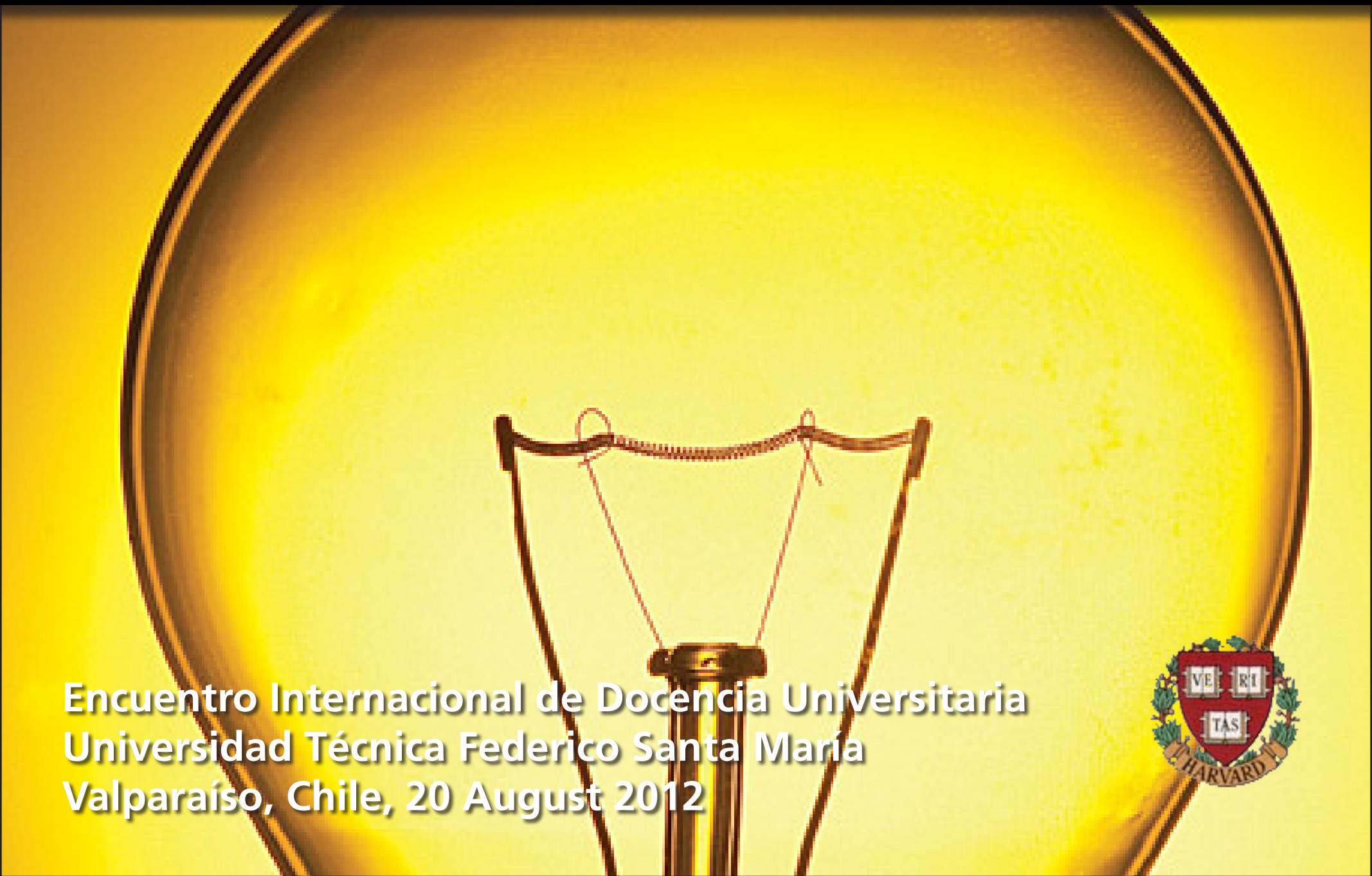
Educating the innovators of the 21st century



Encuentro Internacional de Docencia Universitaria
Universidad Técnica Federico Santa María
Valparaíso, Chile, 20 August 2012

