

# Interactive Learning: Technology in the Classroom GROUP



Symposium on Education and Technology  
Harvard University  
Cambridge, MA, 16 June 2014



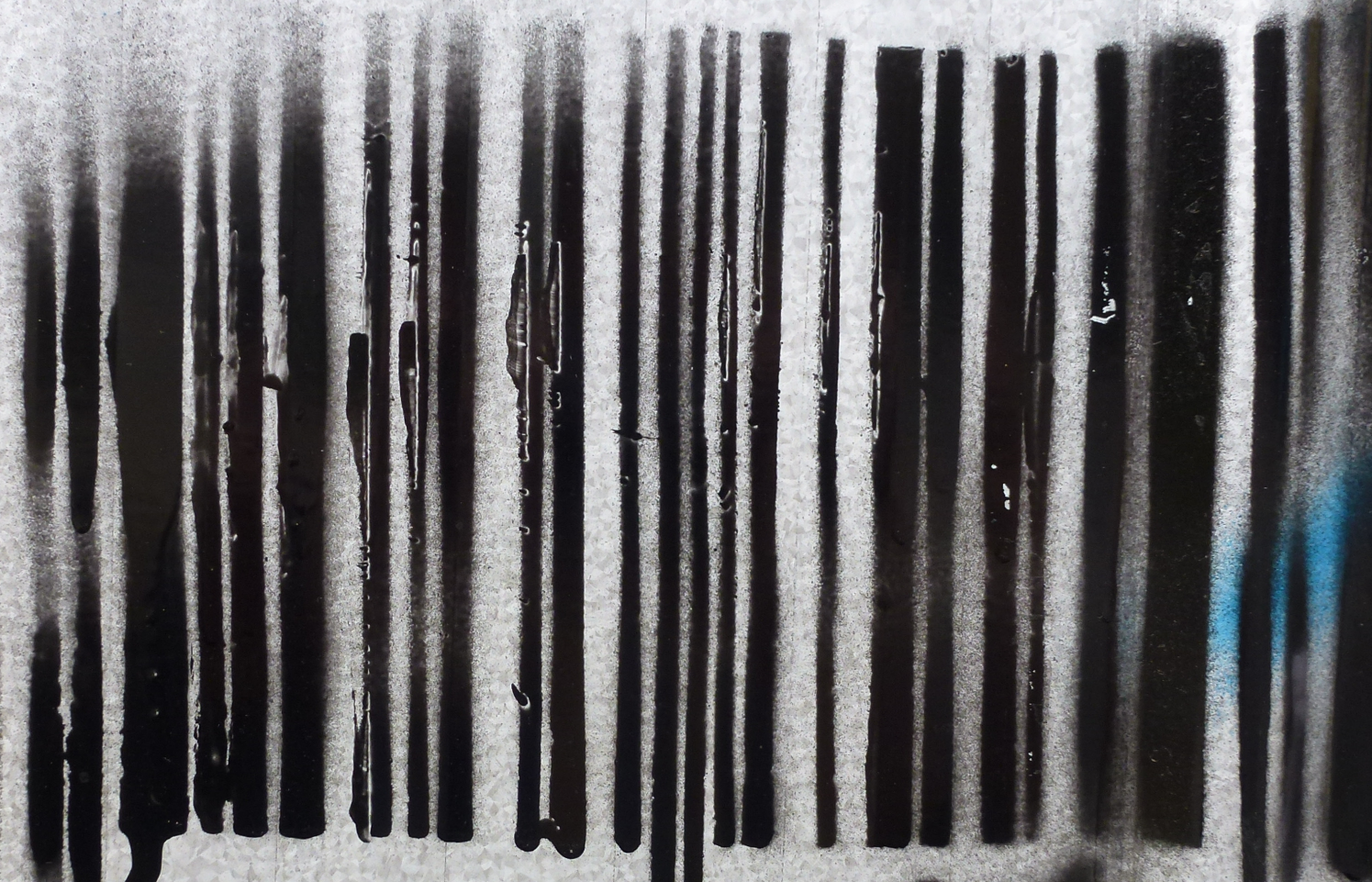
# Interactive Learning: Technology in the Classroom



@eric\_mazur

Symposium on Education and Technology  
Harvard University  
Cambridge, MA, 16 June 2014





EDUCACION

2





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



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unique ID on back of clicker



**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**

**EDUCACION**







**1** lecture



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?**



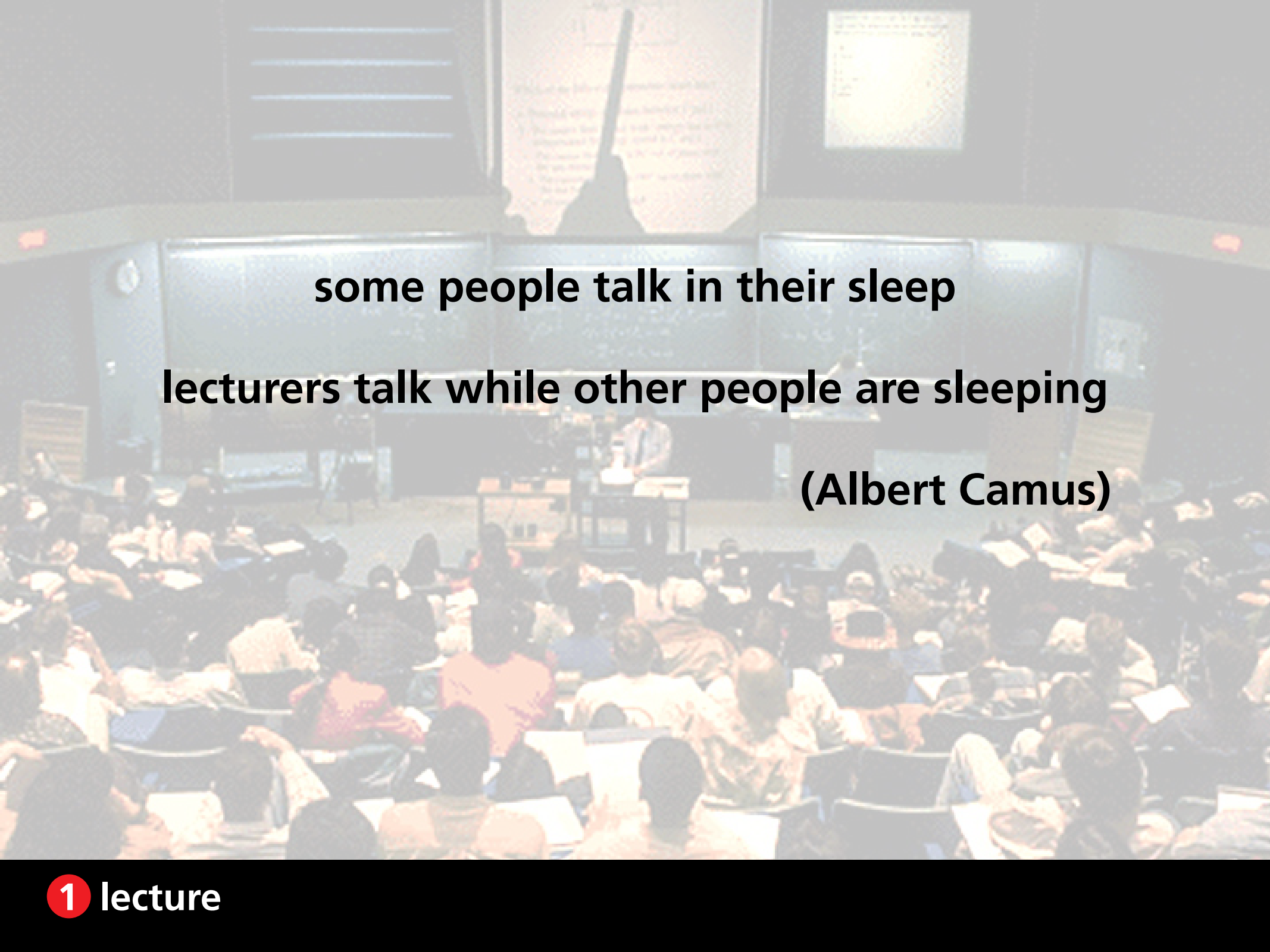
**1** lecture



A large lecture hall with a professor at a podium and students in the audience. The professor is standing at a podium on a stage, facing the audience. The audience is seated in rows of chairs, filling the hall. The stage has a large screen behind the professor displaying text. The text on the screen is partially legible and includes the following:

1. The first step in the process of...  
2. The second step is to...  
3. The third step is to...  
4. The fourth step is to...  
5. The fifth step is to...

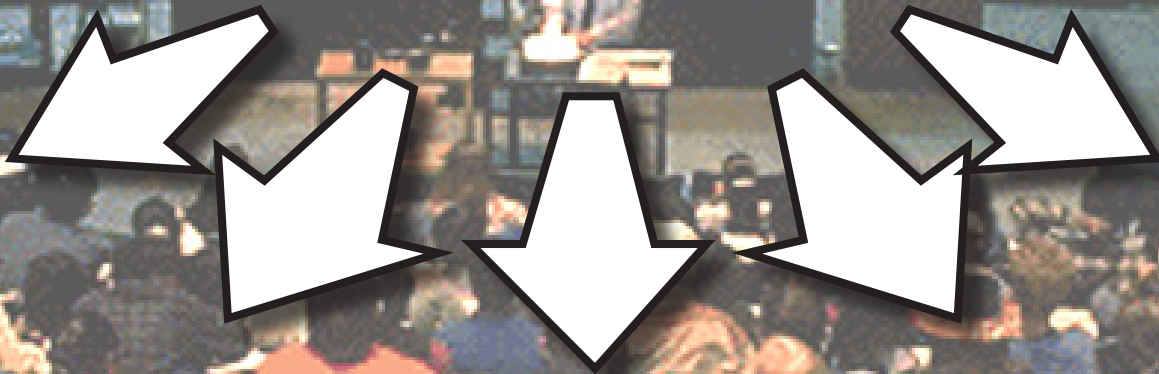
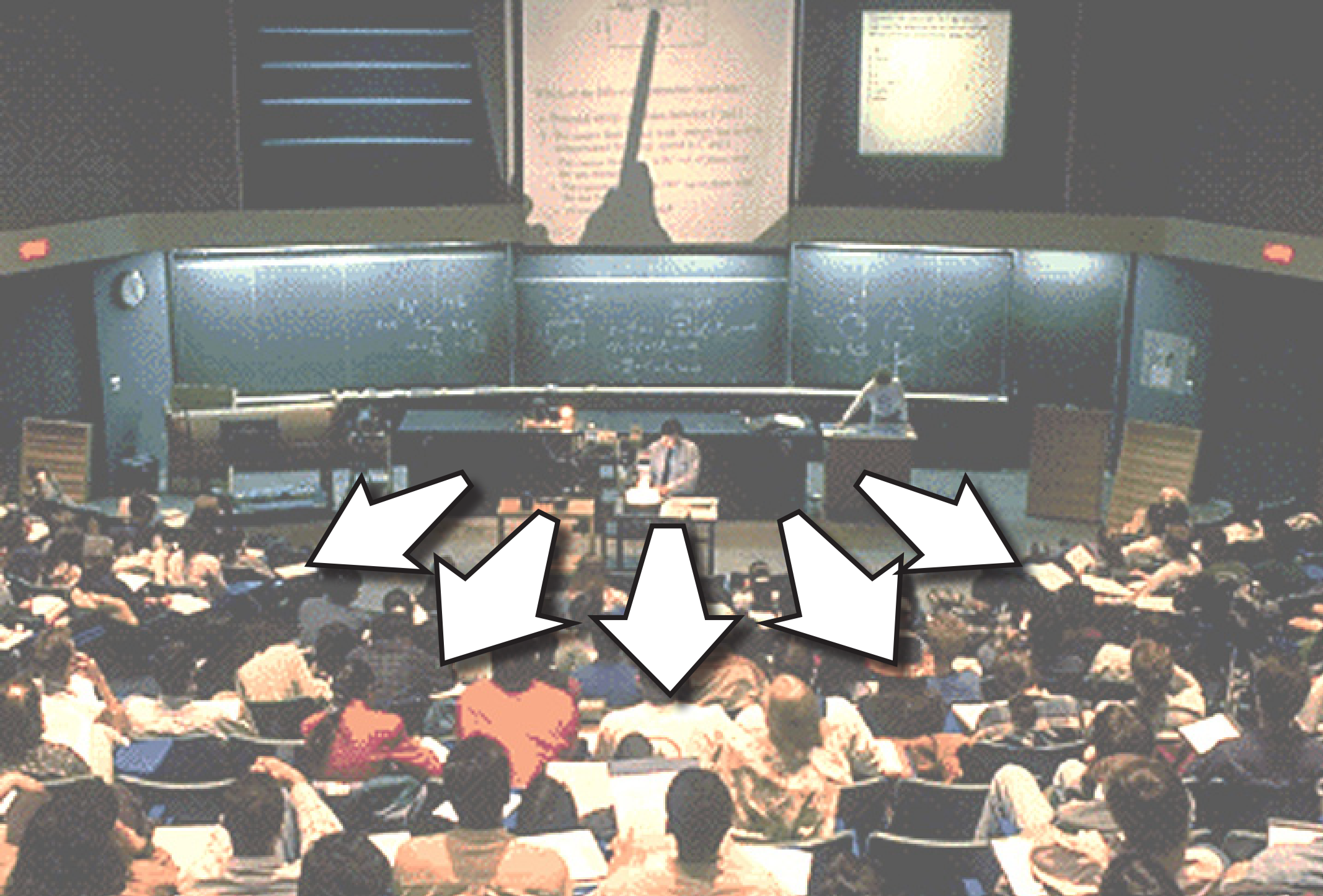
**some people talk in their sleep**



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



**1** lecture



The result?

EDUCACION

**Lack of learning**

EDUCACION

**Lack of learning**

**Lack of retention**

**not transfer but assimilation of information is key**

**EDUCACION**





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)

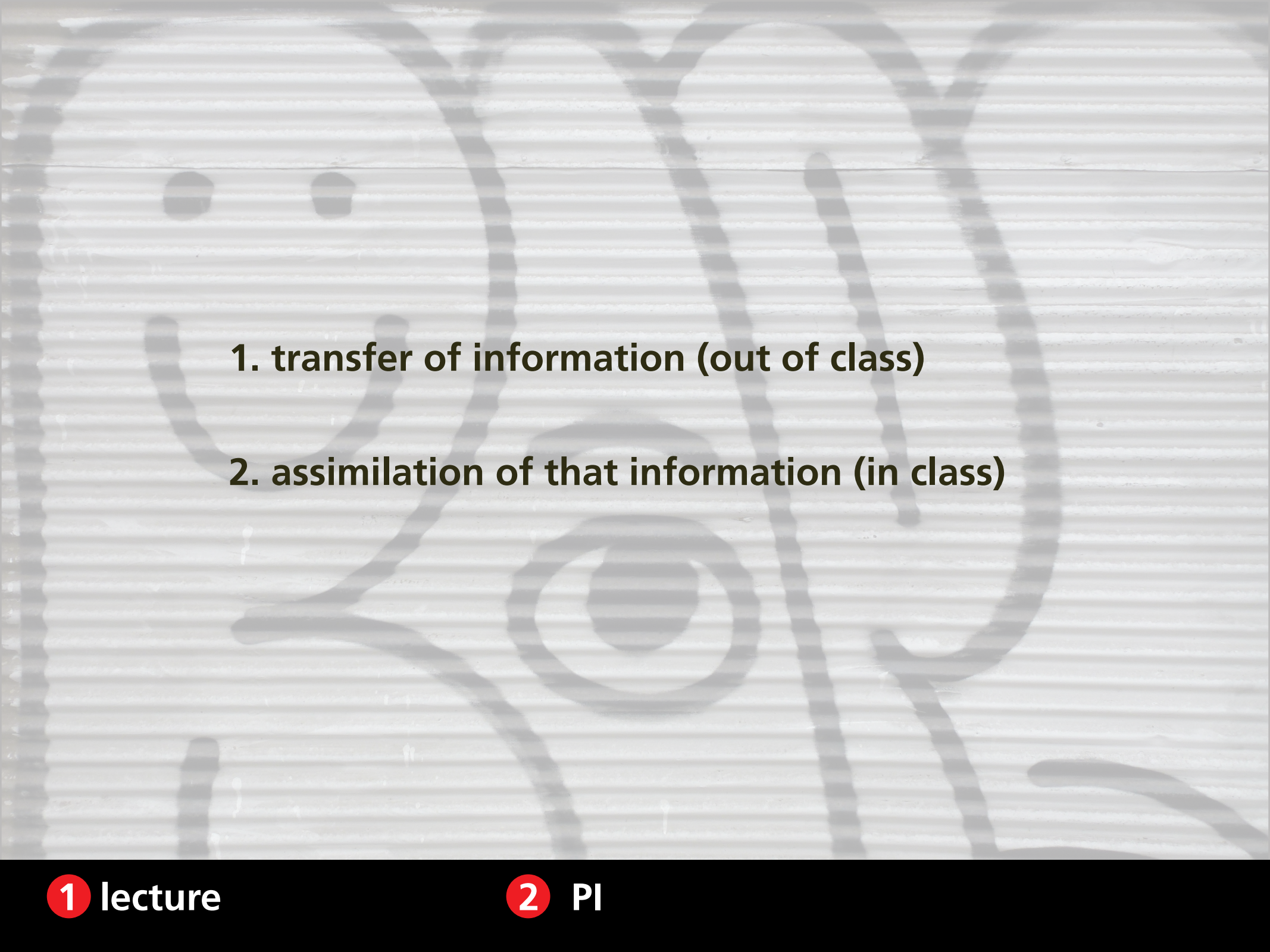


**Should focus  
on THIS!**

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 man in a dark suit and red tie leaning over a group of students in a lecture hall. He is pointing at a document held by one of the students. The students are seated in green chairs with purple carpeting. The background shows other students and a wooden wall.

