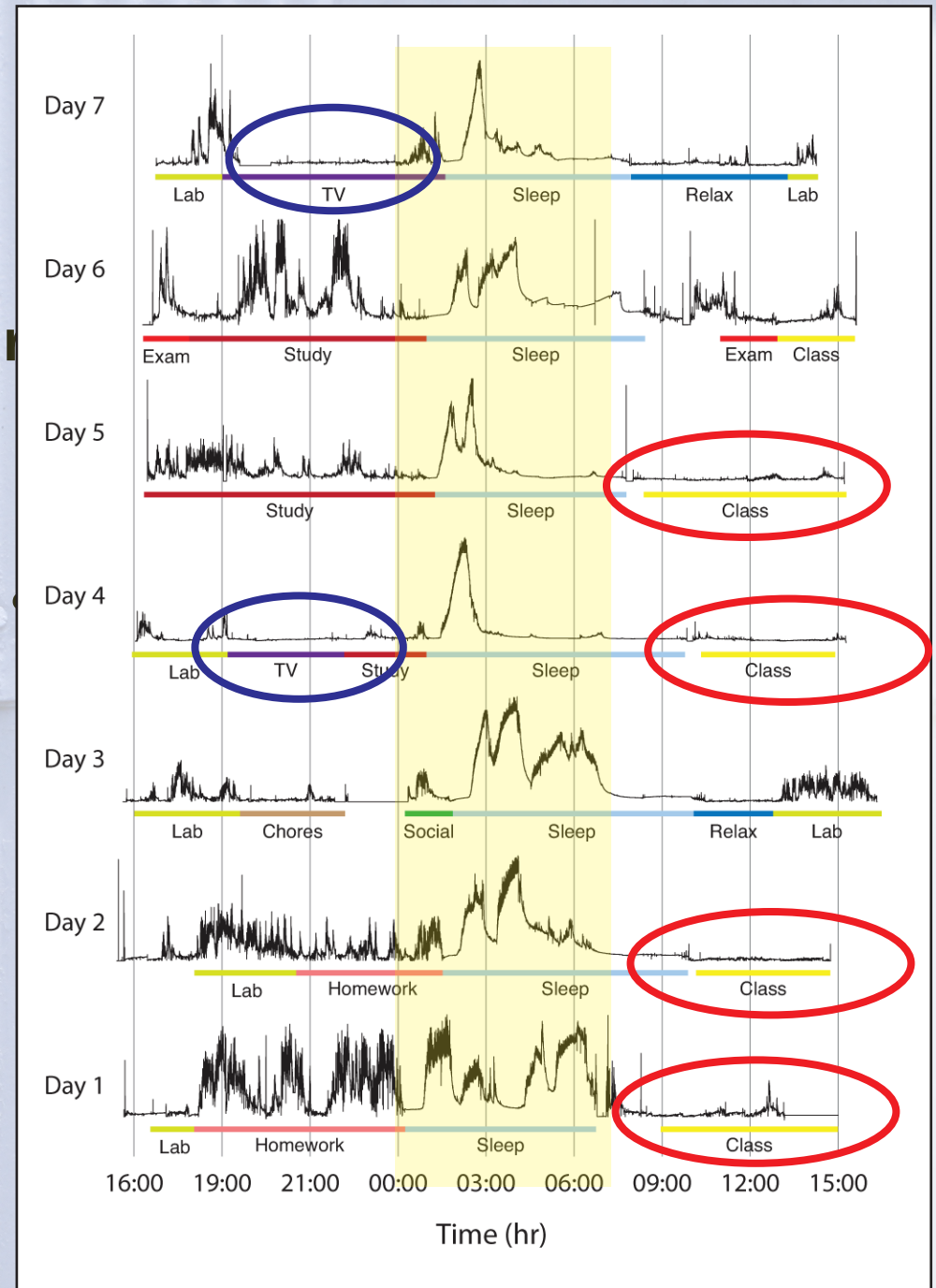
1 lecture

2 PI

3 PI 2.0

in a lecture

1. don't pay utmost



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1 lecture

2 PI

3 PI 2.0

in a lecture, students...

- 1. don't pay utmost attention**
- 2. think they know it**

in a lecture, students...

- 1. don't pay utmost attention**
- 2. think they know it**
- 3. are not confronted with misconceptions**

in a lecture, students...

1. don't pay utmost attention

2. think they know it

3. are not confronted with misconceptions

false
sense of security



an illusion. . .