Educating the innovators of the 21st century

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Universidad Técnica Federico Santa María
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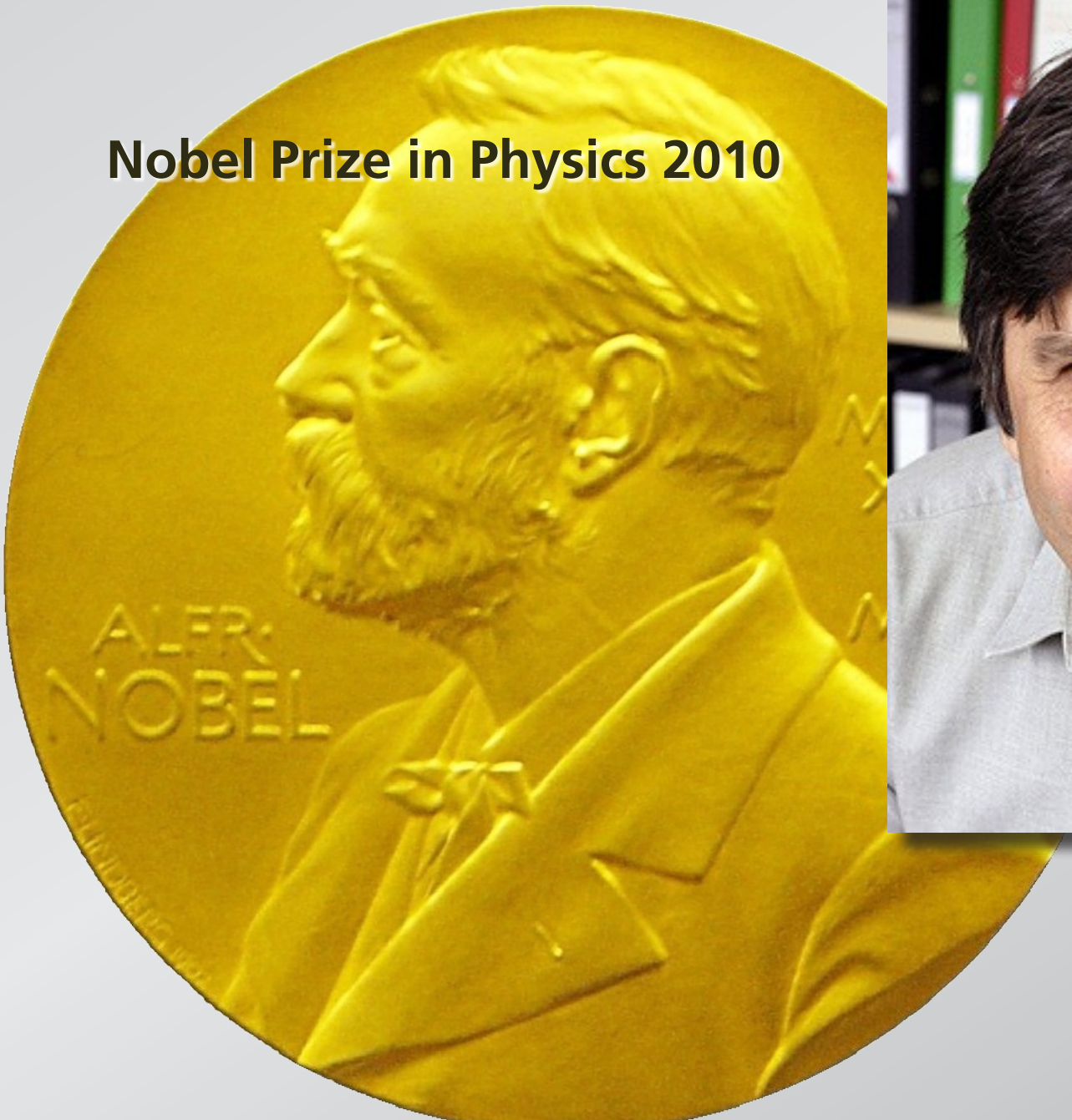
Innovation