**1. transfer of information (out of class)**

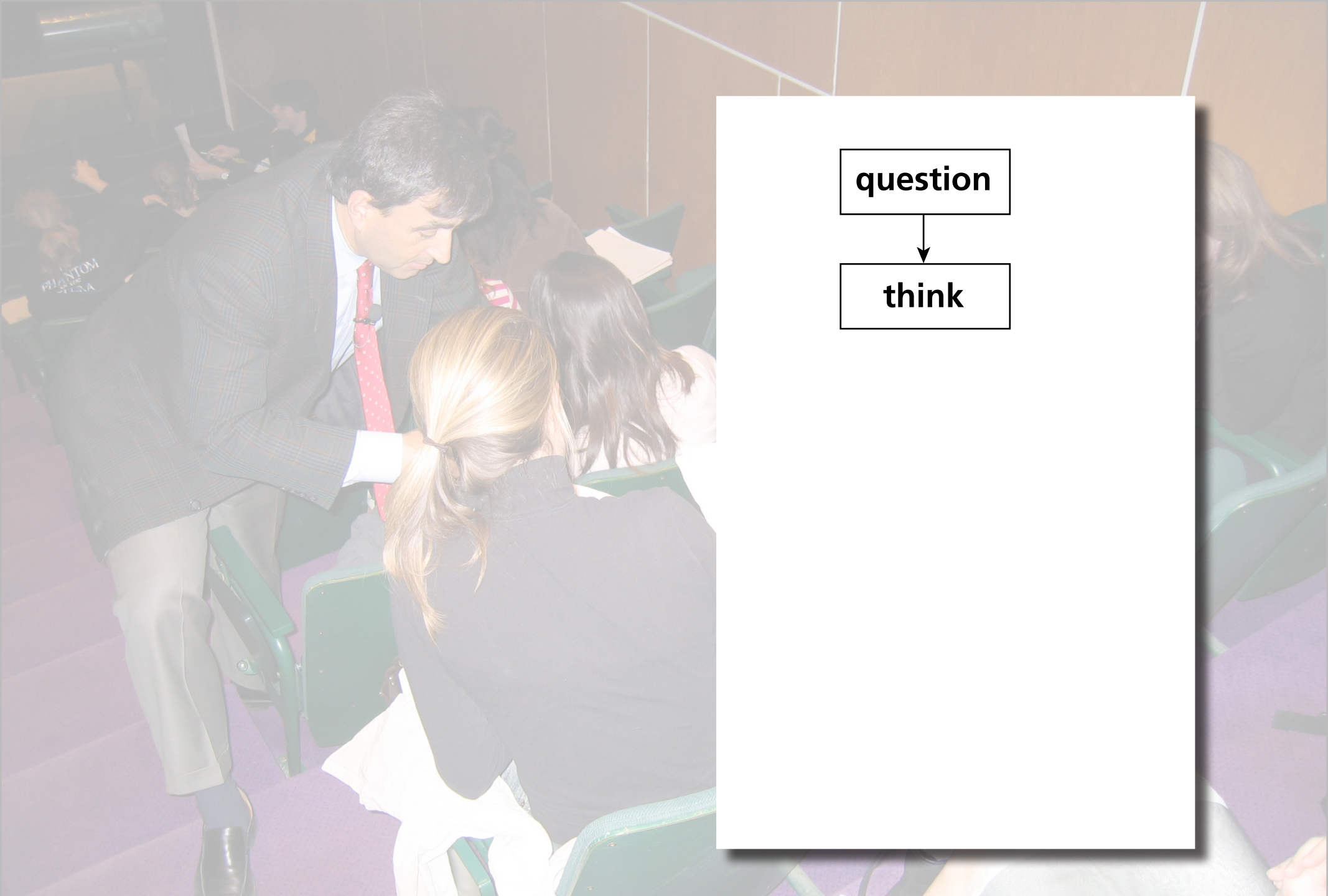
**2. assimilation of that information (in class)**

A man in a dark plaid suit and red tie is leaning over a woman with long blonde hair in a lecture hall. He appears to be adjusting her chair or providing assistance. Other people are visible in the background, some sitting at desks. The room has wood-paneled walls and purple carpeting.

question

1 lecture

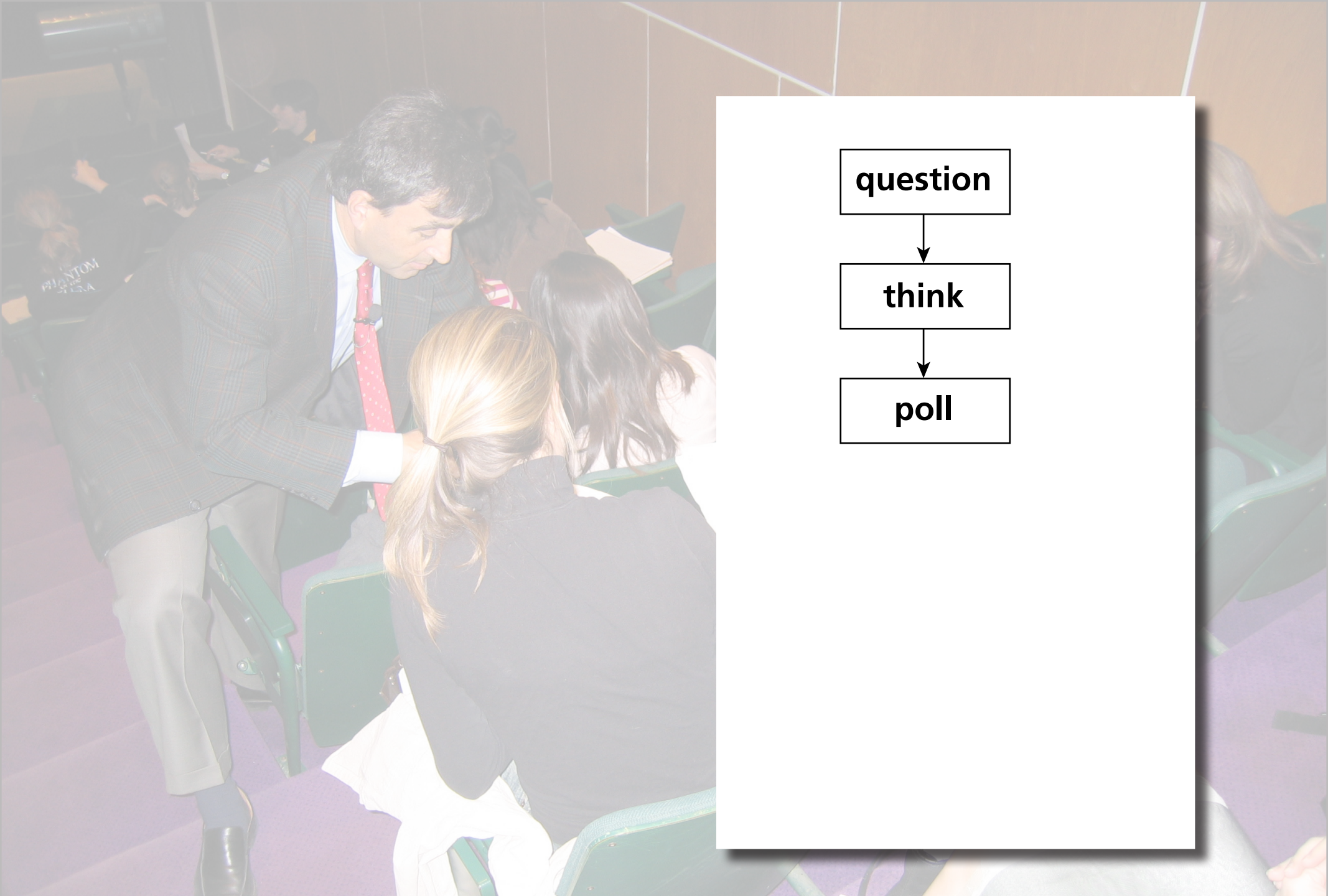
2 PI



question



think



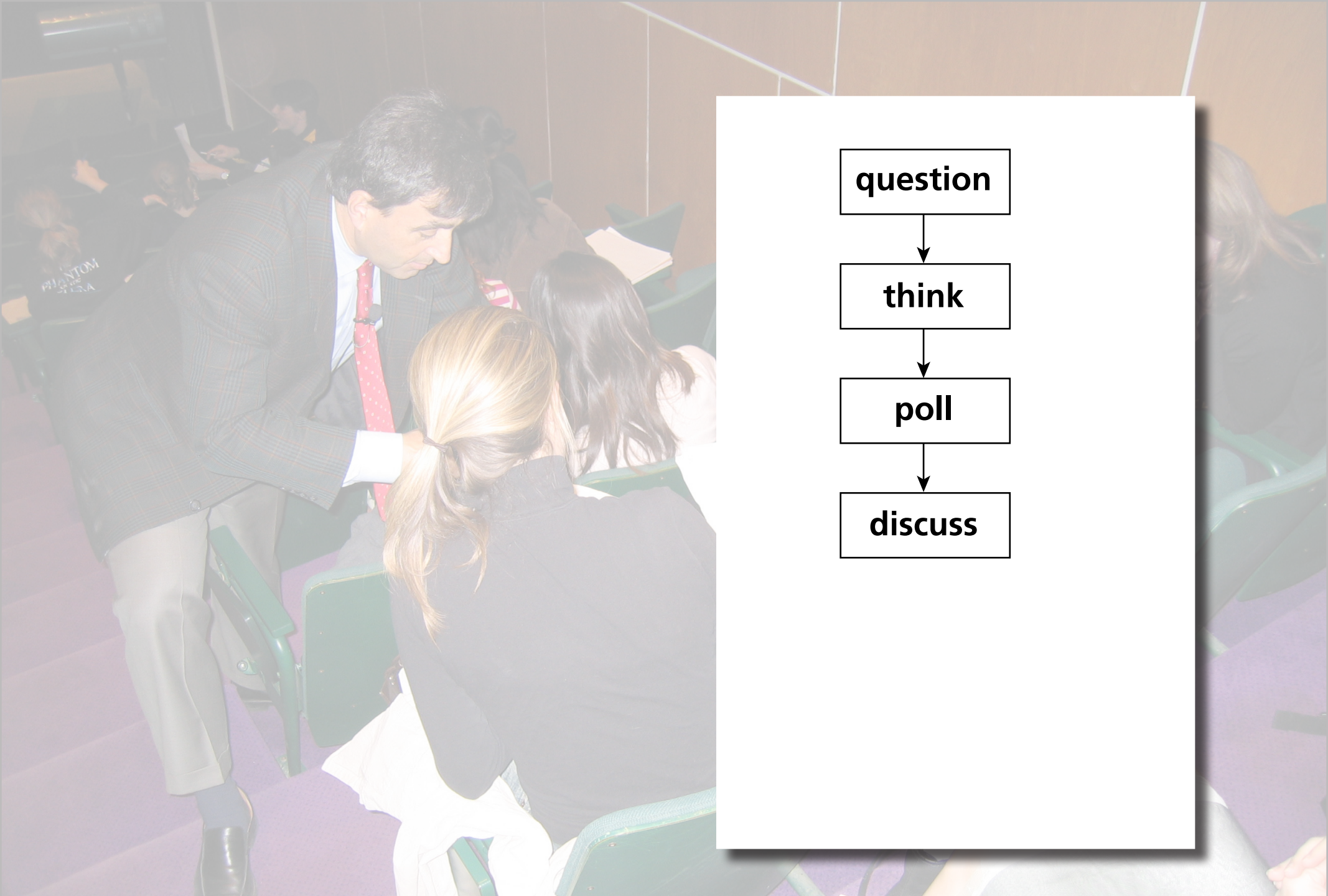
question



think



poll



**question**



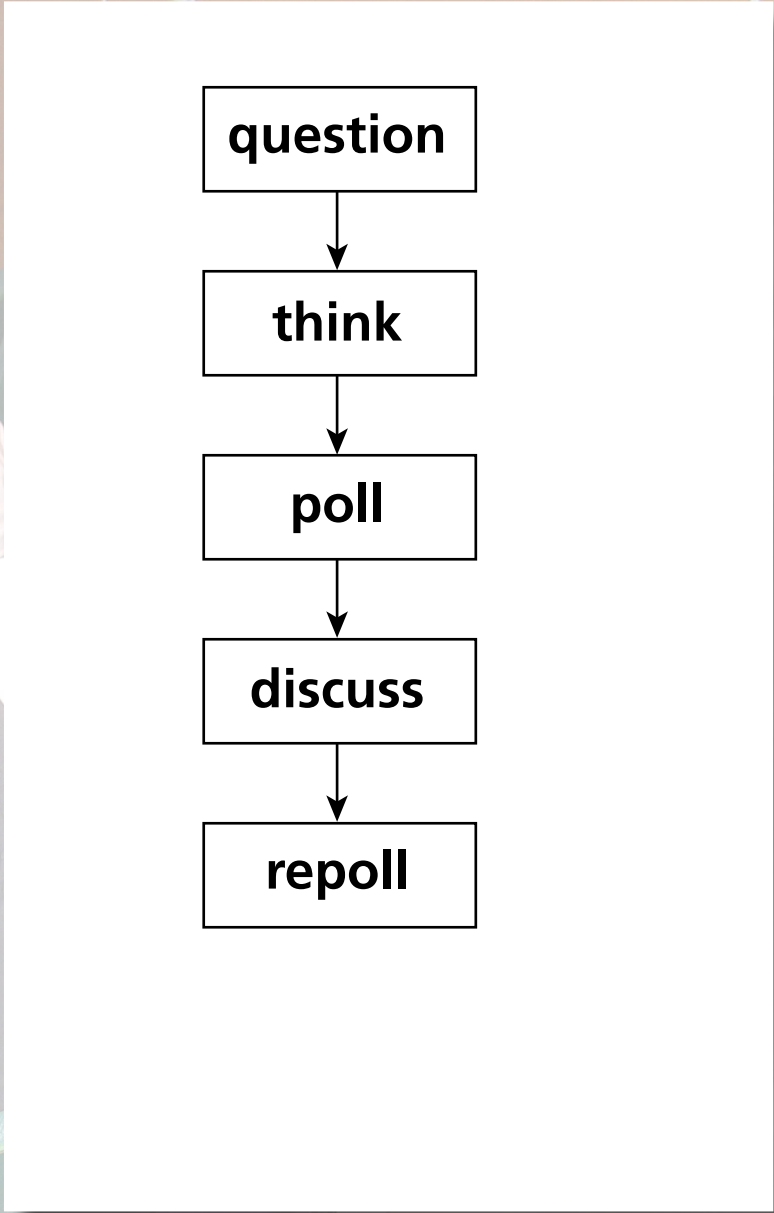
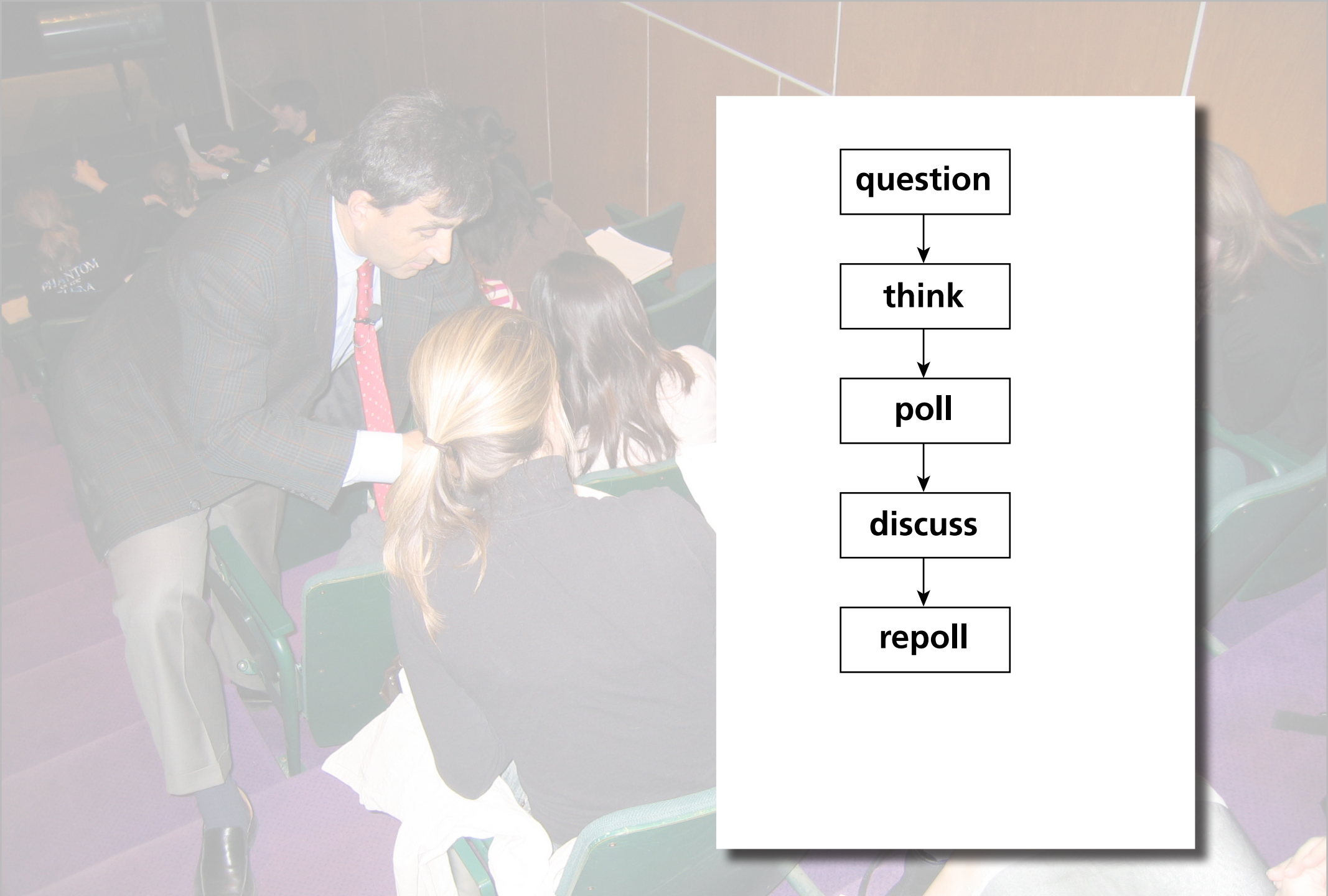
**think**

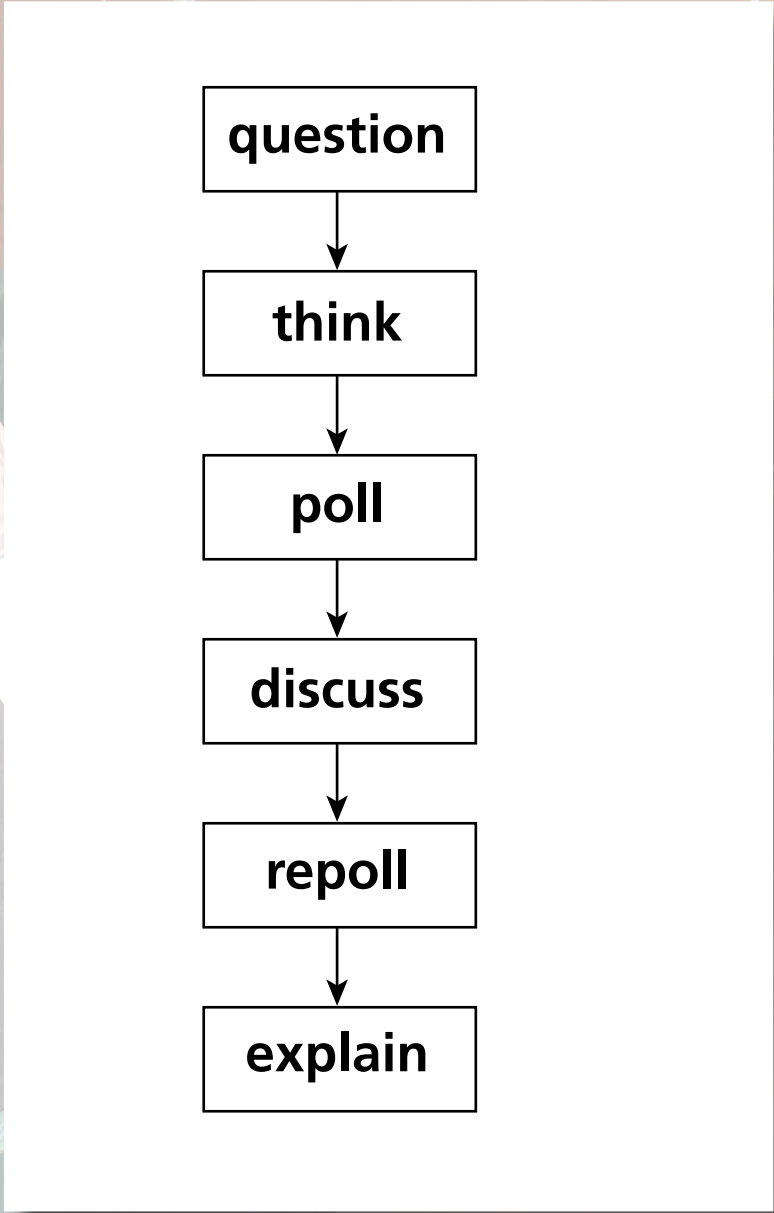
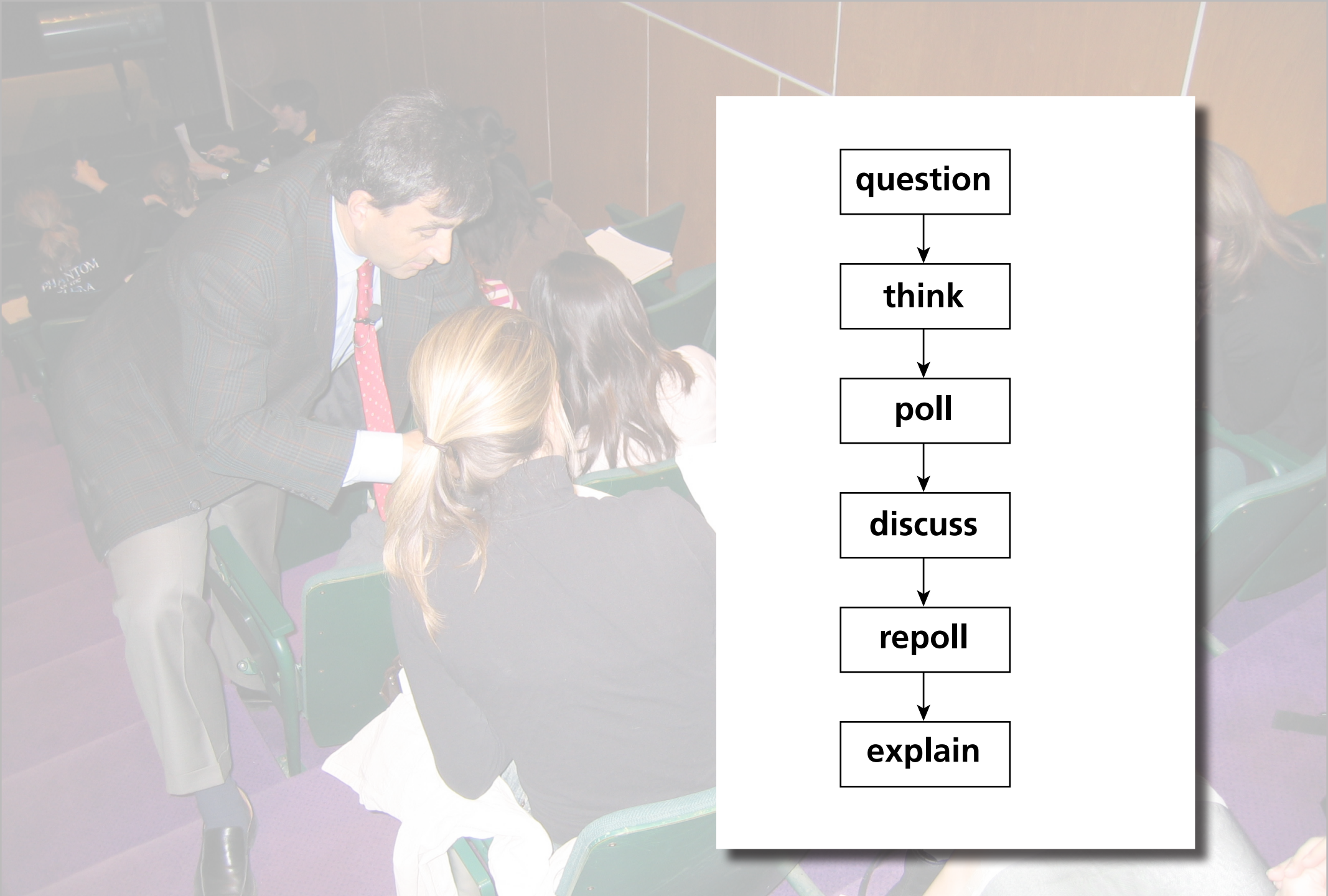