1 lecture

2 PI

3 PI 2.0



1 lecture

2 PI

3 PI 2.0



Education is not just about:

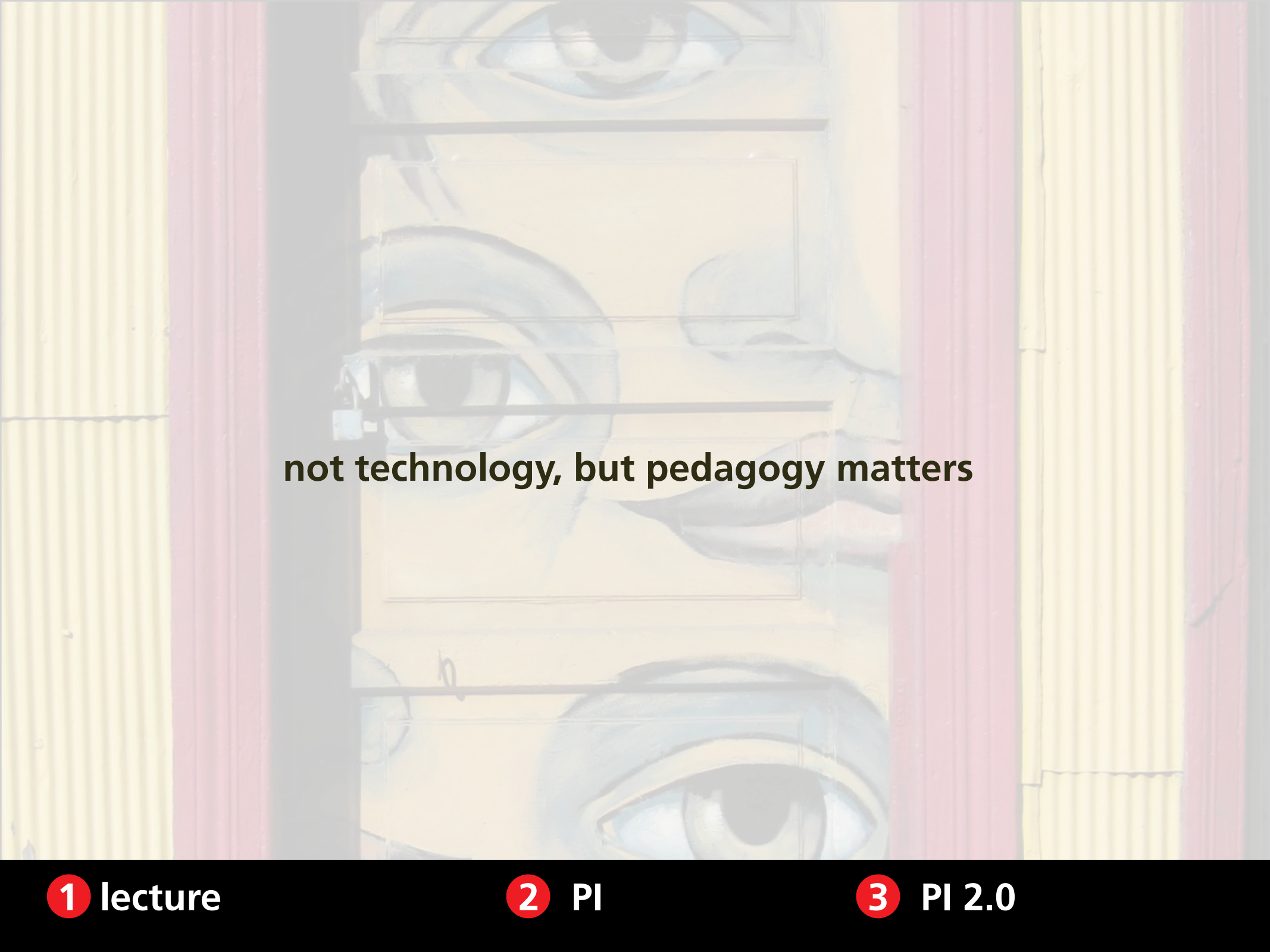
- **transferring information**
- **getting students to do what we do**



Education is not just about:

- **transferring information**
- **getting students to do what we do**

discovery & exploration a must!



not technology, but pedagogy matters



Learning Catalytics:

- **implement proven, researched pedagogy**



Learning Catalytics:

- **implement proven, researched pedagogy**
- **use consumer devices**



Learning Catalytics:

- implement proven, researched pedagogy
- use consumer devices
- avoid pitfalls of MC assessment

Learning Catalytics:

- implement proven, researched pedagogy
- use consumer devices
- avoid pitfalls of MC assessment
- create a smart classroom *anywhere*

Funding:

National Science Foundation

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