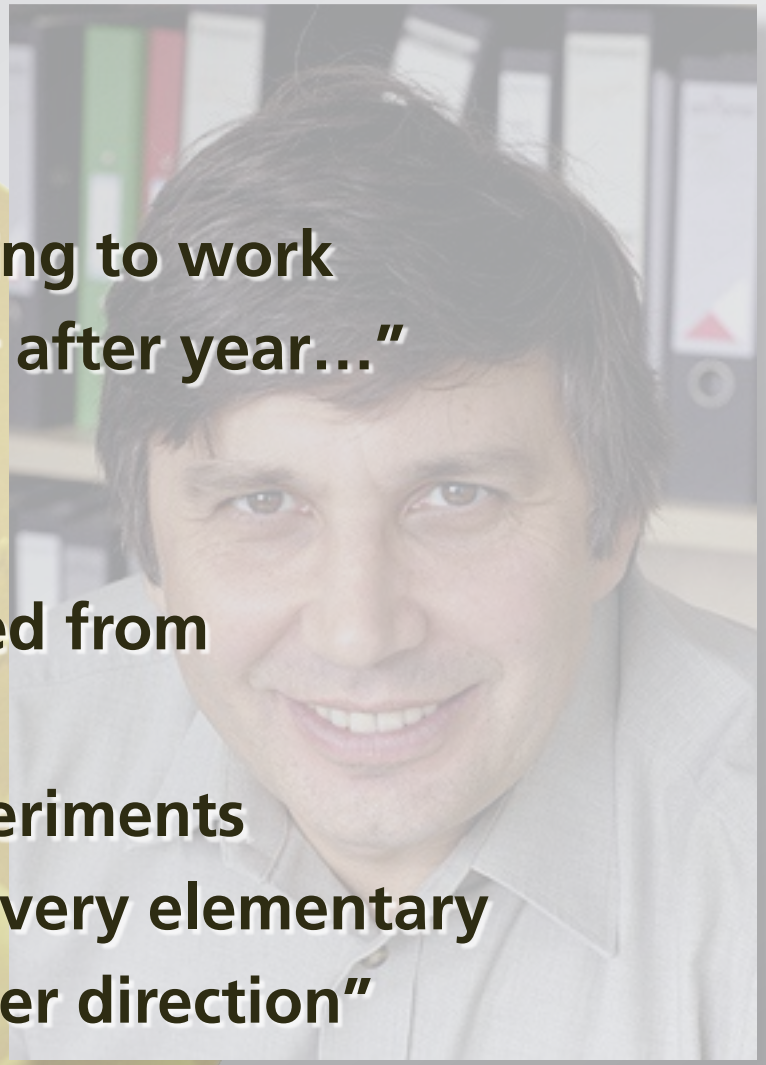
Nobel Prize in Physics 2010



Nobel Prize in Physics 2010

Ig Nobel Prize in 2000

“For me it’s very boring to work on the same thing year after year…”