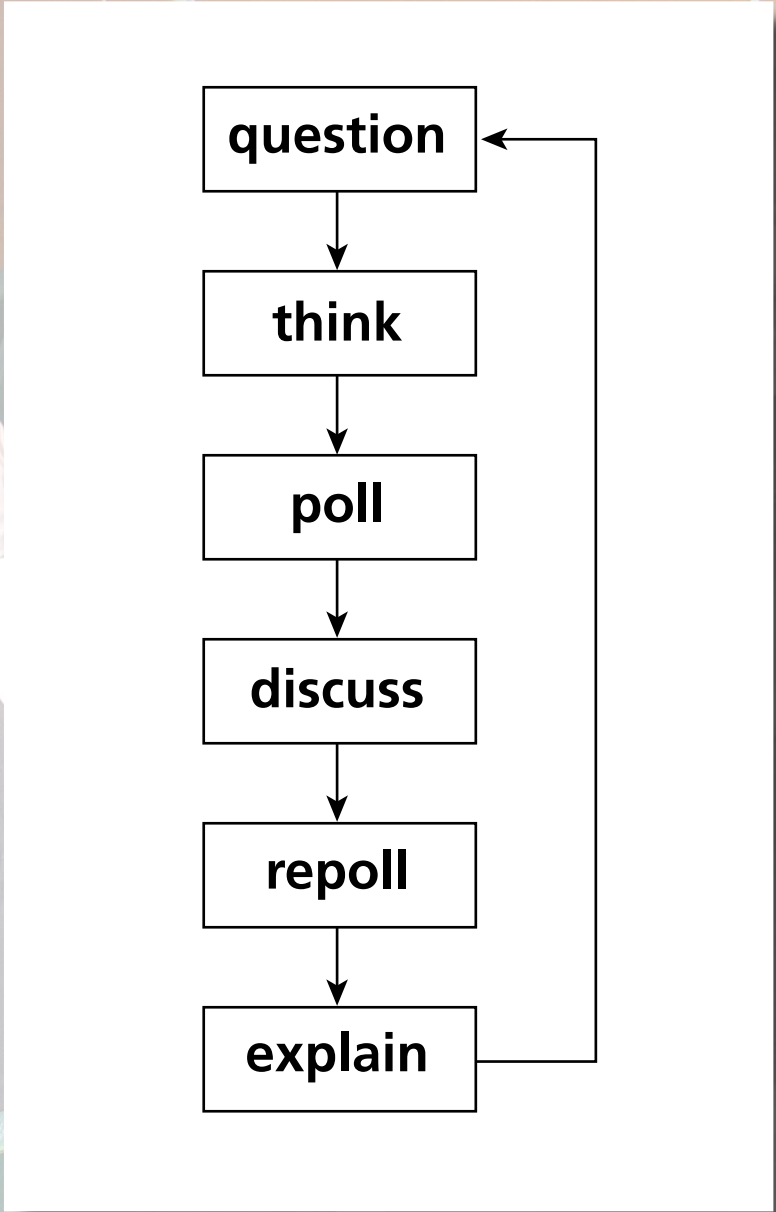
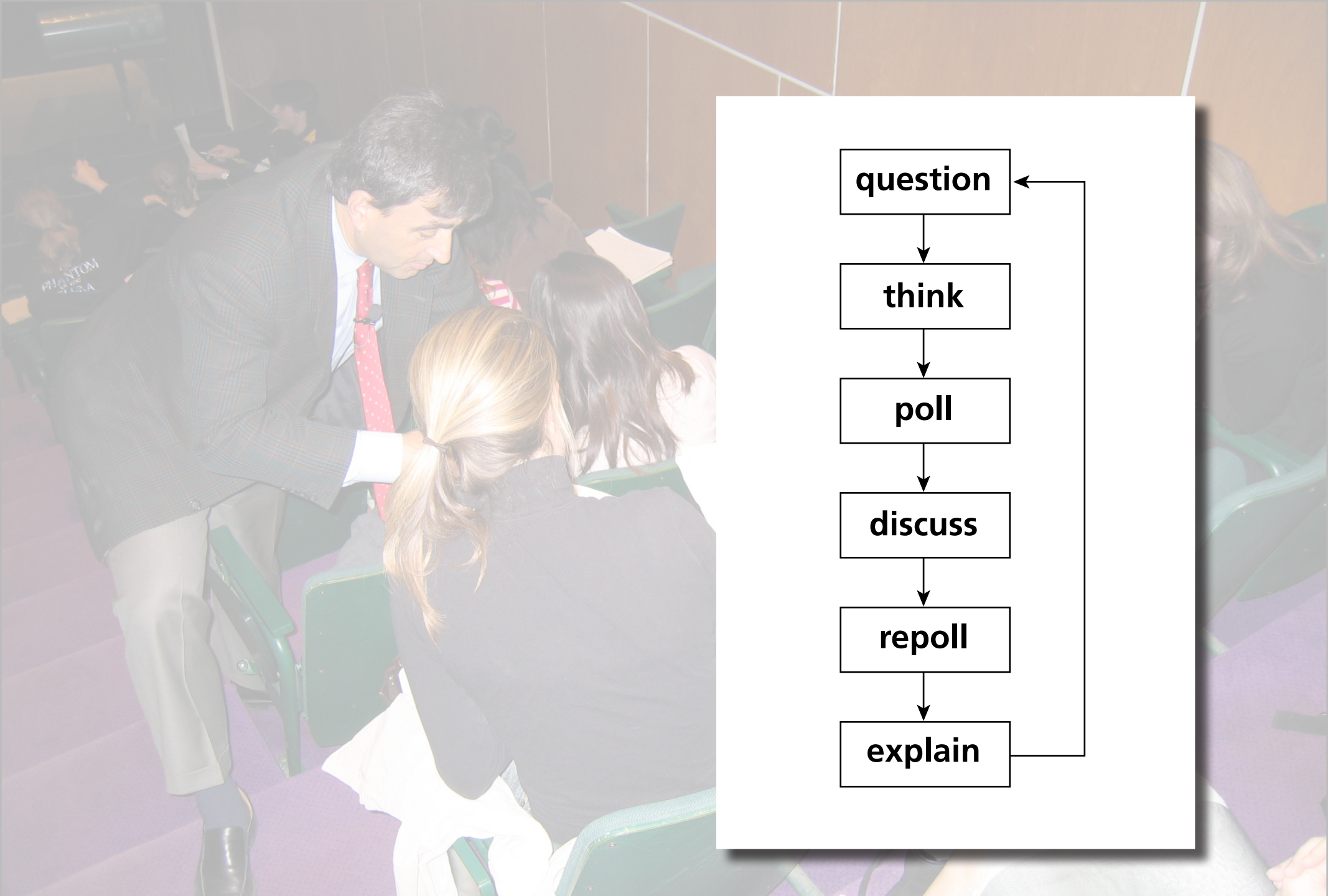
**poll**



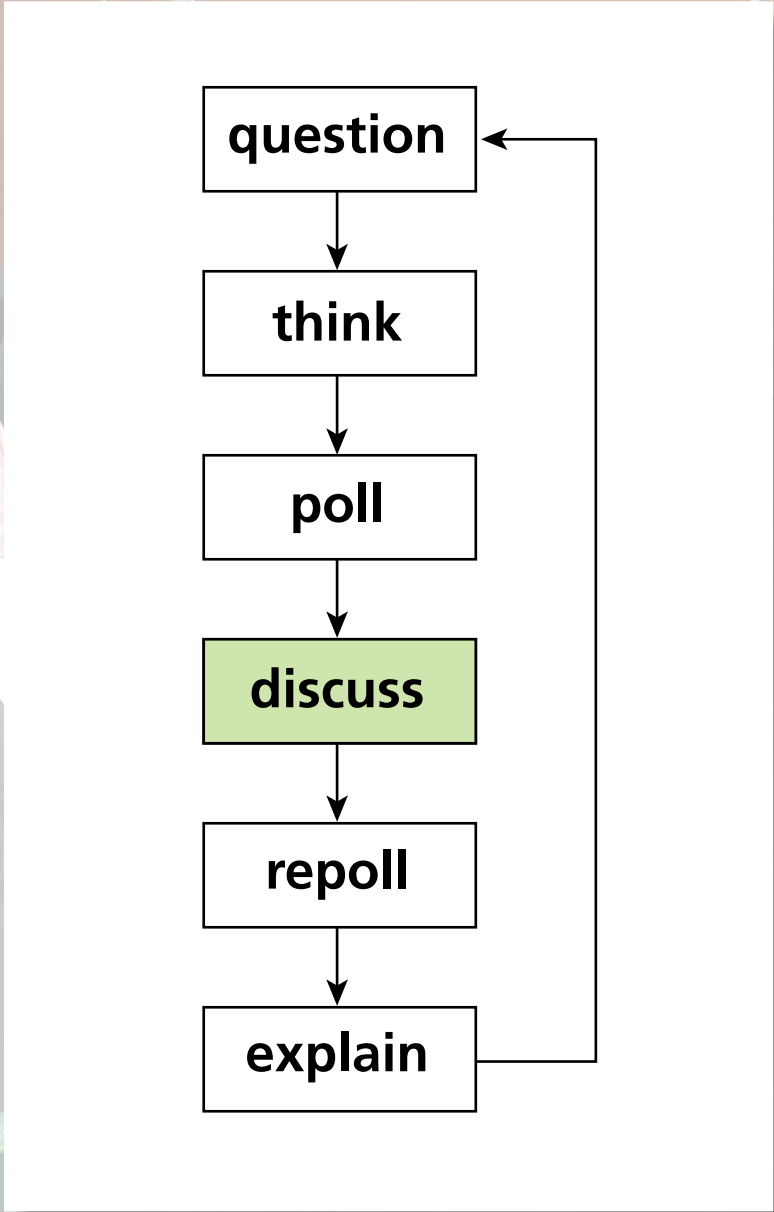
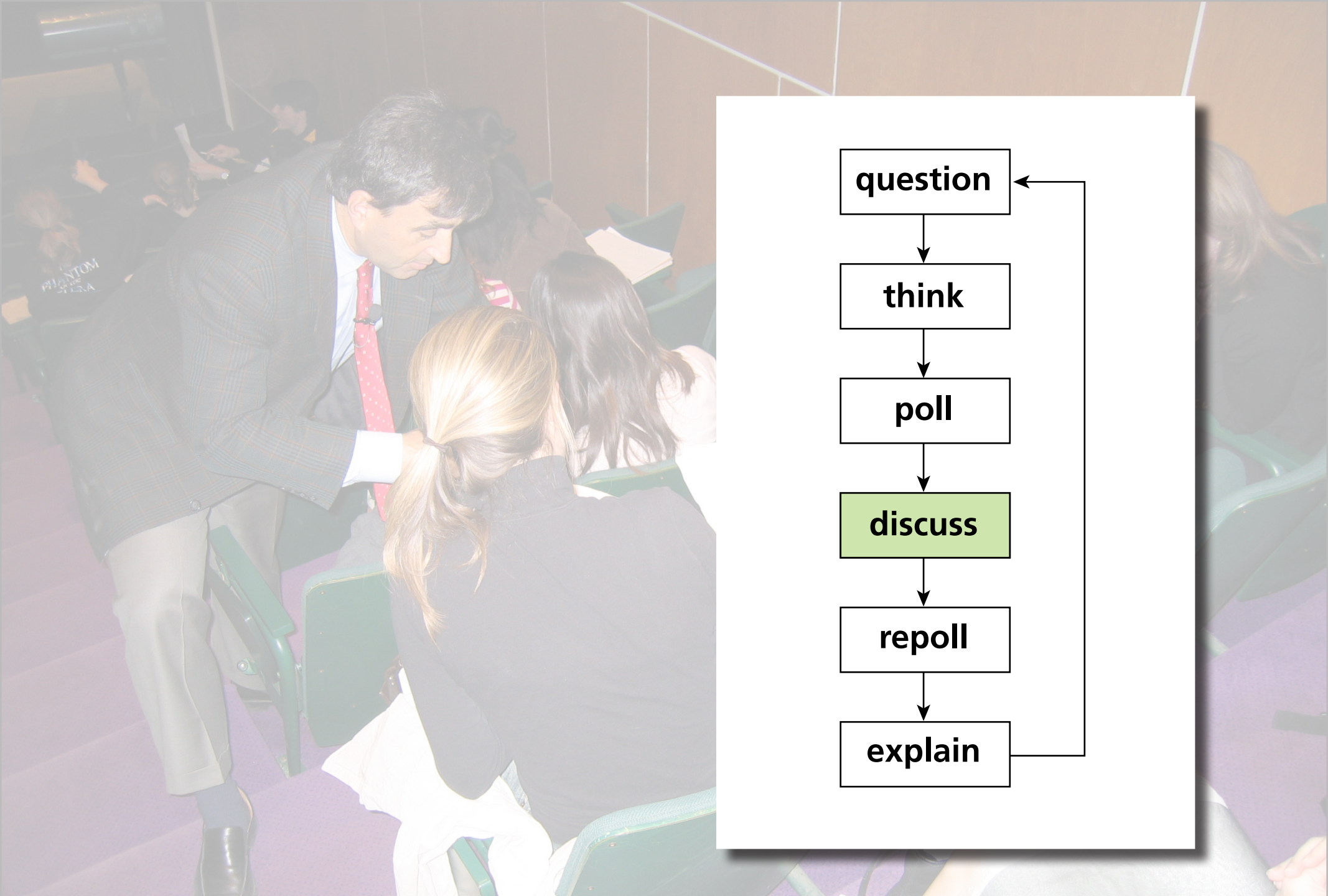
**discuss**











**1** education

**2** PI

# Peer INSTRUCTION

The title 'Peer INSTRUCTION' is displayed in a large, white, sans-serif font. The word 'Peer' is positioned above 'INSTRUCTION'. The 'e' in 'Peer' is highlighted with a dashed yellow line and a yellow arrow pointing to its right. A dotted blue line starts from the right side of the 'e' and curves downwards and to the right, ending near the word 'INSTRUCTION'. A dashed yellow line with a yellow arrow points from the bottom left towards the 'e'.