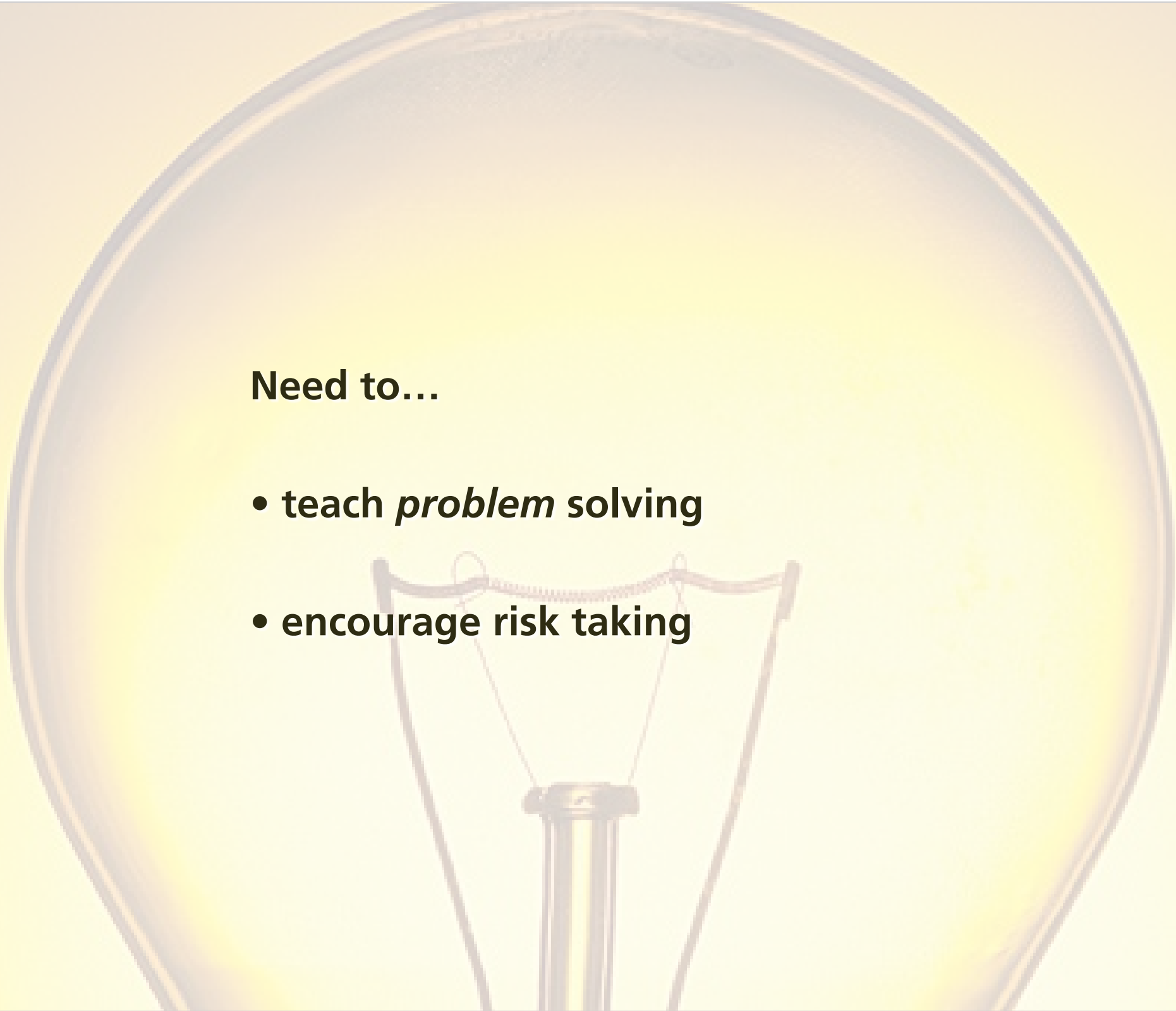


“For me it’s very boring to work
on the same thing year after year…”

graphene resulted from

“Friday night experiments
where you try something very elementary
and try to go in another direction”

how can we foster/teach innovation?



Need to…

- **teach *problem* solving**
- **encourage risk taking**

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

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unique ID on back of clicker

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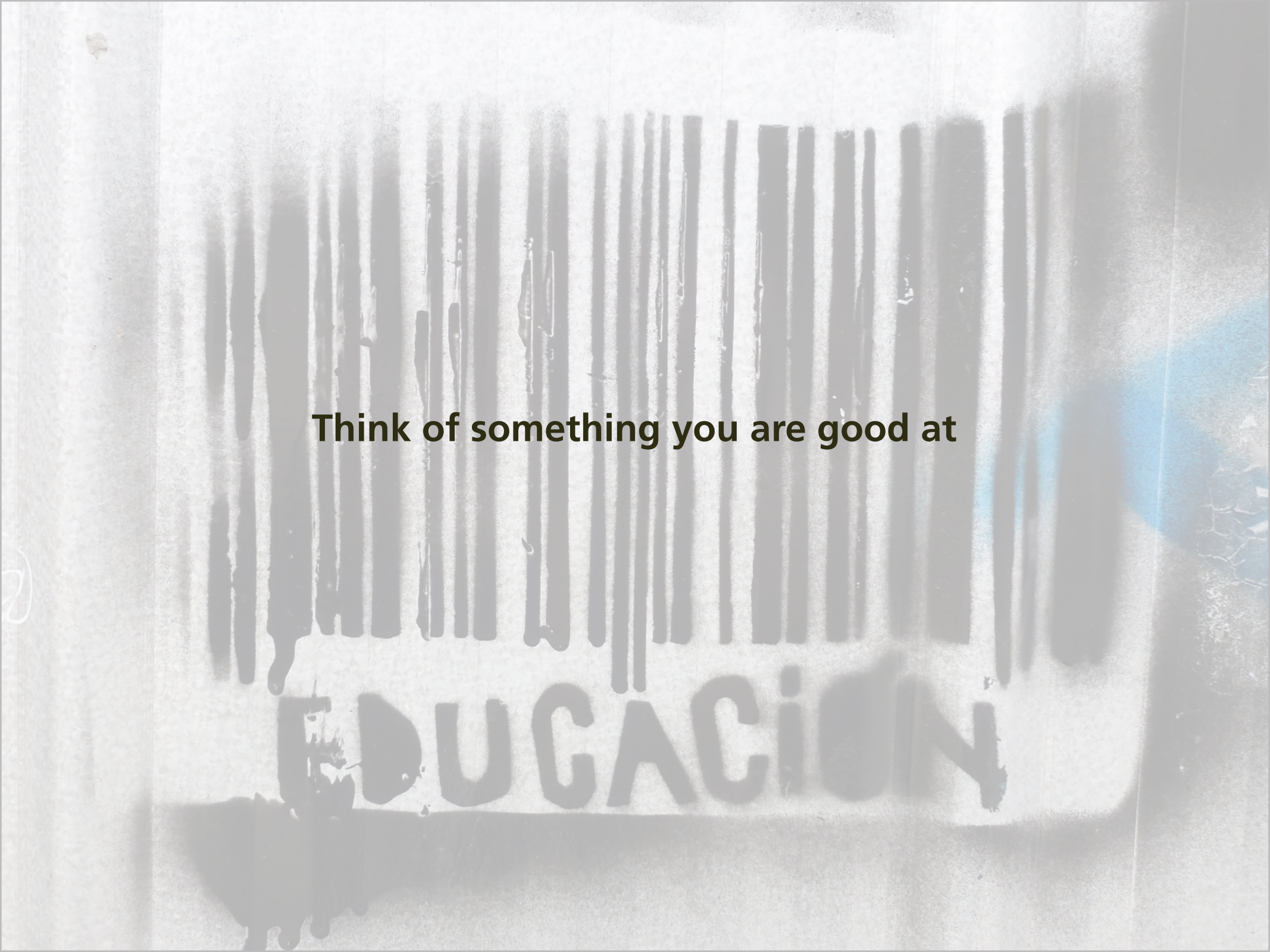
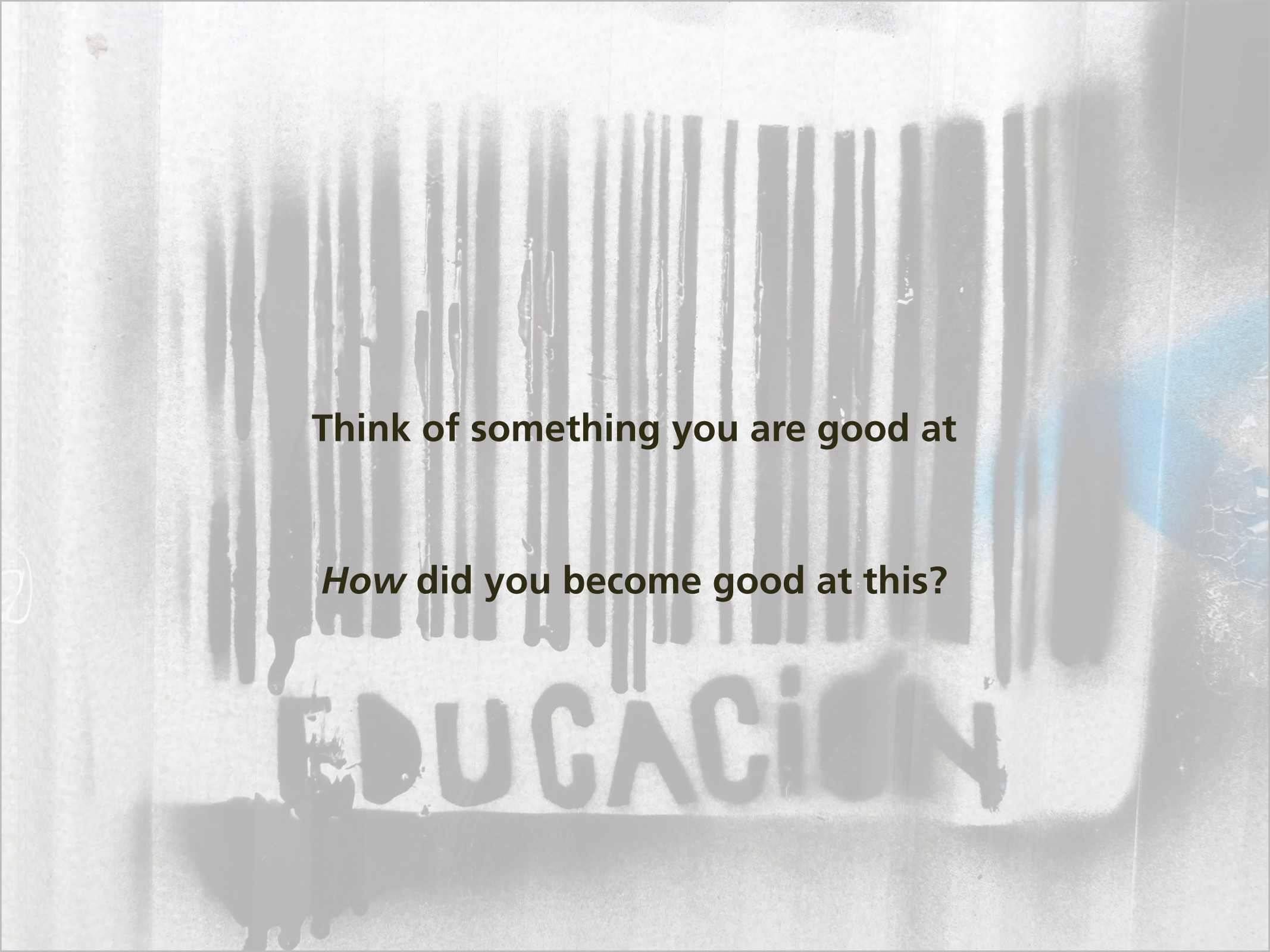