1 lecture

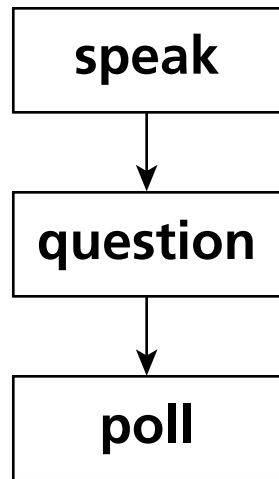
2 PI

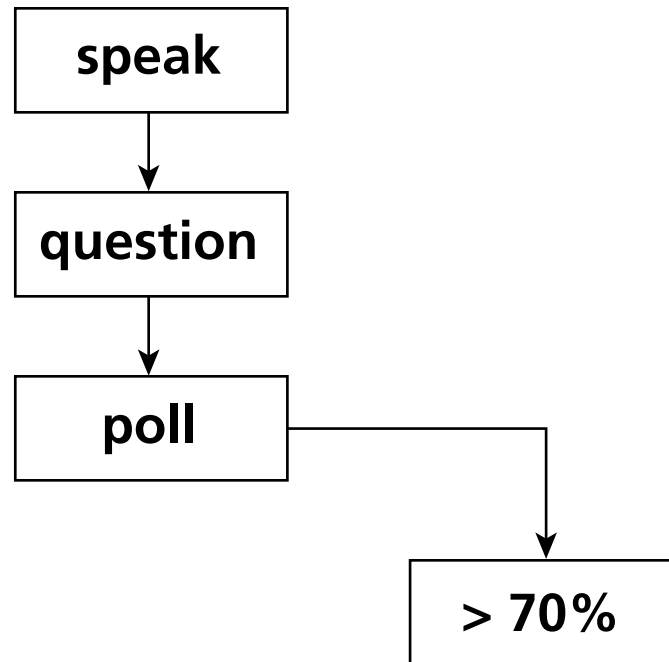
Speak

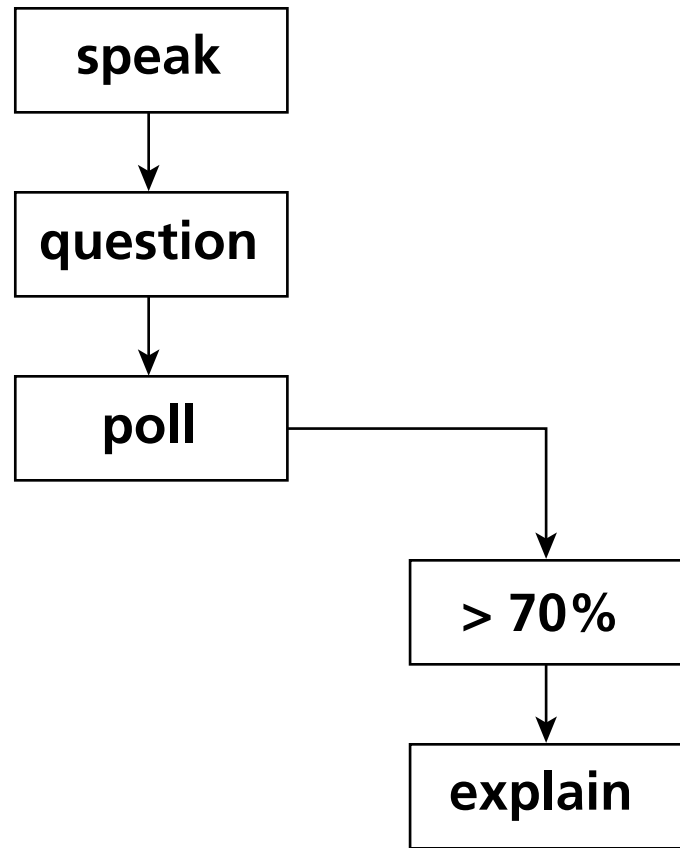
Speak



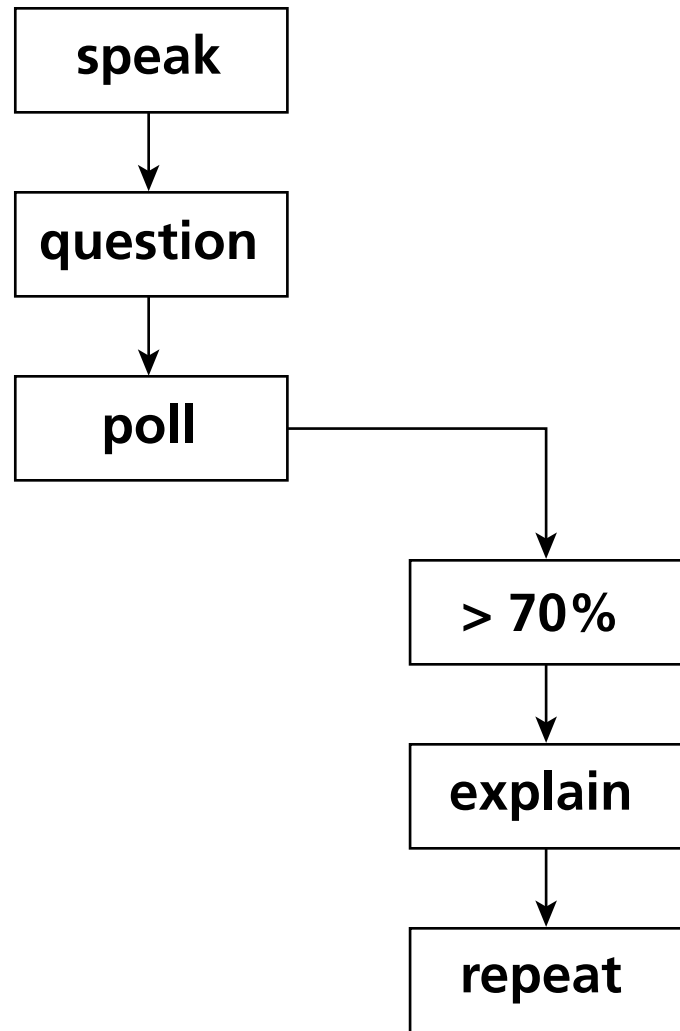
Question

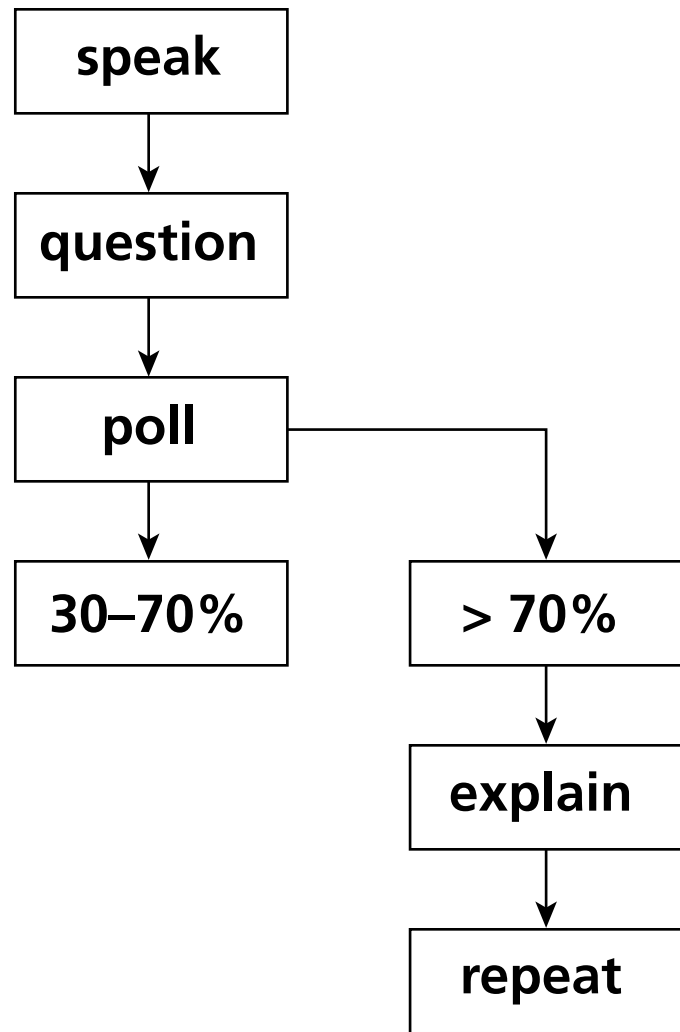


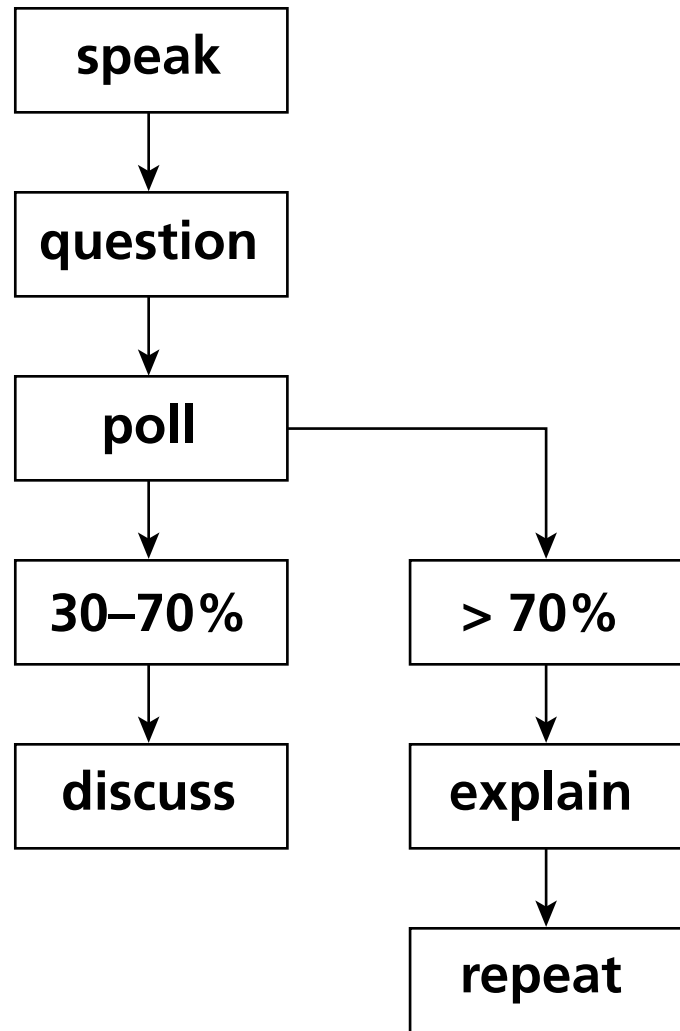


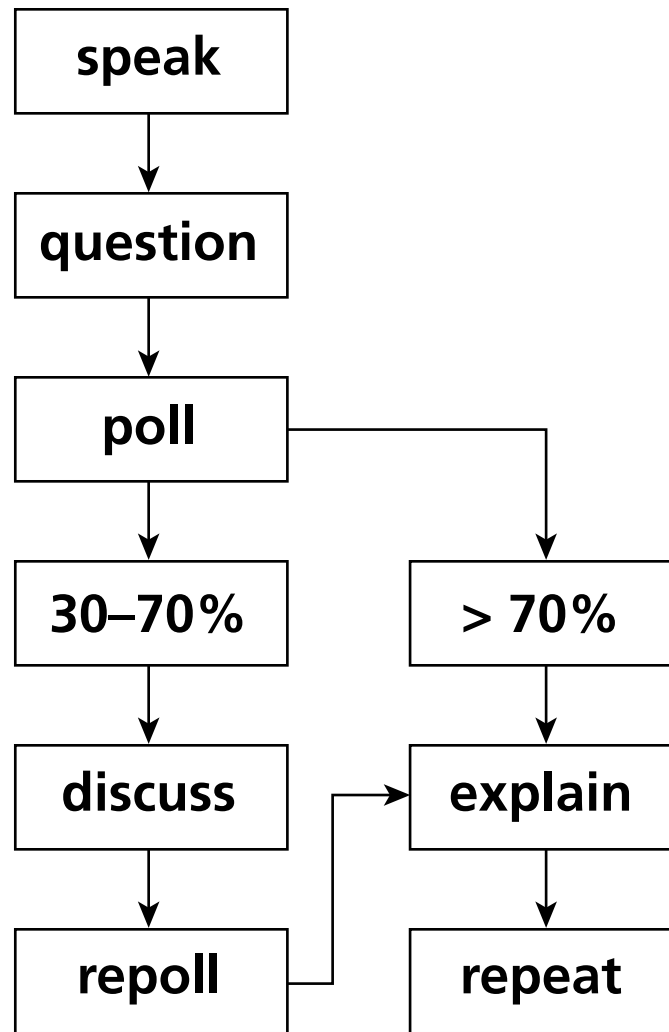


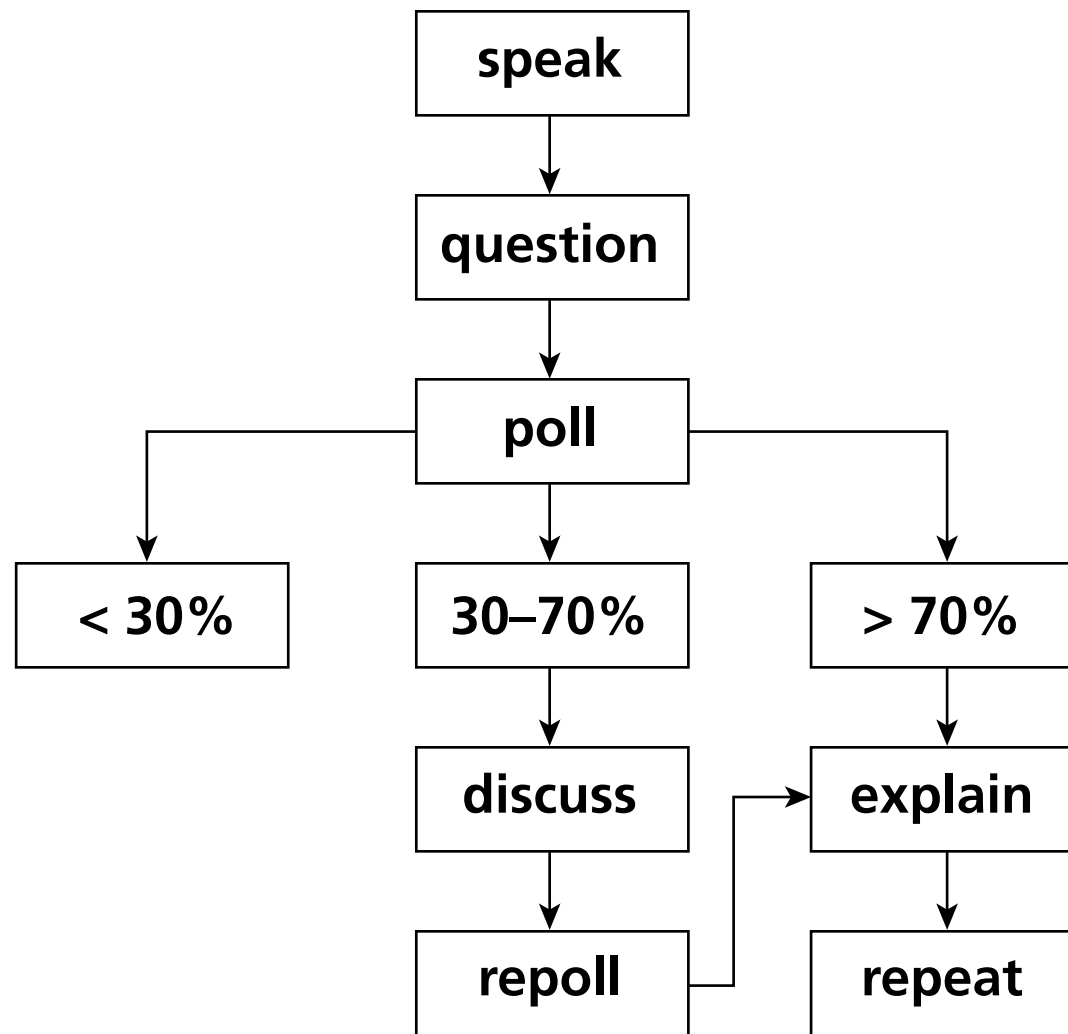


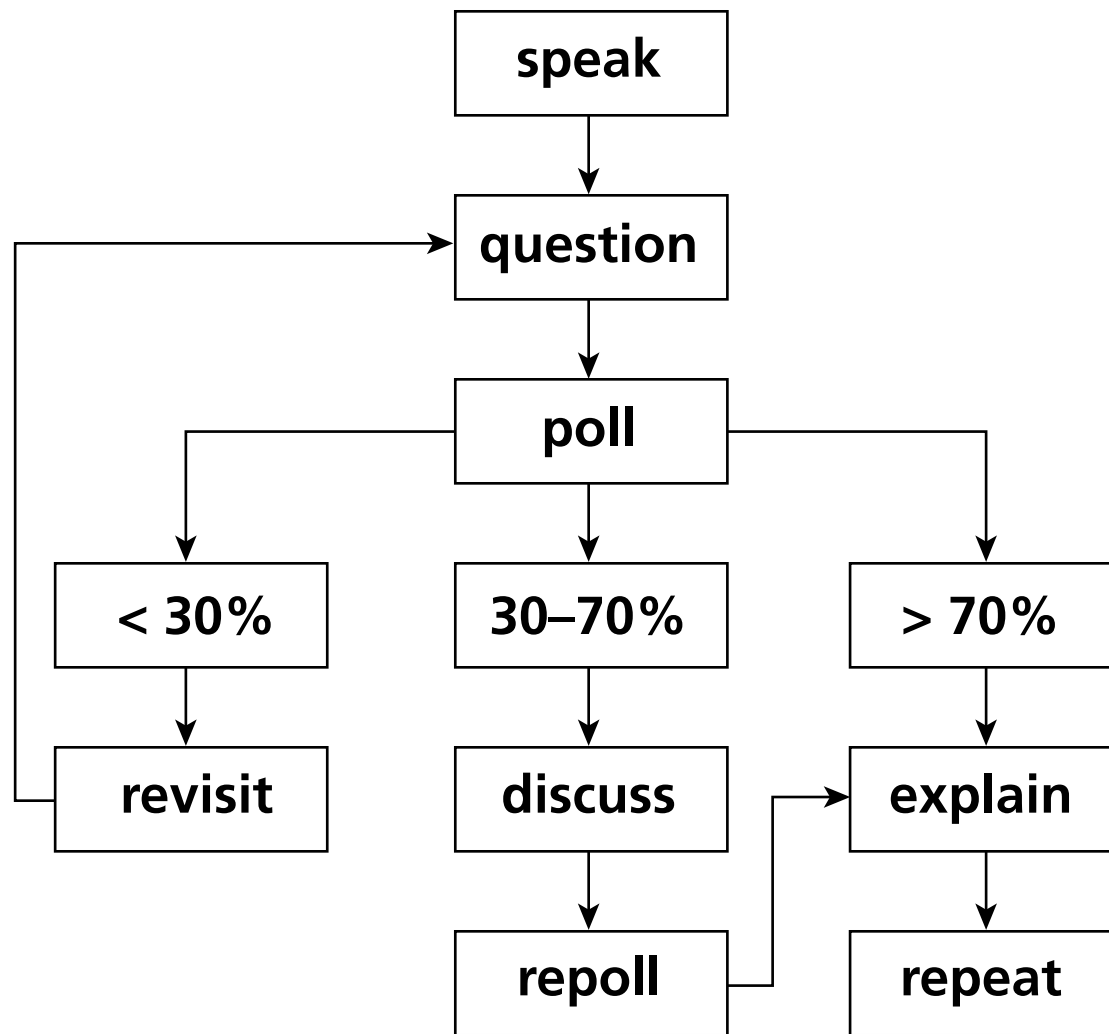


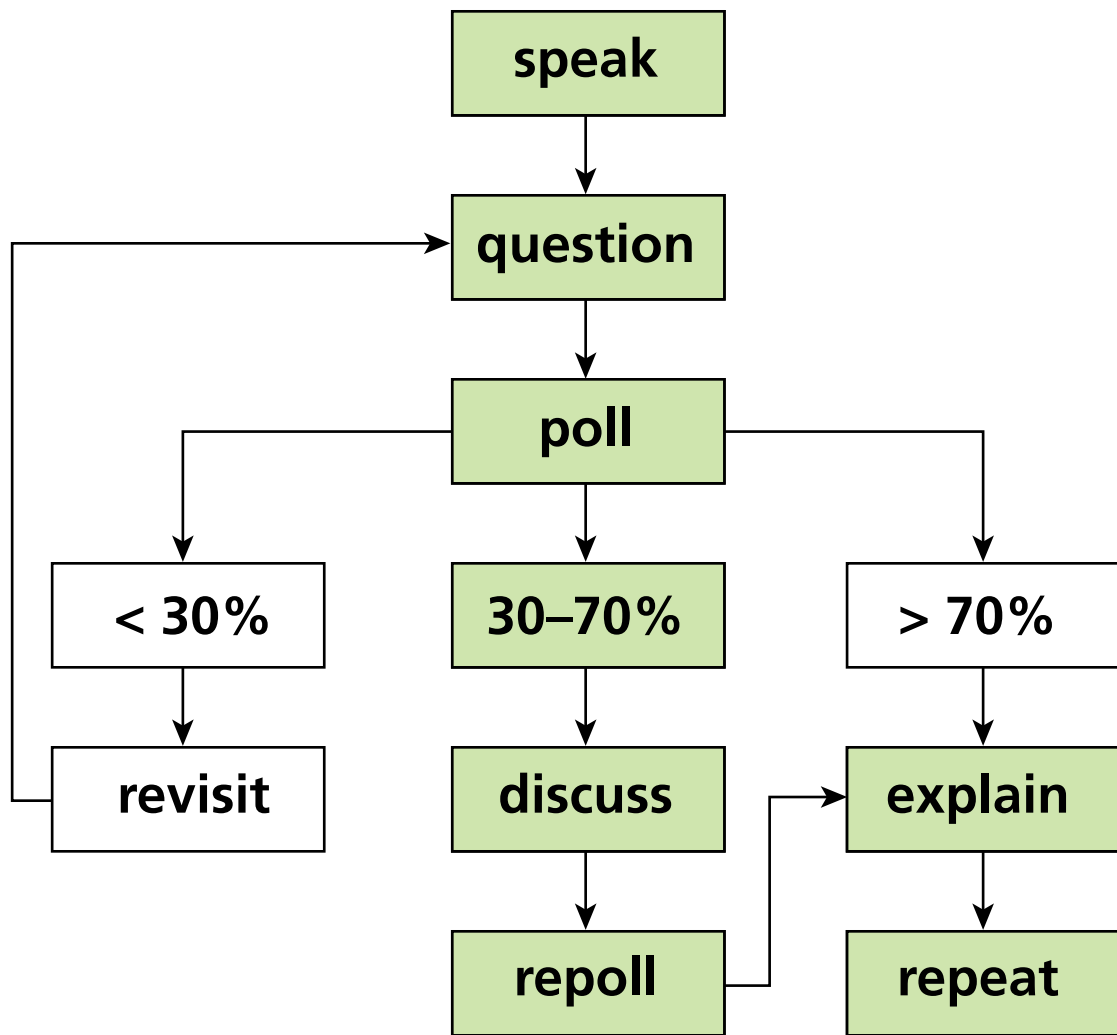


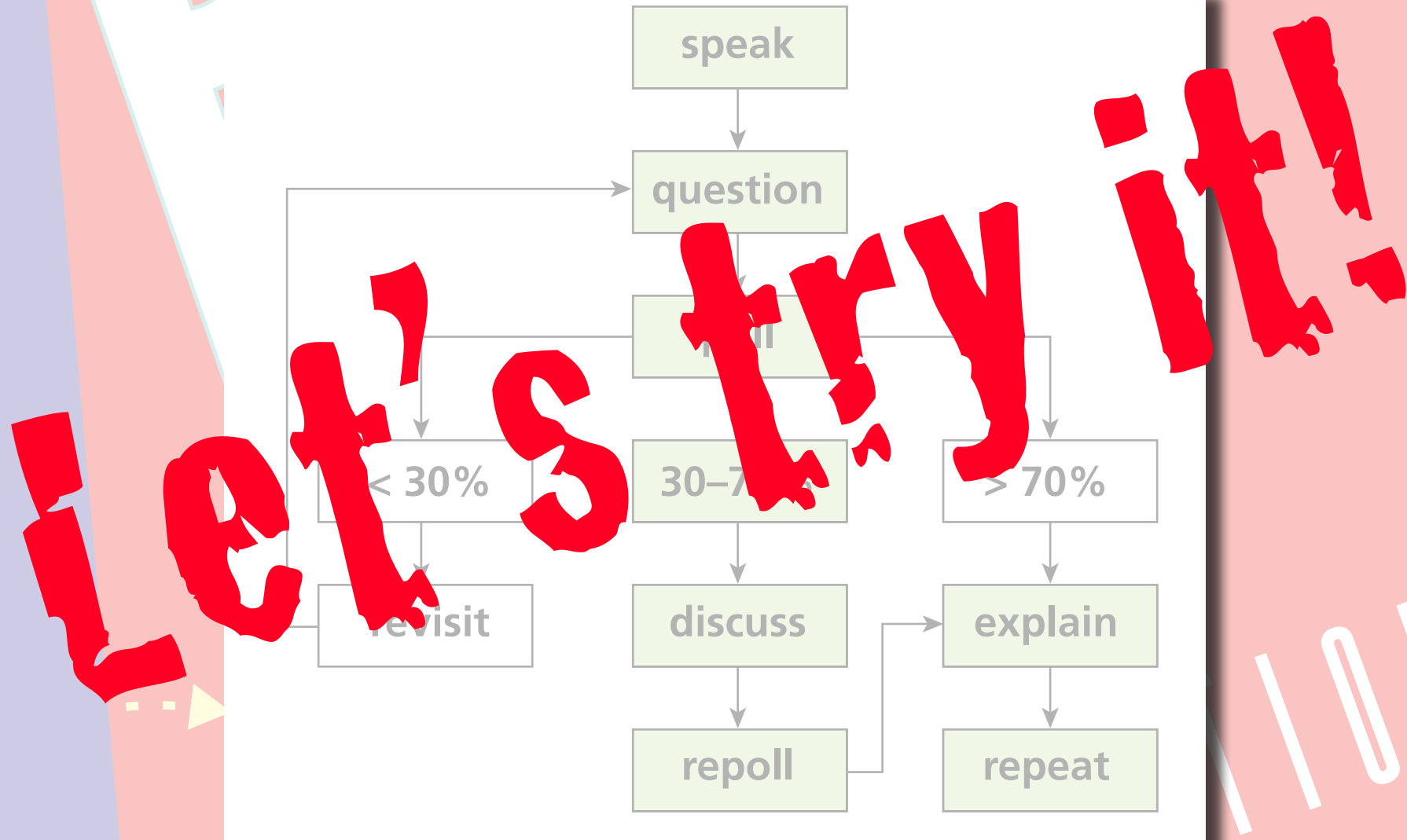








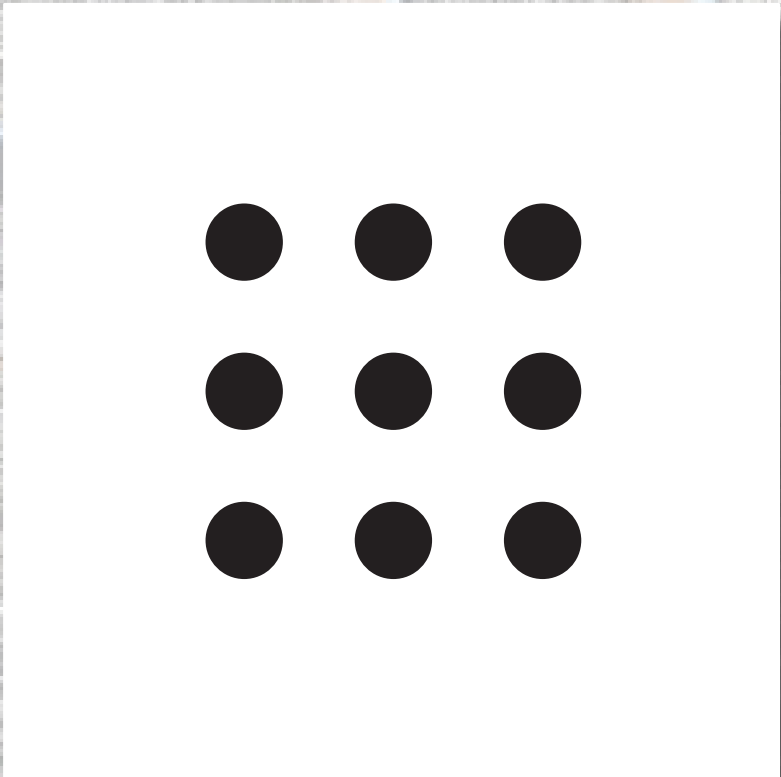


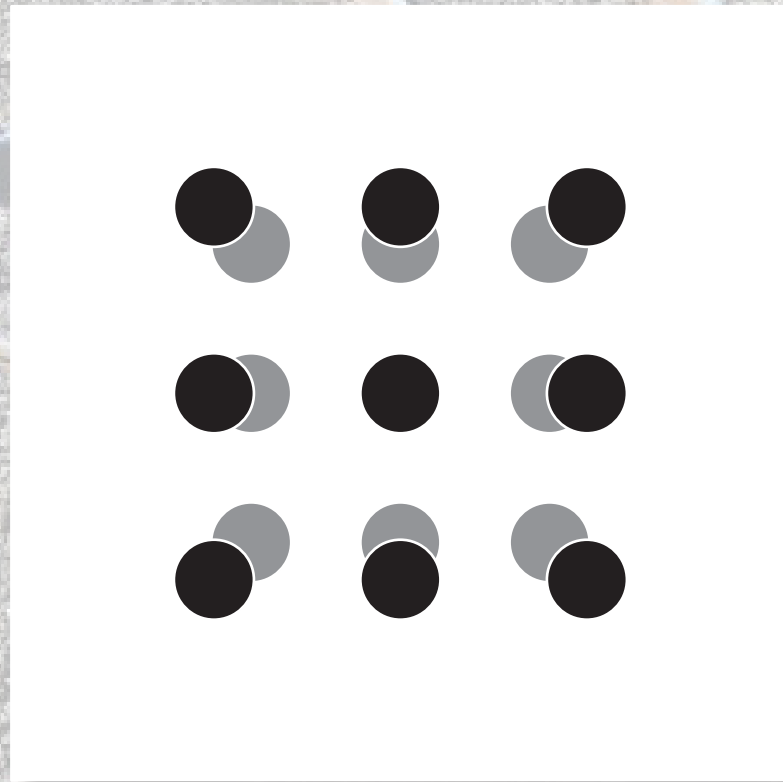




An aerial photograph showing a long, wavy metal expansion joint installed on a gravel surface. The joint is made of a dark, possibly steel, material and is designed to allow for thermal expansion and contraction. The gravel is a mix of grey and brown tones. The joint is set in a series of connected, rounded curves that run diagonally across the frame. The background shows a green lawn on either side of the gravel area.

**thermal expansion**

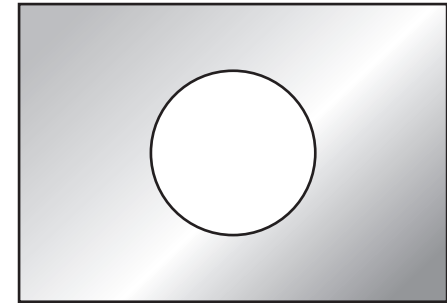




all of them

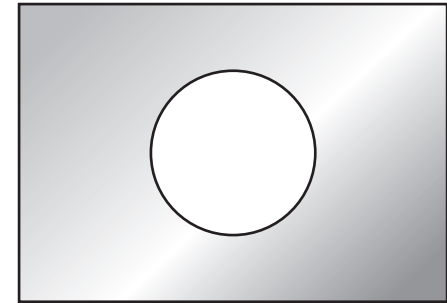
A white square is centered on the page, containing a 3x3 grid of black dots. Overlaid on this square and extending to the left and right is the text "all of them" in a large, red, stylized, handwritten-style font. The background of the entire slide is a photograph of a gravel path with several circular pits dug into it, set against a grassy area.

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



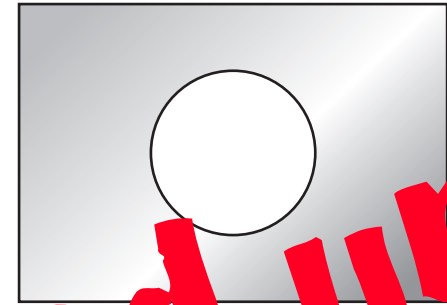
**Consider a rectangular metal plate with a circular hole in it.**

**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.



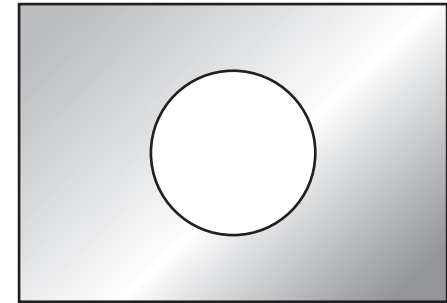
When the plate is uniformly heated, the diameter of the hole

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**

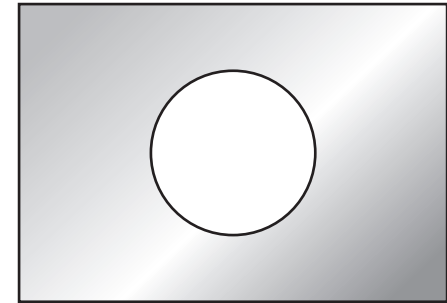
**Before I tell you the answer, let's analyze what happened.**

**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**

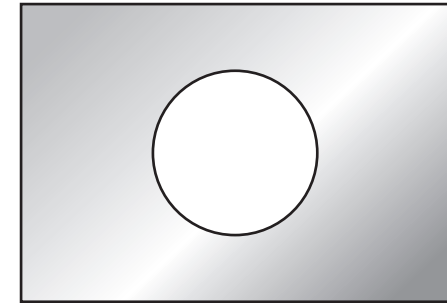
**Consider a rectangular metal plate with a circular hole in it.**

**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.**

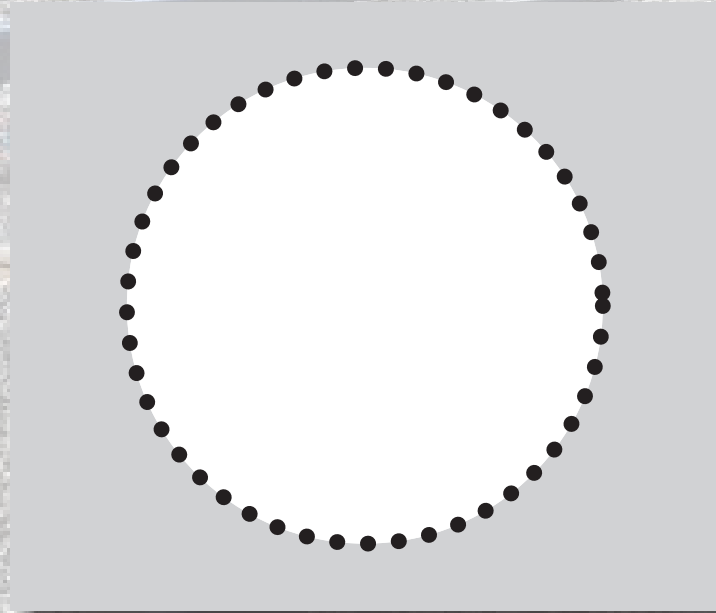