Think of something you are good at
EDUCACION

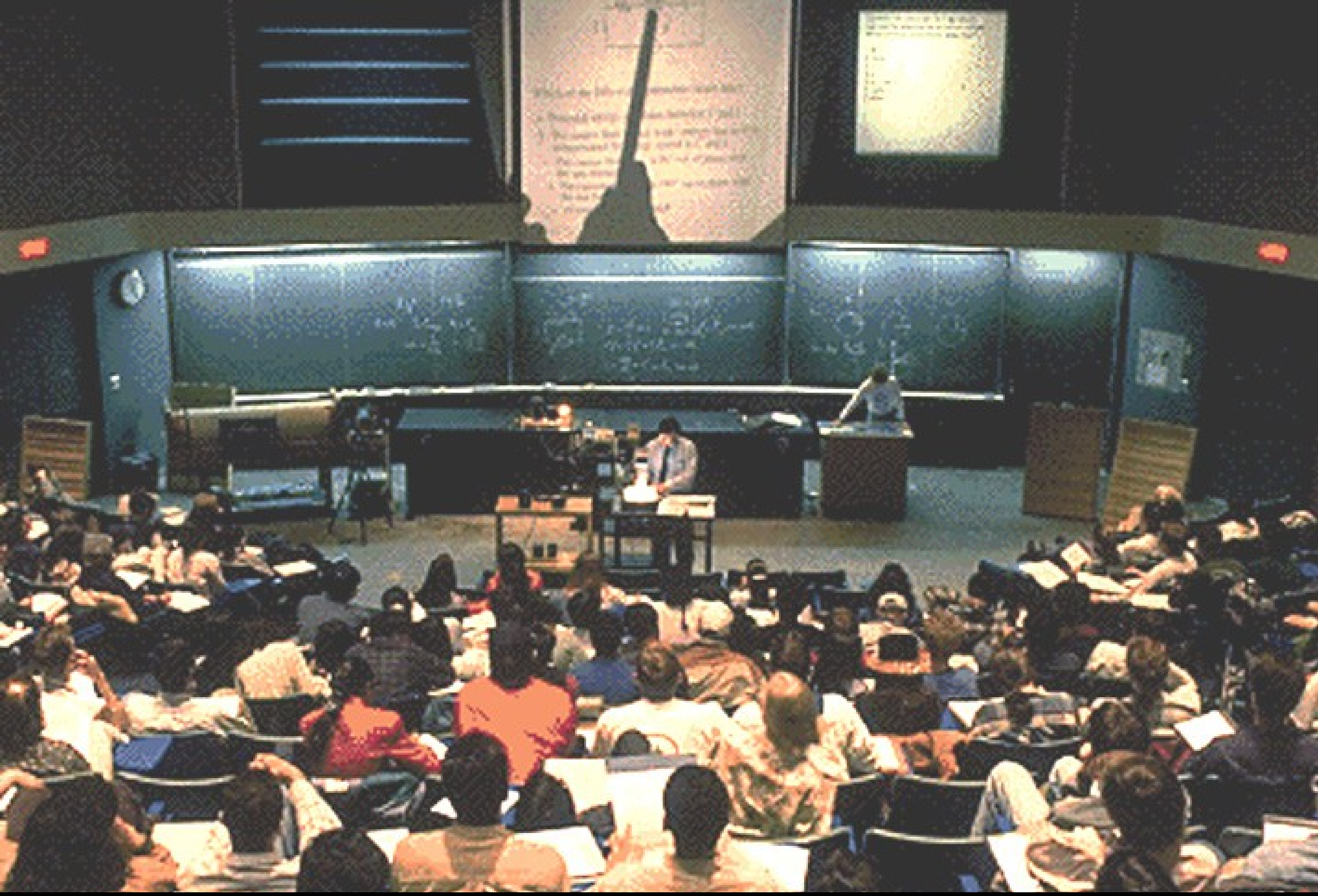


Think of something you are good at

How did you become good at this?