**When the plate is uniformly heated, the diameter of the hole**

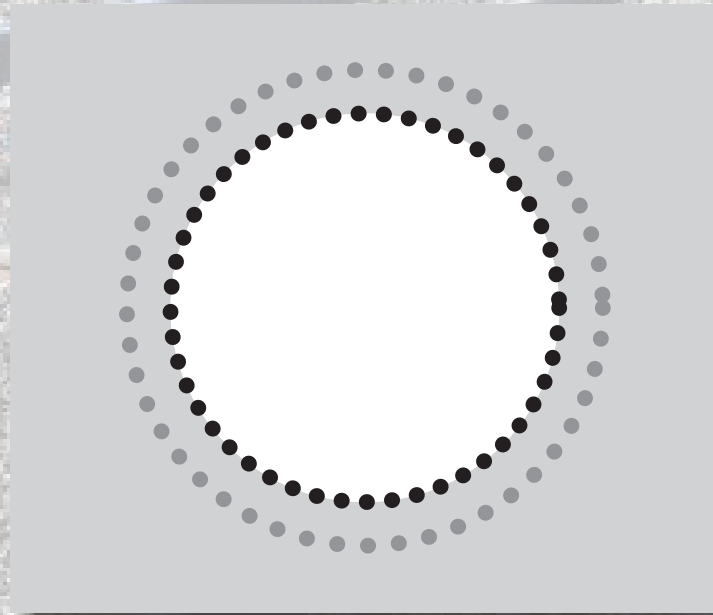
- 1. increases. ✓**
2. stays the same.
3. decreases.



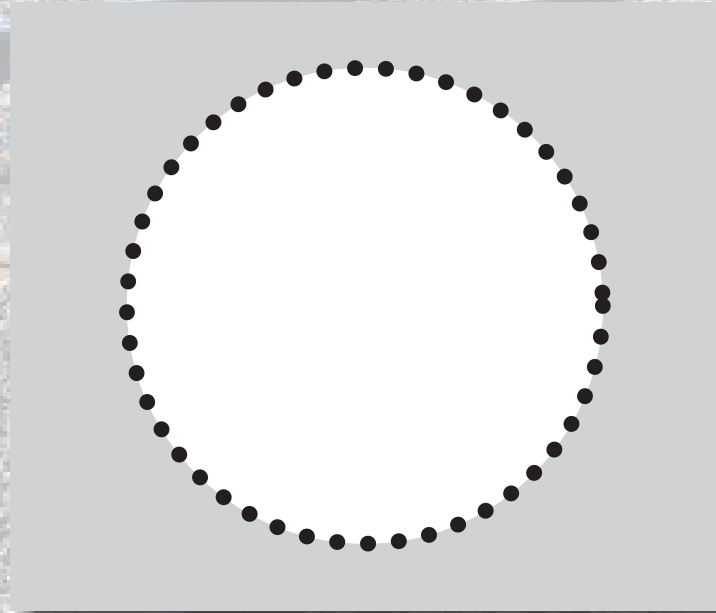
consider atoms at rim of hole



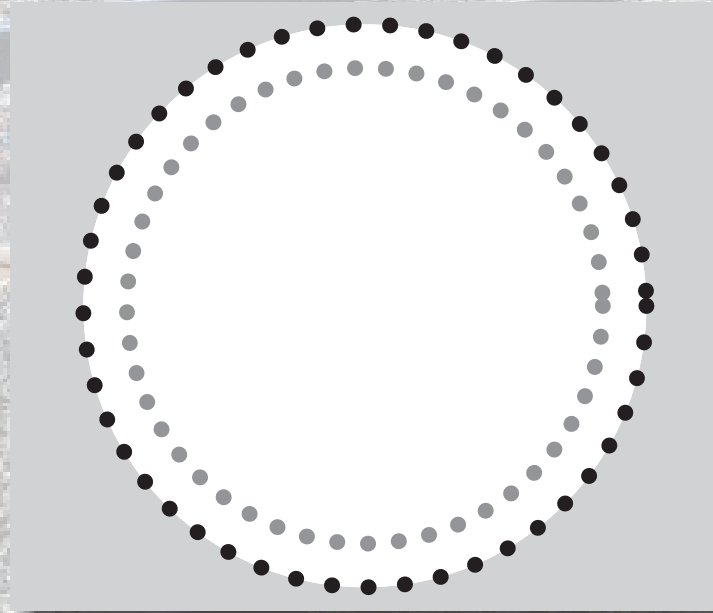
consider atoms at rim of hole



consider atoms at rim of hole



consider atoms at rim of hole



consider atoms at rim of hole

**you won't forget this**

A diagram of a circular hole with a dotted border, overlaid on a background of a winding path in a field. The text "you won't forget this" is written in a large, red, stylized font across the diagram.

# Peer

back to pi

INSTRUCTION

# Peer INSTRUCTION

1 lecture

2 PI

Peer  
**Higher learning & gains**

INSTRUCTION

1 lecture

2 PI



**Higher learning gains**

**Better retention**

**INSTRUCTION**



**Join now!**

**PeerInstruction.net**

1. Go to [learningcatalytics.com/demo](https://learningcatalytics.com/demo)
2. Enter info, click "Start"
3. Join session 123456789

EDUCACION



**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

1 lecture

2 PI

3 PI 2.0

A black handheld device, possibly a remote control or a small keypad, is shown at an angle. It features a numeric keypad with buttons labeled 1 through 9, 0, and a red button. A green logo with the letters 'FRS' is visible on the bottom right. The year '1998' is overlaid in large white text in the center.

# 1998





1 lecture

2 PI

3 PI 2.0



# technology

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...

learning | catalytics

- improve questioning
- manage discussions
- facilitate time management/flow

- 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. capital
  - c. market research
  - d. depreciation?

## extensible plug-in architecture for question types

- 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 over 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.  $Assets = Liabilities + Owners' equity$
- b.  $Liabilities = Assets + Owners' equity$
- c.  $Owner's equity = Assets + Liabilities$
- d.  $Revenue = Assets - Liabilities$

4. In order to present a business plan to a group of potential investors, a businessperson should most likely use which of the following?