Became good at it by:

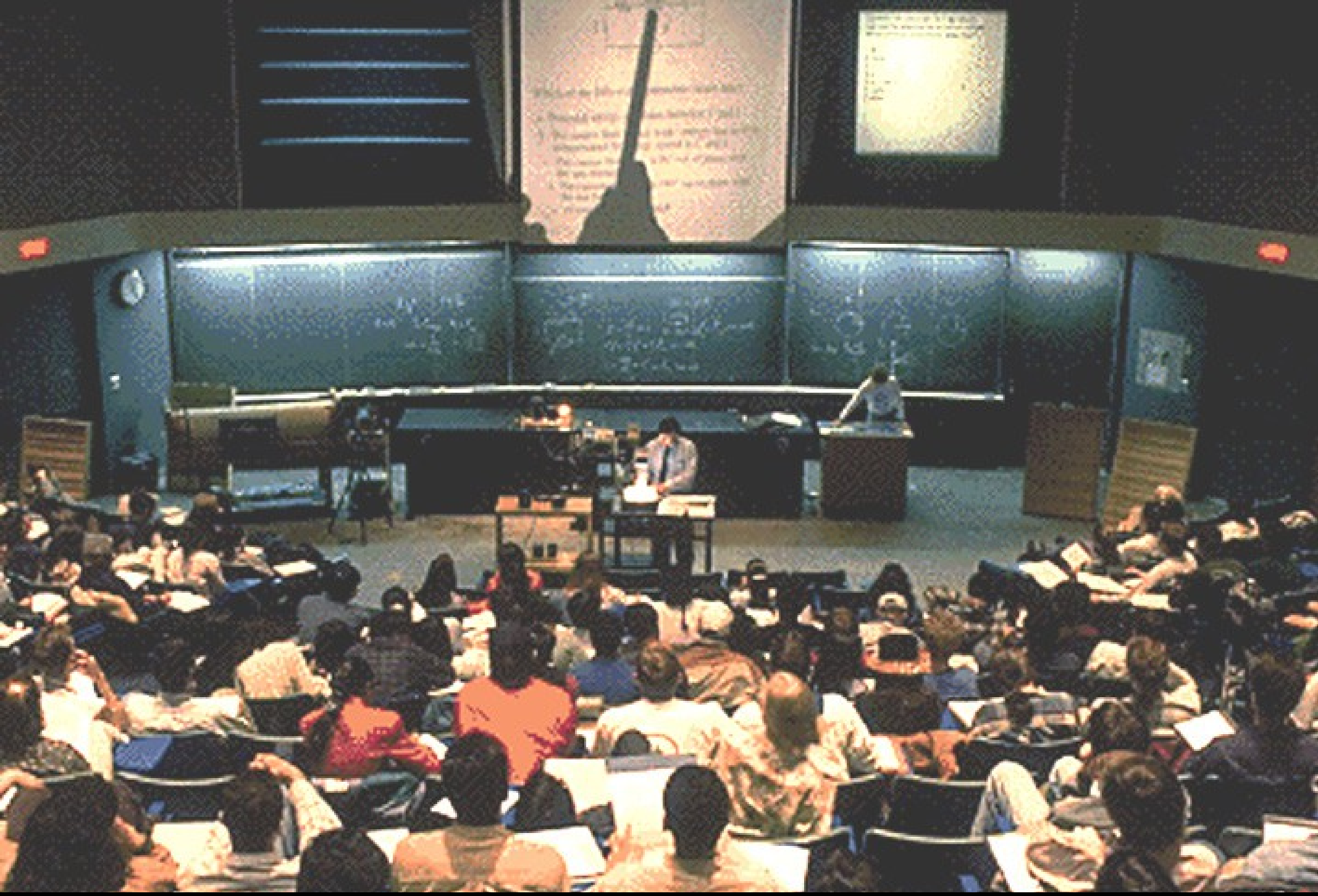
1. trial and error
2. lectures
3. practicing
4. apprenticeship
5. other