- a. Powerpoint
- b. Quickbooks
- c. Peoplesoft
- d. Excel

5. In order to start an online business, an individual would need all but which of the following:

business model



## 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



**1** [learningcatalytics.com/demo](https://learningcatalytics.com/demo) **2** enter info **3** ID 123456789

# learning | catalytics

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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

2

3

4

5

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7

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9

10

11

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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current session: **766079** | 69 students

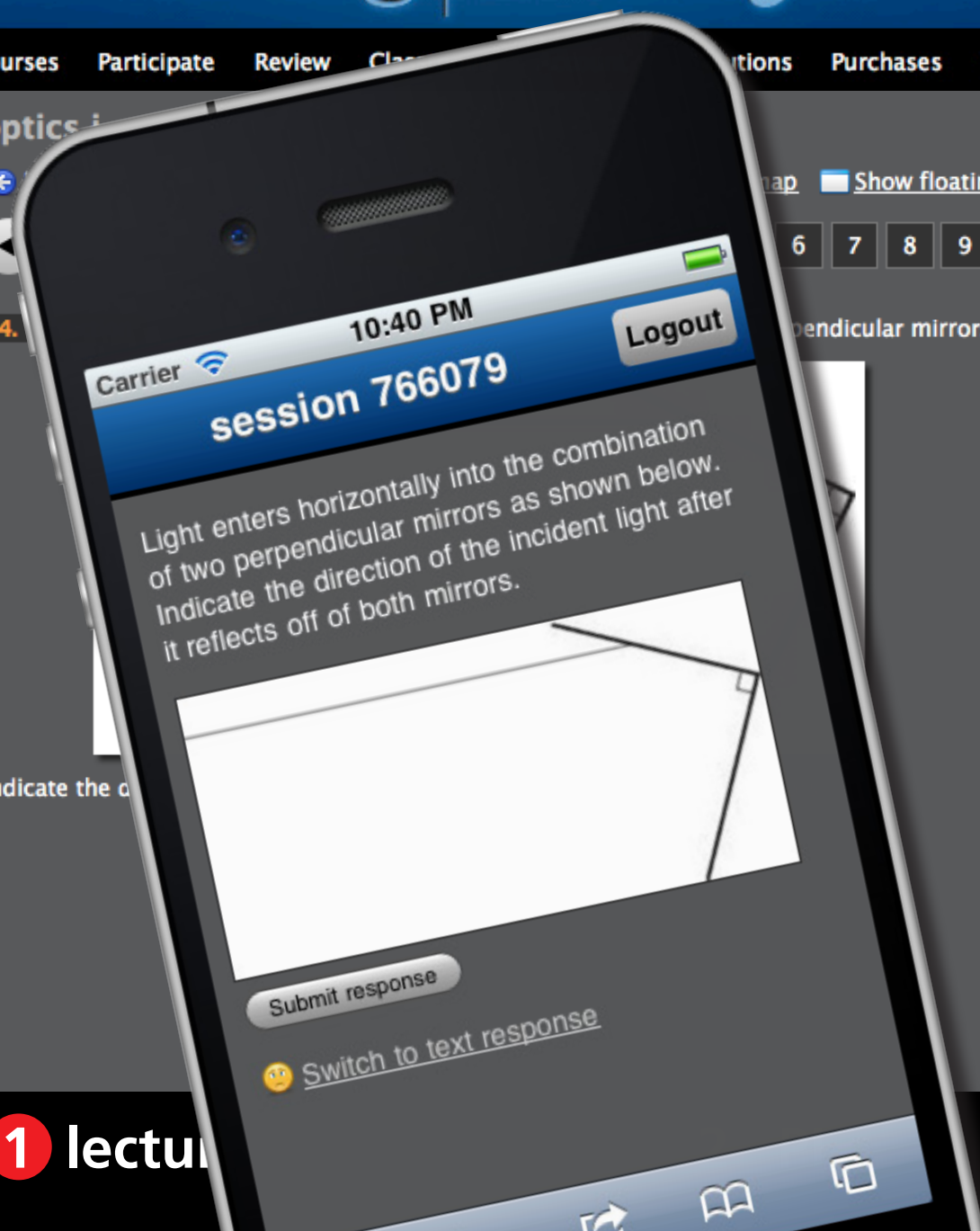
[Map](#) [Show floating session ID](#) [Edit](#) [Delete](#)

6 7 8 9 10 11 12 13 14 15

perpendicular mirrors as shown below.

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[feedback & support](#)



1 lecture

3 PI 2.0

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current session: **766079** | 69 students

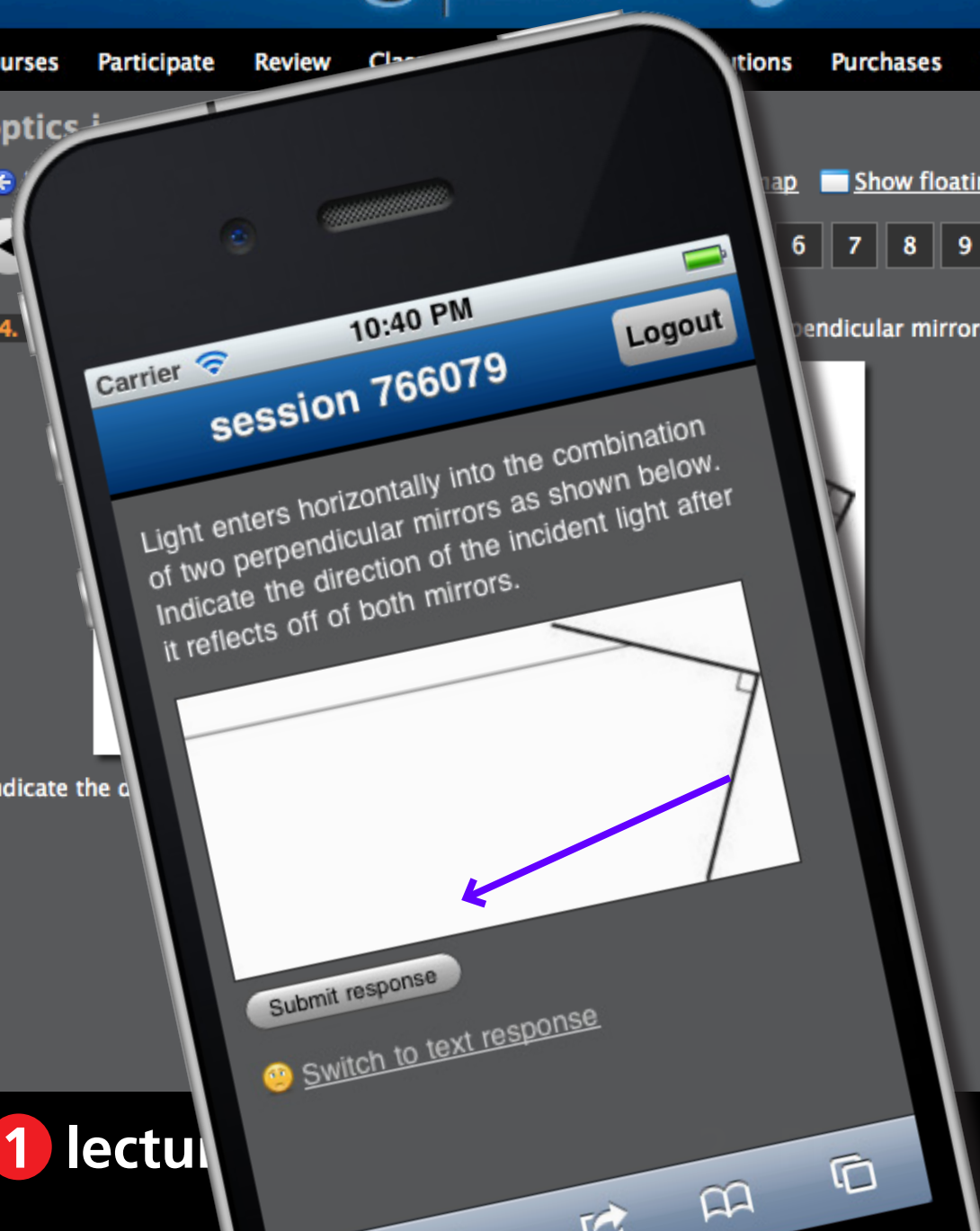
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6 7 8 9 10 11 12 13 14 15

perpendicular mirrors as shown below.

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[feedback & support](#)



1 lecture

3 PI 2.0

# learning | catalytics

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current session: **766079** | 69 students

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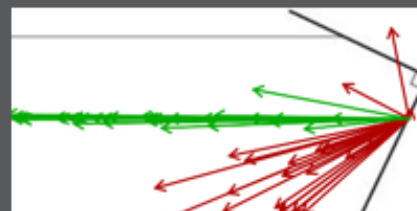
6 7 8 9 10 11 12 13 14 15



perpendicular mirrors as shown below.

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

Round 1   
● 57 responses, 58% correct



[feedback & support](#)



1 lecture

3 PI 2.0

# learning | catalytics

Courses Participate Review Classifications Purchases Users Tour Help

current session: **766079** | 69 students

Map  Show floating session ID  Edit  Delete

6 7 8 9 10 11 12 13 14 15

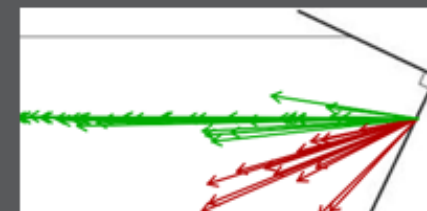
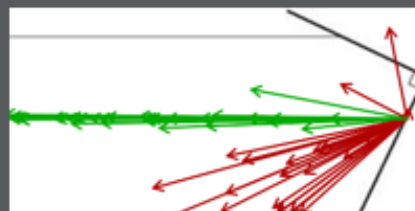


perpendicular mirrors as shown below.

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

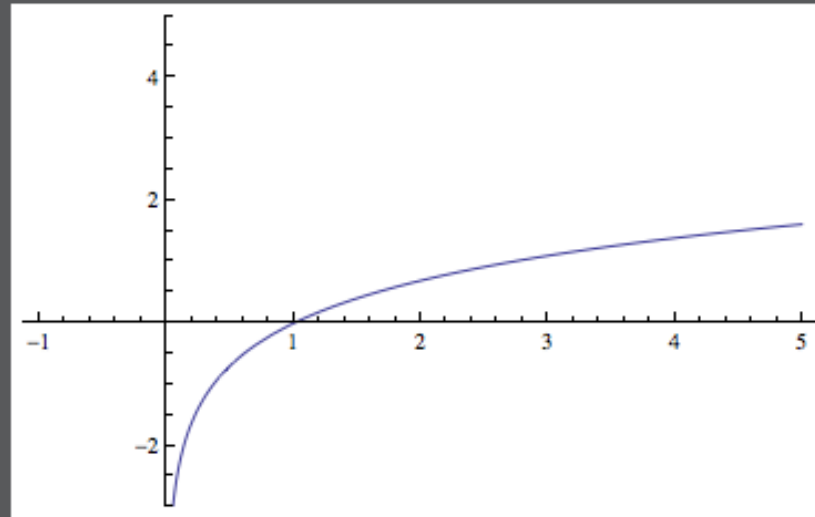
**If  $2x - y = 4$ , then  $x =$**



# learning | catalytics

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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

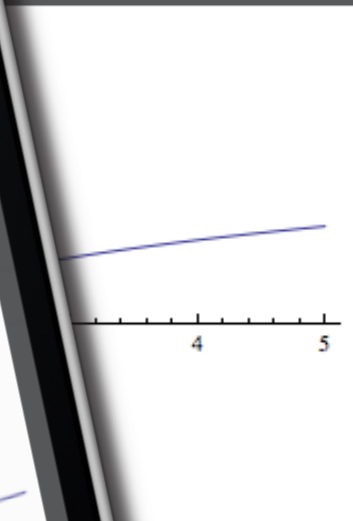
**3** PI 2.0

# learning | catalytics

Courses Participate

ases Users Tour Help

This is a graph of  $f(x) =$



**1** lecture

**3** PI 2.0

# learning | catalytics

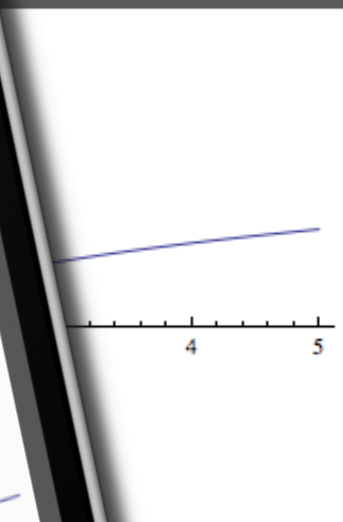
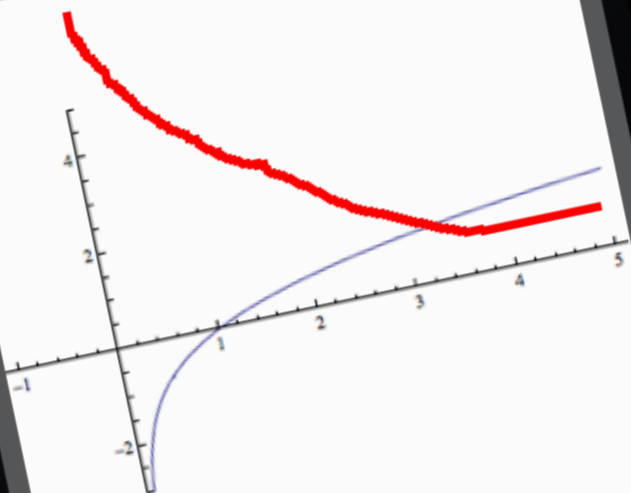
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This is a graph of  $f(x) =$

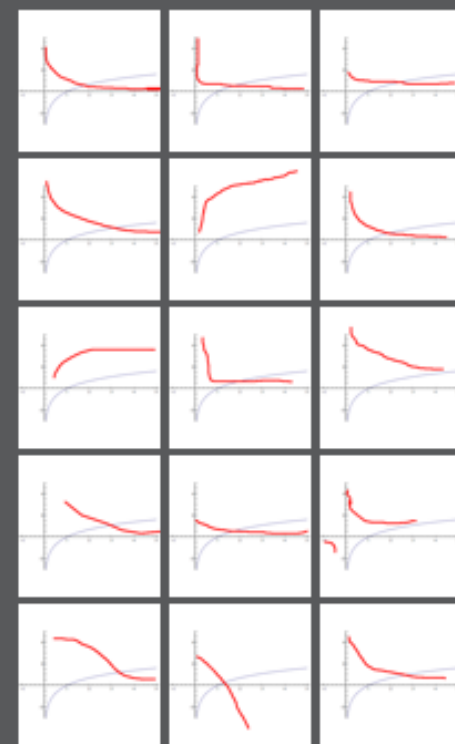


This is a graph of  $f(x) = \ln x$ . Sketch a graph of the derivative  $f'(x)$ .



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

current session: **773885** | 9 students

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Jump to ▾

1

2

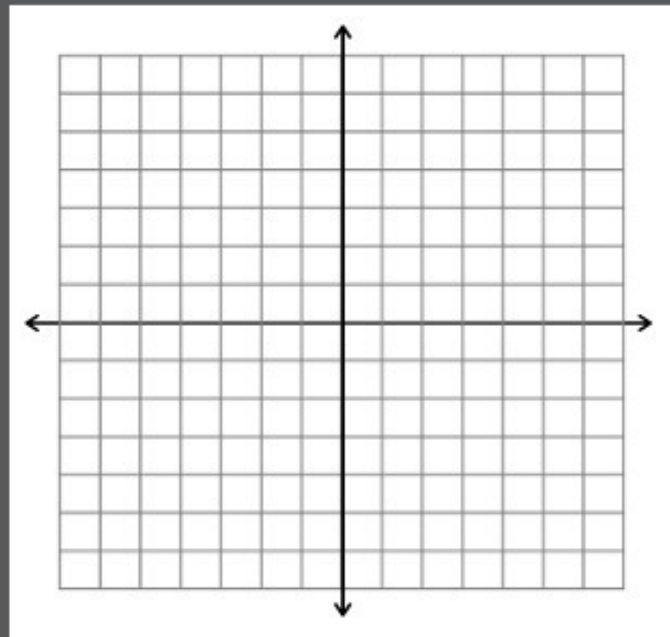
3

4



4. sketch Sketch a graph of the function  $f(x) = (x - 3)^2 + 2$ .

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1 lecture

2 PI

3 PI 2.0

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## transformations of parabolas

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1

2

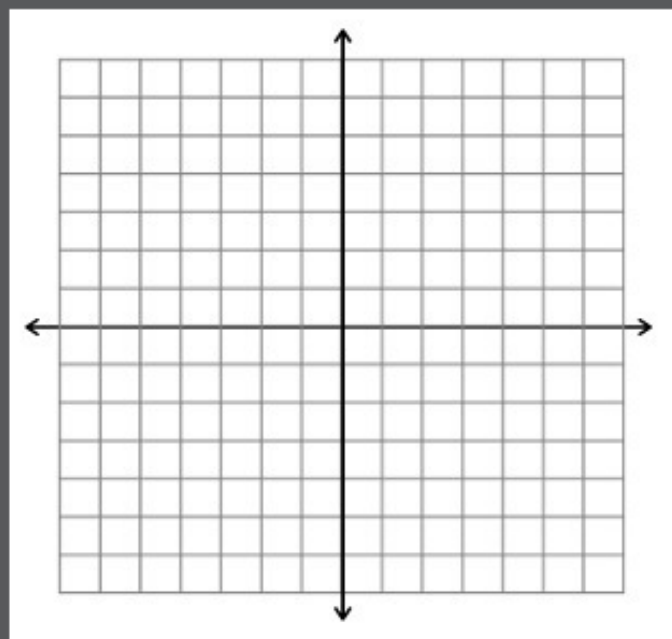
3

4



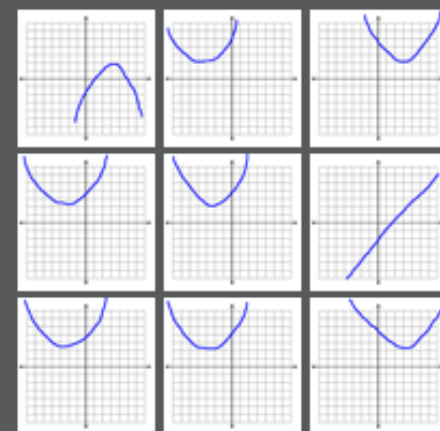
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Round 1

9 responses



1 lecture

2 PI

3 PI 2.0

# learning | catalytics

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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

# learning | catalytics

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1. highlighting  
sonnet?

[his Shakespeare](#) [Stop delivery](#) [Deliver again](#) [Assign groups](#) [Show all results](#)



1 lecture

3 PI 2.0

# learning | catalytics

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1. highlighting  
sonnet?

this Shakespeare

[Stop delivery](#)

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[Assign groups](#)

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## Round 1

3 responses

For shame! deny that thou bear'st  
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**Seeking that beauteous roof to  
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Which to repair should be thy  
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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 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,  
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1 lecture

3 PI 2.0



## 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

**data analytics**



1 lecture

2 PI

3 PI 2.0



# human interaction

1 lecture

2 PI

3 PI 2.0

Carrier 9:31 PM 100%

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Jump to 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

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:

1 lecture

2 PI

3 PI 2.0

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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 as illustrated below. The potential difference from A to B is

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**Round 1**  
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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: \_\_\_\_\_

1 lecture

2 PI

3 PI 2.0

Carrier 9:31 PM 100%

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Search:

1 lecture

2 PI

3 PI 2.0

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# learning catalytics

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D. 0%
E. 0%

Search: \_\_\_\_\_

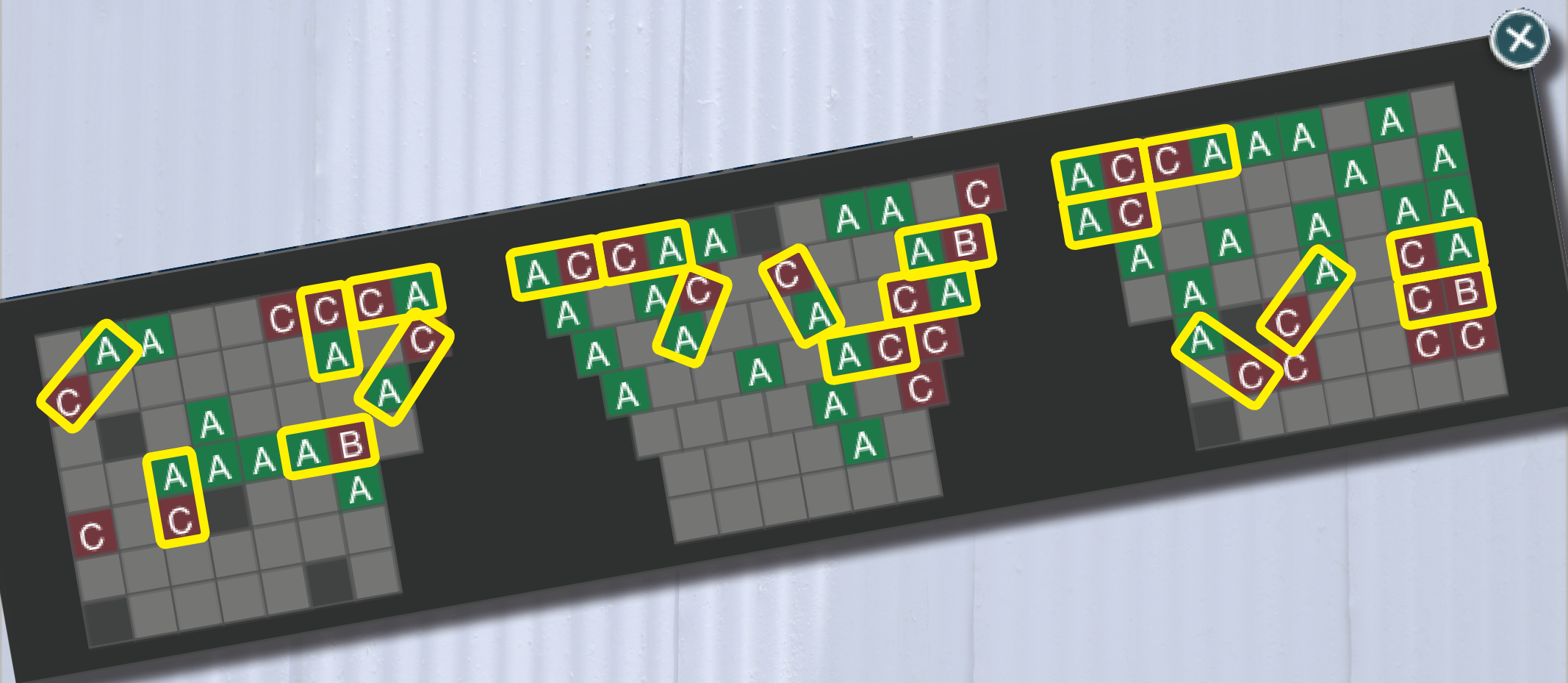
1 lecture

2 PI

3 PI 2.0

let system manage pairing



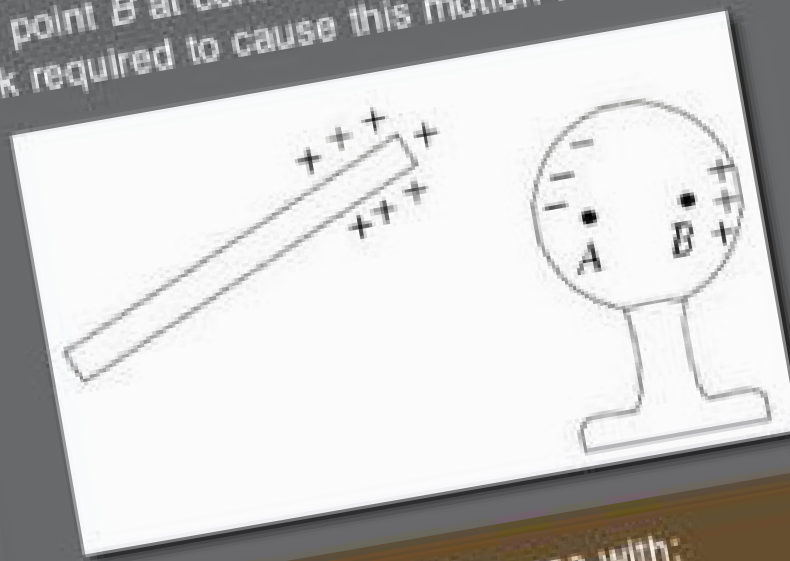


1 lecture

2 PI

3 PI 2.0

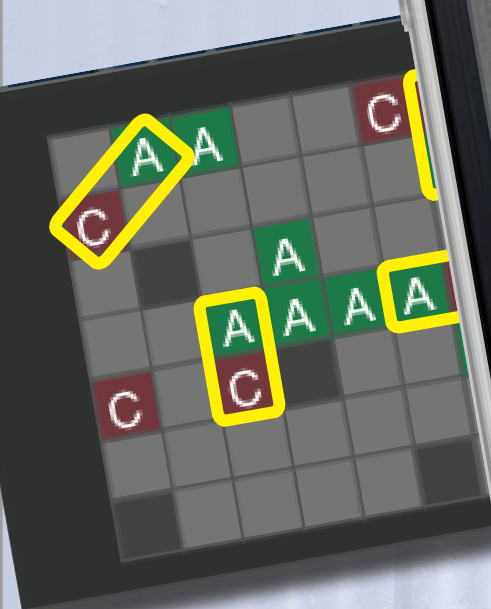
A positively charged rod is held near a neutral conducting sphere as illustrated below. A positively charged particle is moved from point A to point B at constant speed. The mechanical work required to cause this motion is



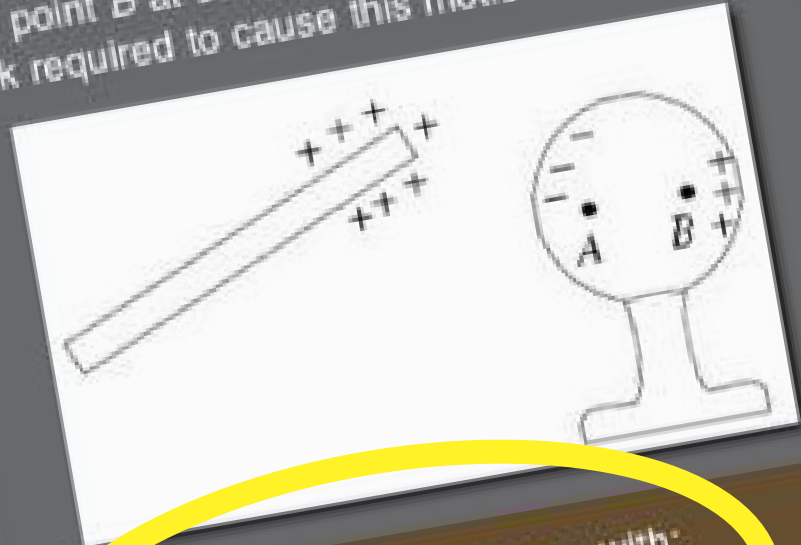
Please discuss your response with:

- Brian Lukoff (to your left)

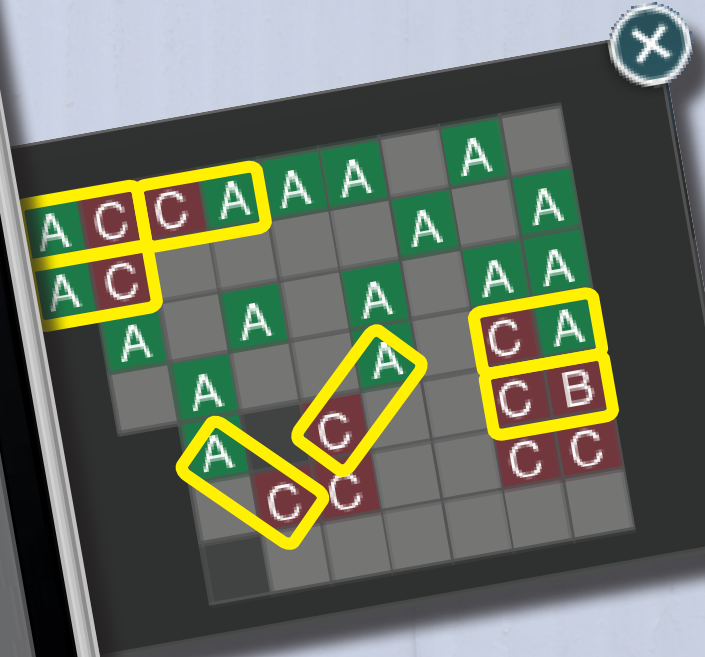
I am talking to this person/people

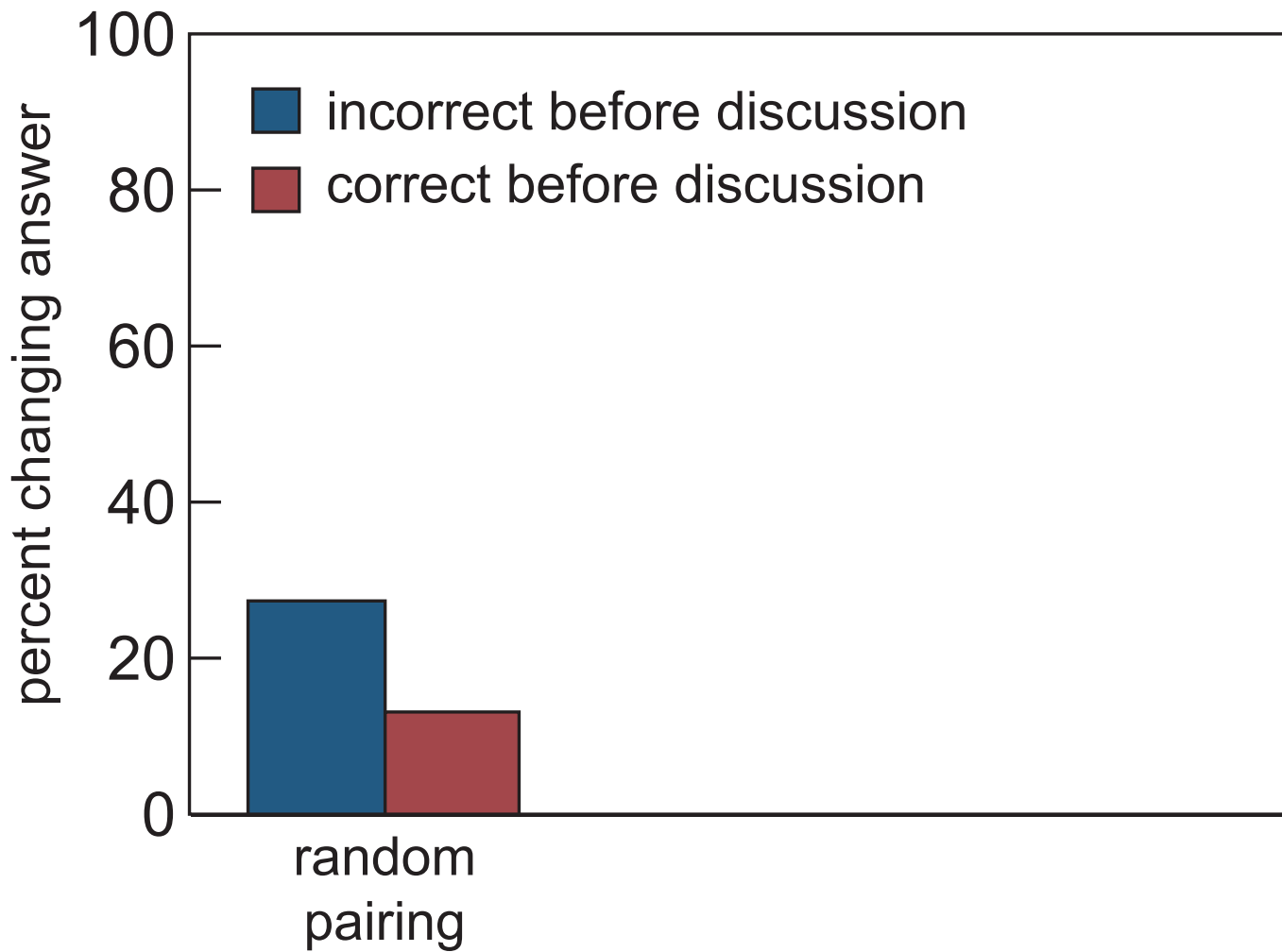


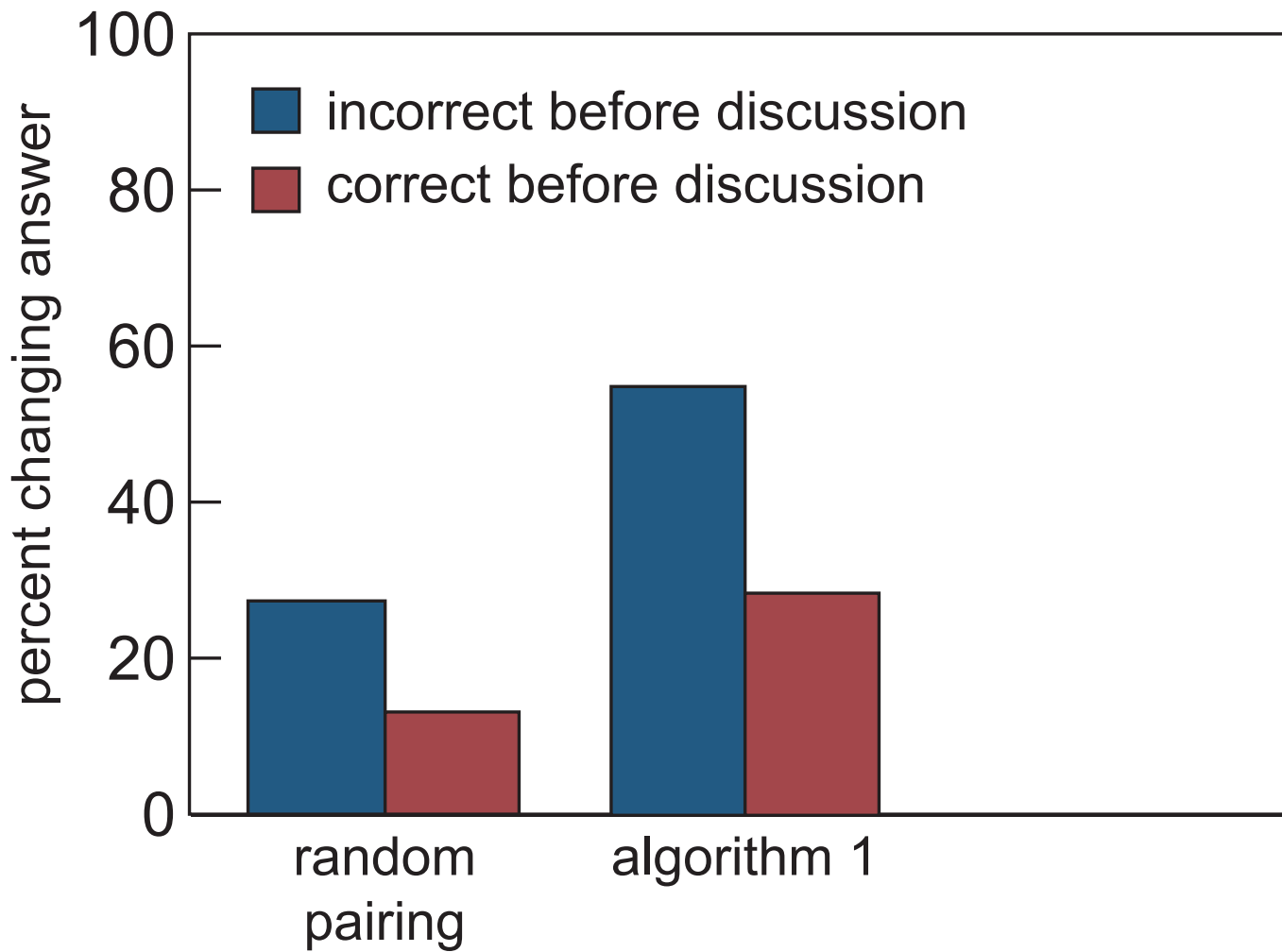
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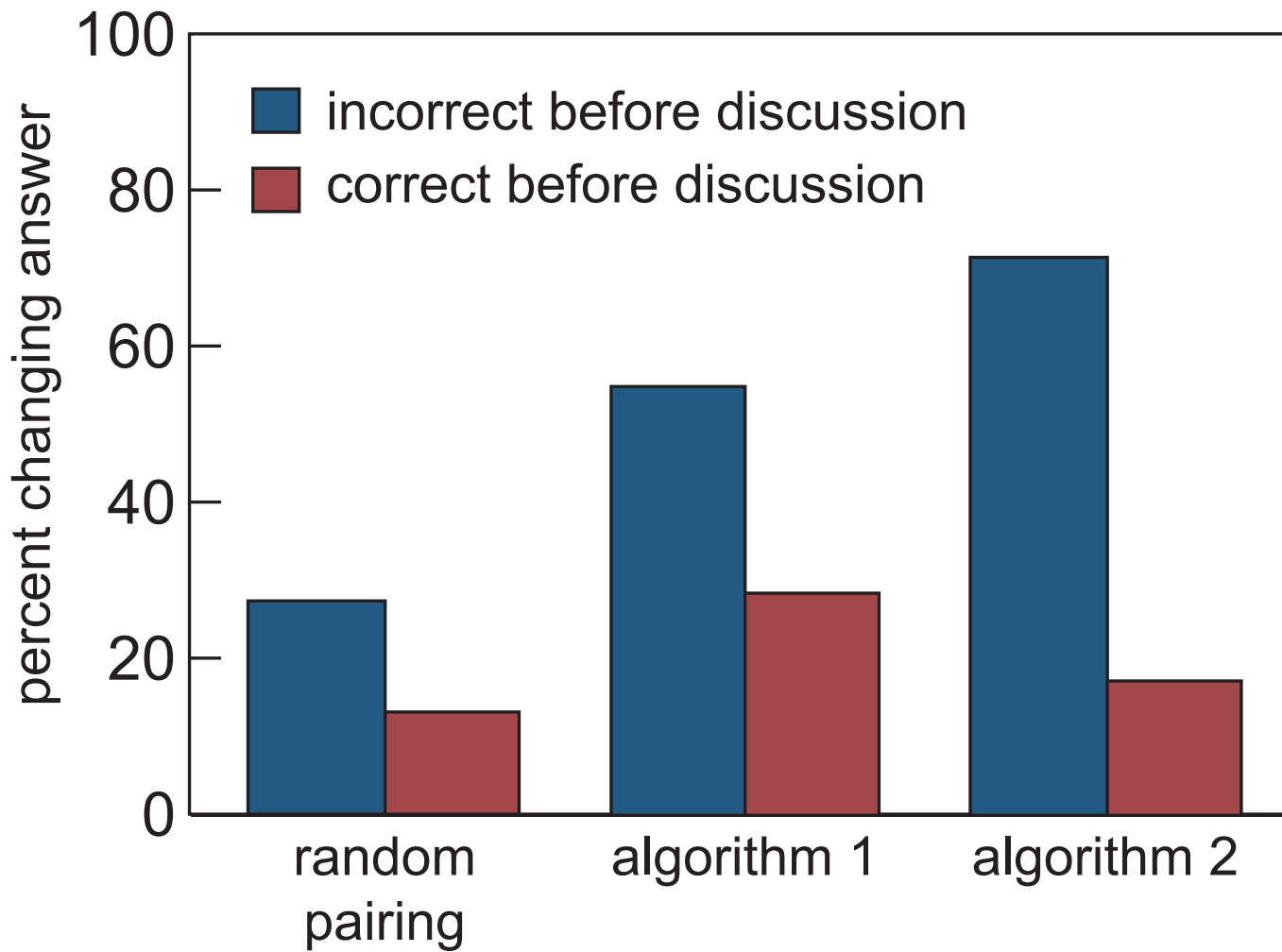


Please discuss your response with:  
• Brian Lukoff (to your left)











**1** lecture

**2** PI

**3** PI 2.0

in a lecture, students...

**1** lecture

**2** PI

**3** PI 2.0

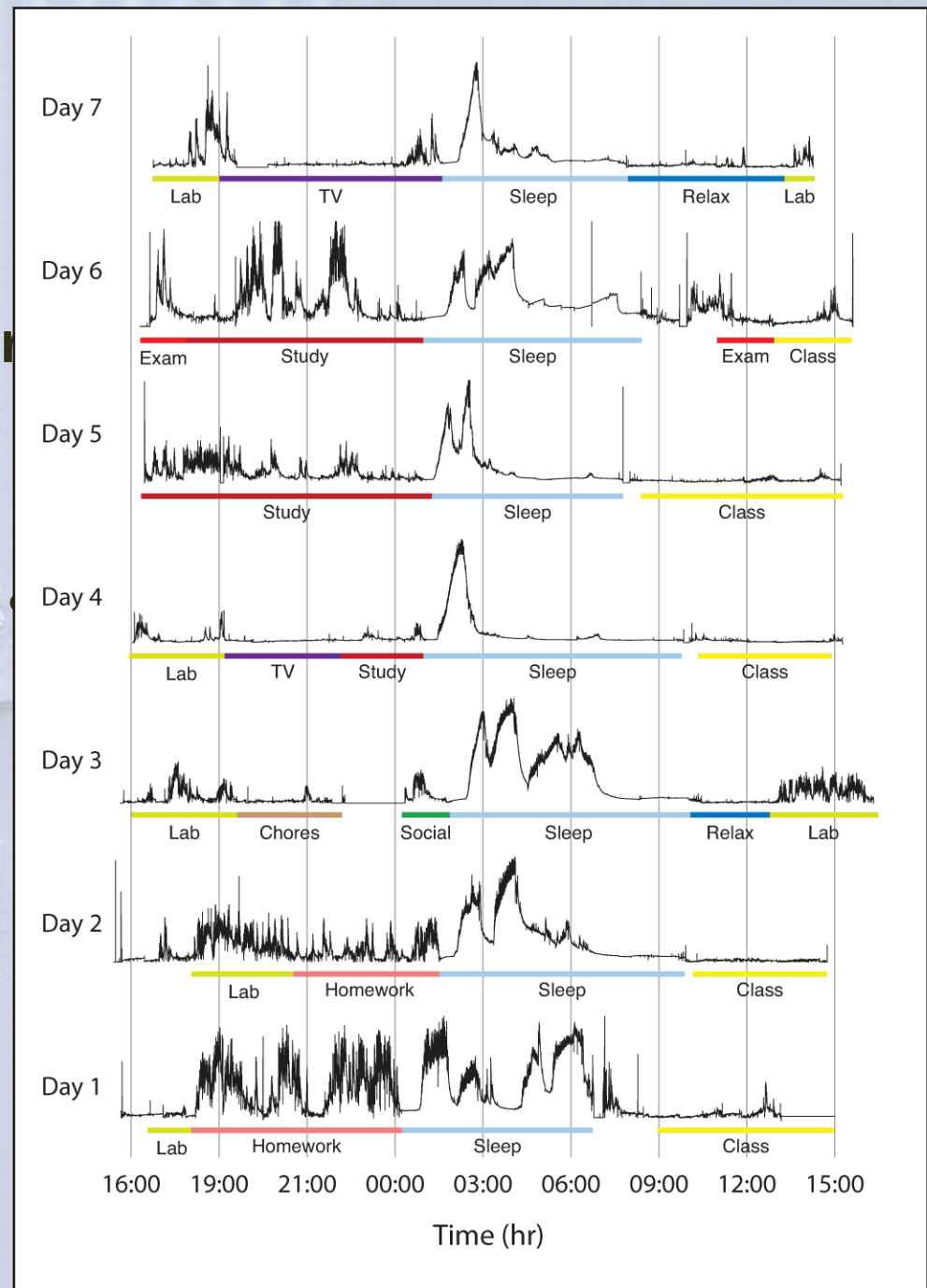


**in a lecture, students...**

**1. don't pay utmost attention**

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

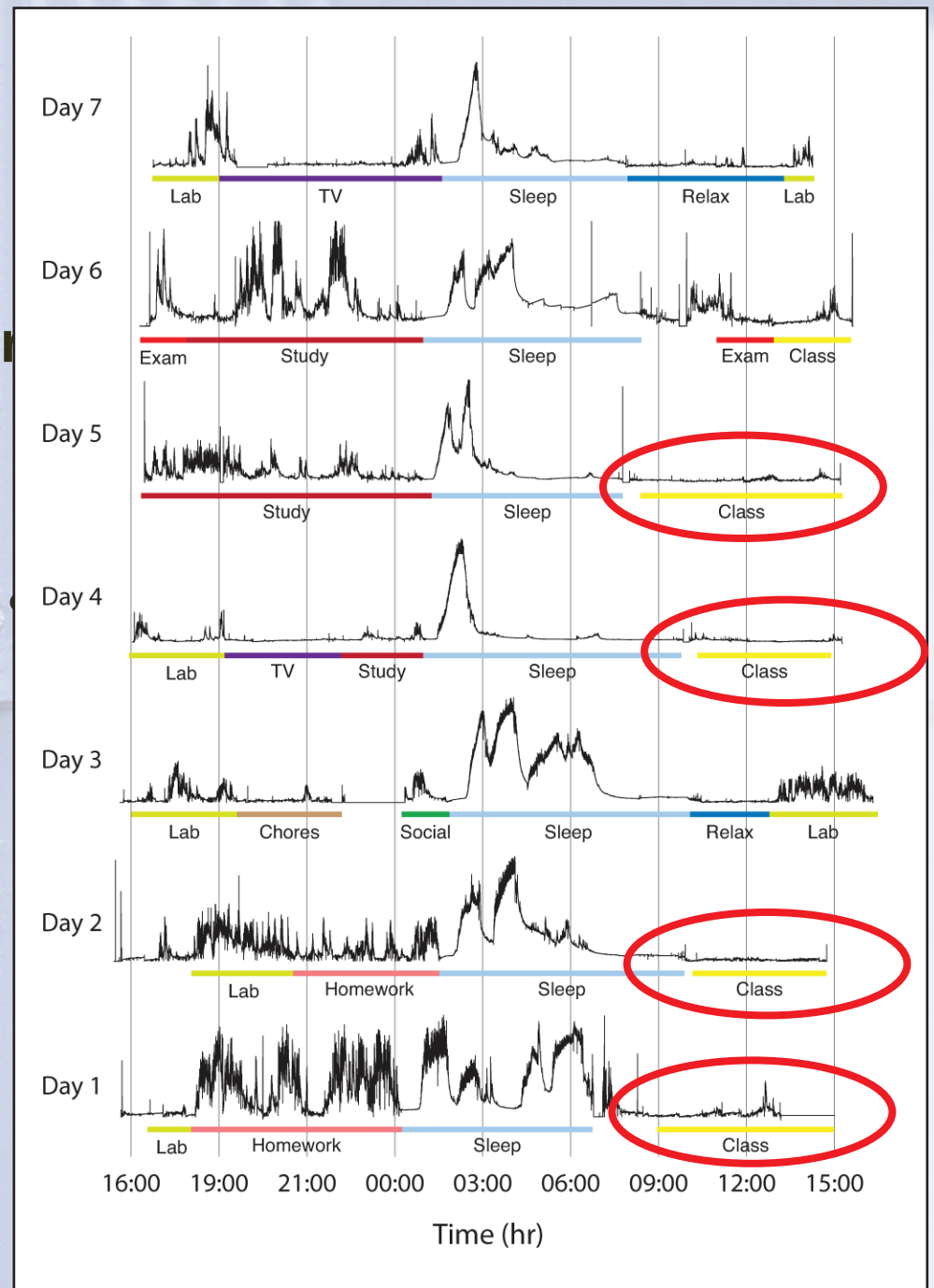
1 lecture

2 PI

3 PI 2.0

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

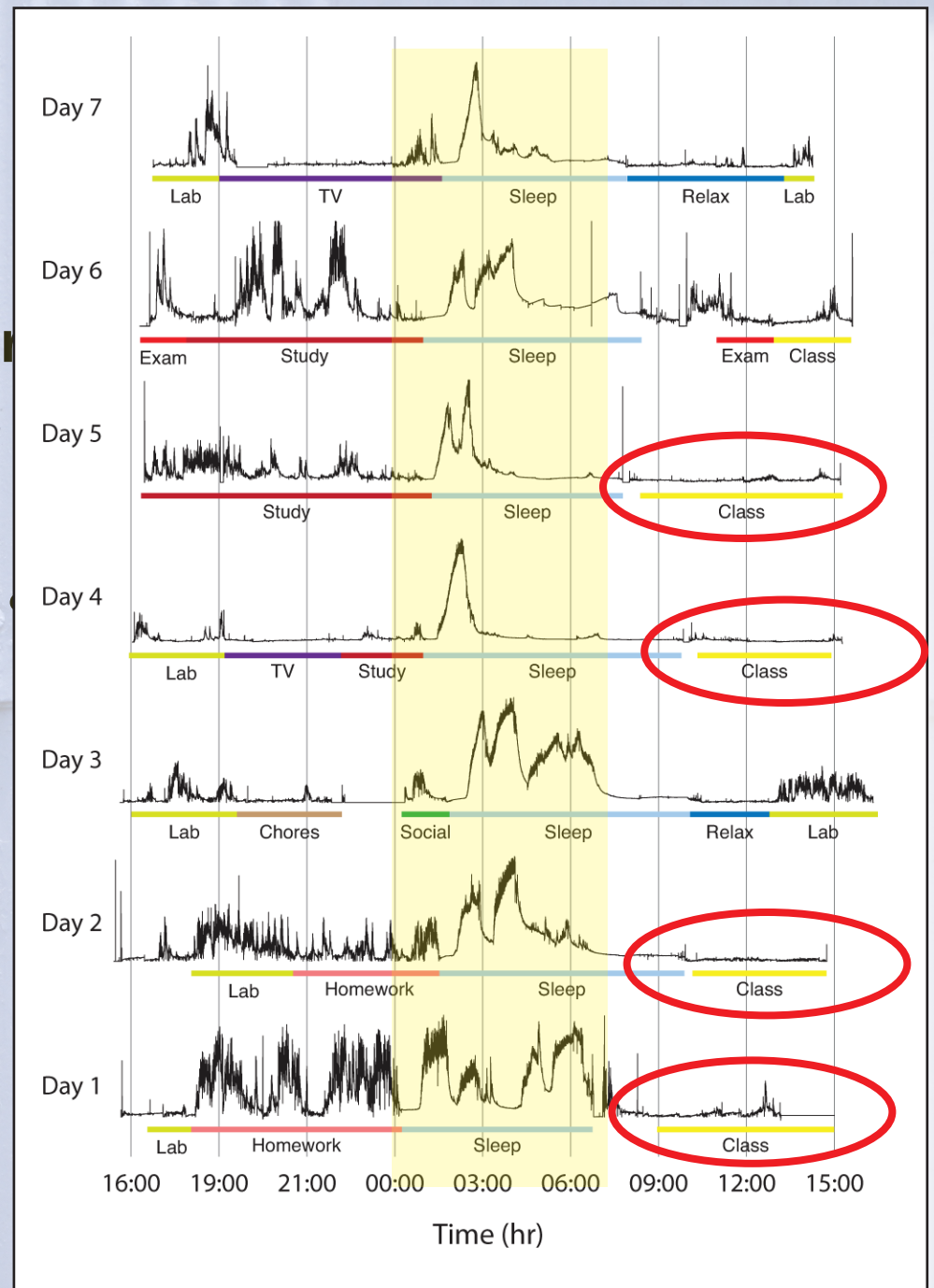
1 lecture

2 PI

3 PI 2.0

in a lecture

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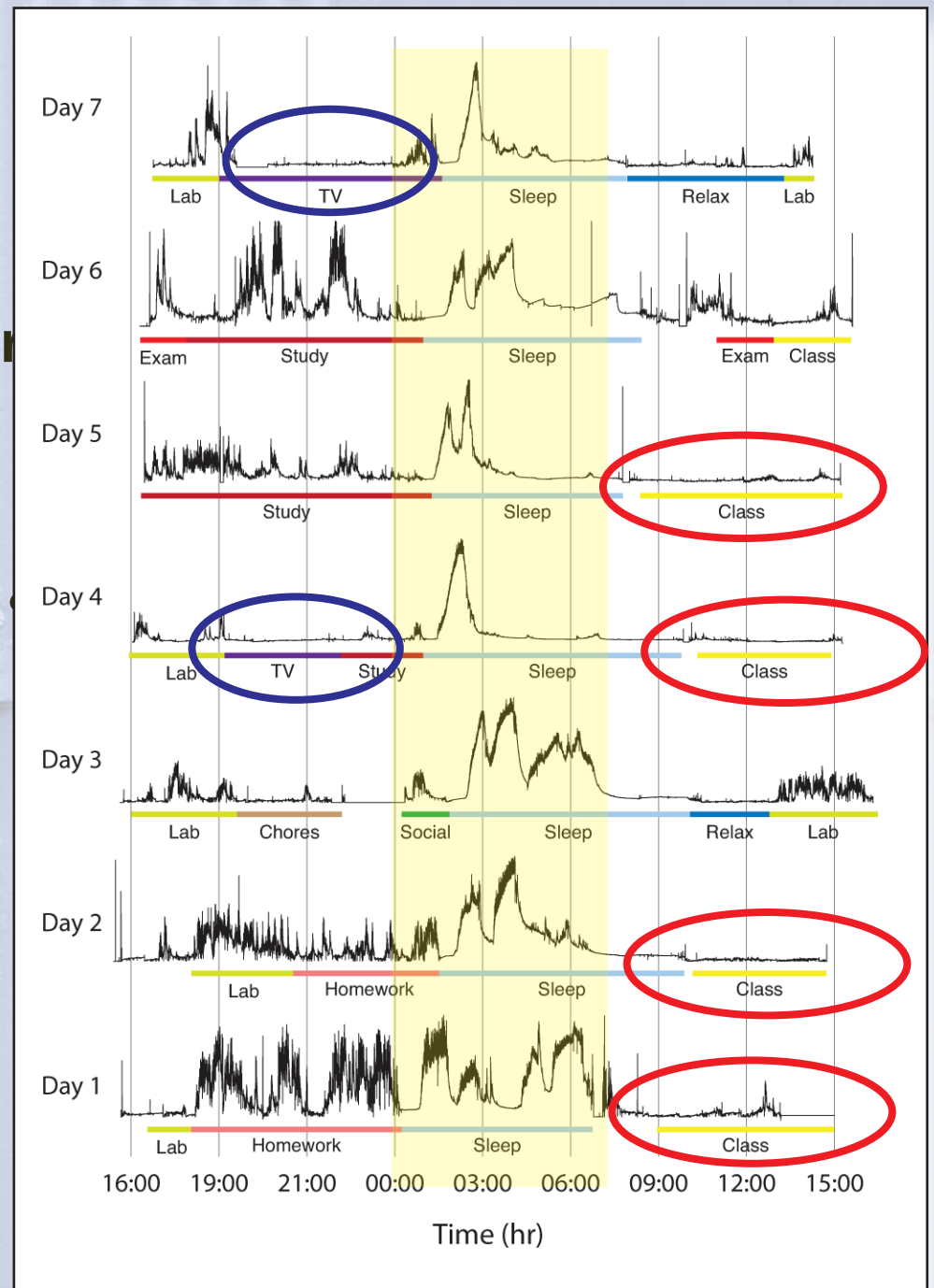
1 lecture

2 PI

3 PI 2.0

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

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:**

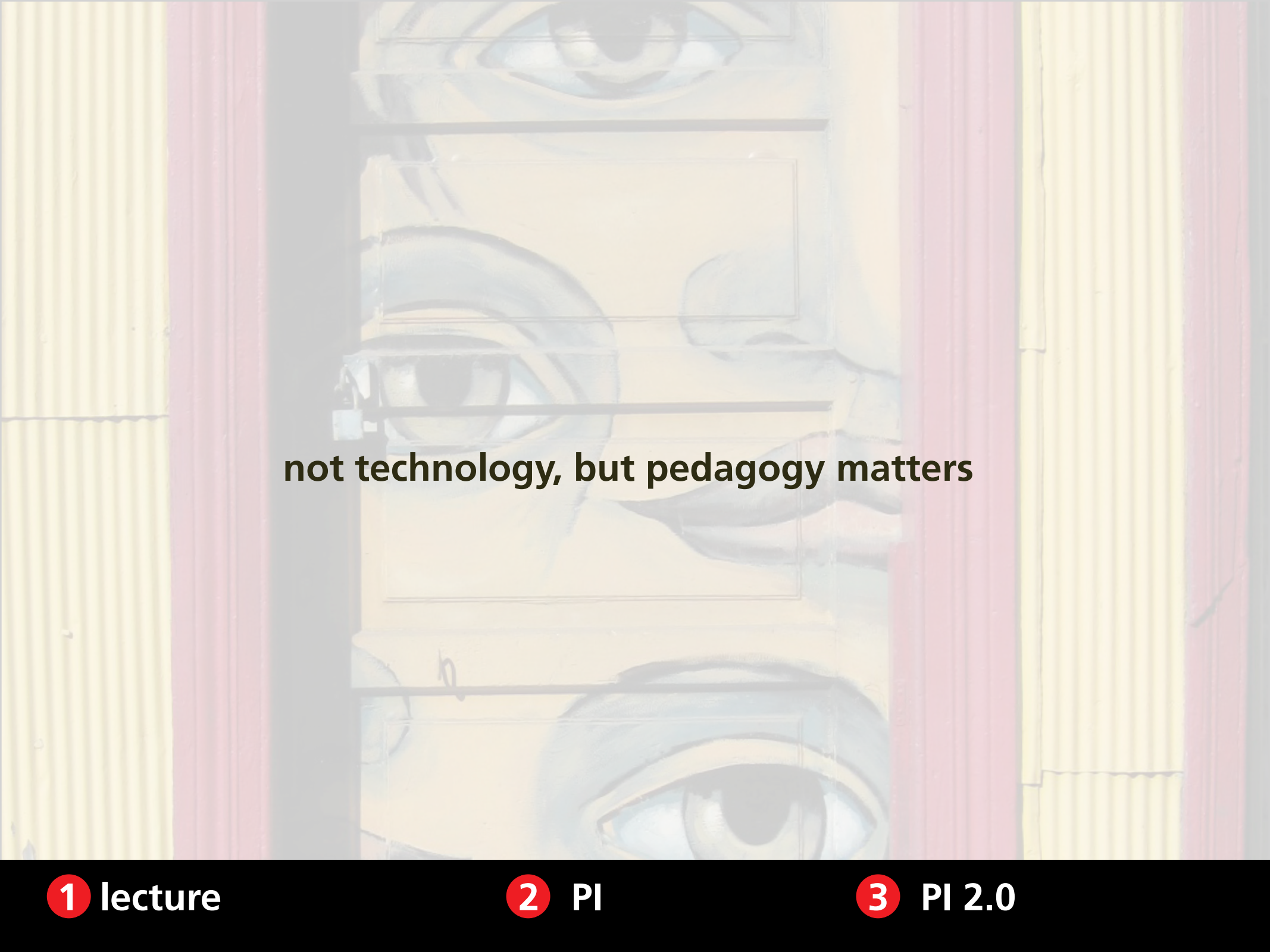
- **transferring information**
- **getting students to do what we do**



**Education is not just about:**

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

**discovery & exploration a must!**

A painting of a face with three eyes looking through window blinds. The face is rendered in a soft, painterly style with muted colors. The eyes are positioned behind horizontal white blinds, with the top and bottom eyes looking directly forward and the middle eye looking slightly to the right. The background consists of vertical yellow and red stripes, suggesting window frames or curtains.

**not technology, but pedagogy matters**

**1** lecture

**2** PI

**3** PI 2.0



## 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:**

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