1 education

1 education

2 PI



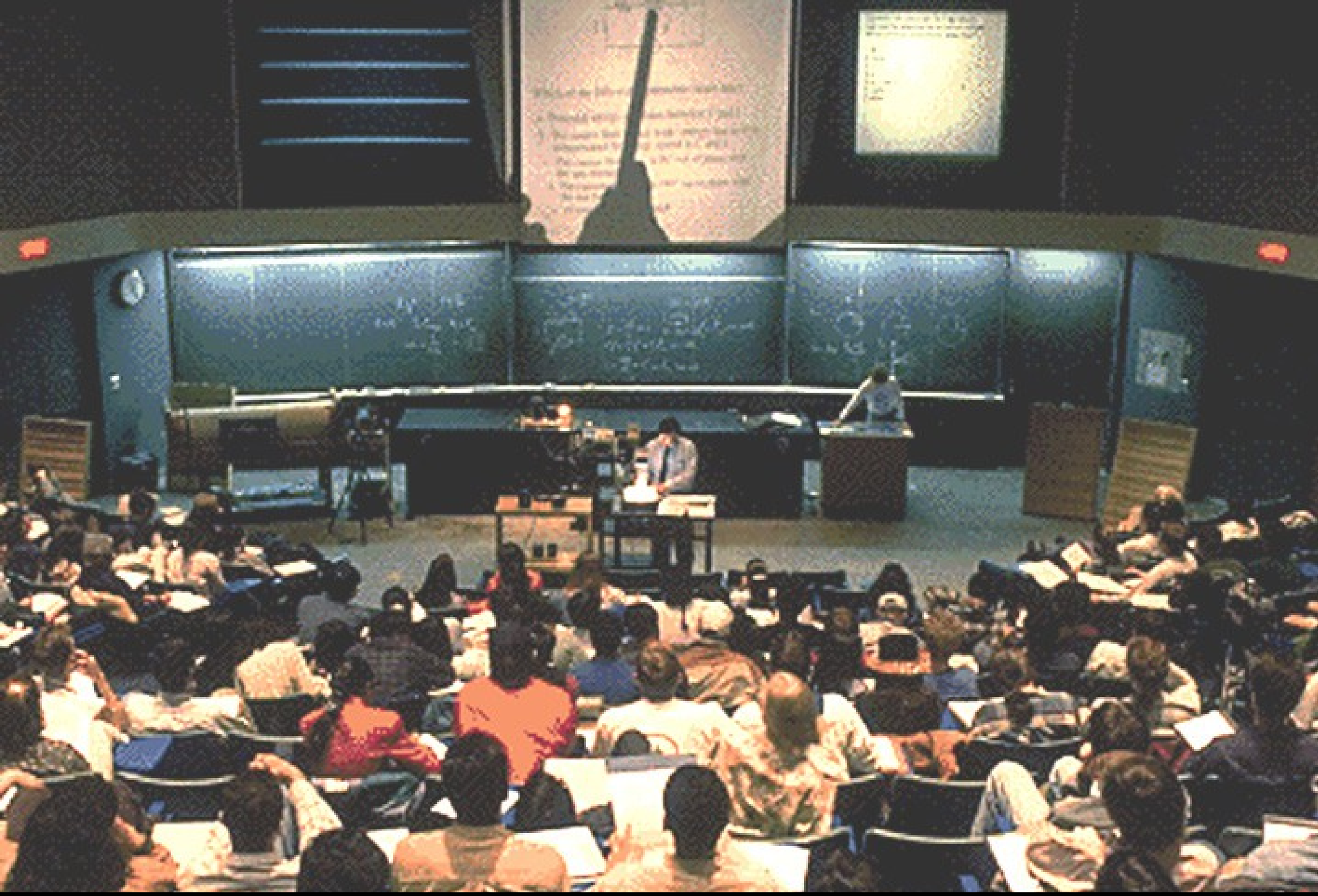
1 education

2 PI

3 test

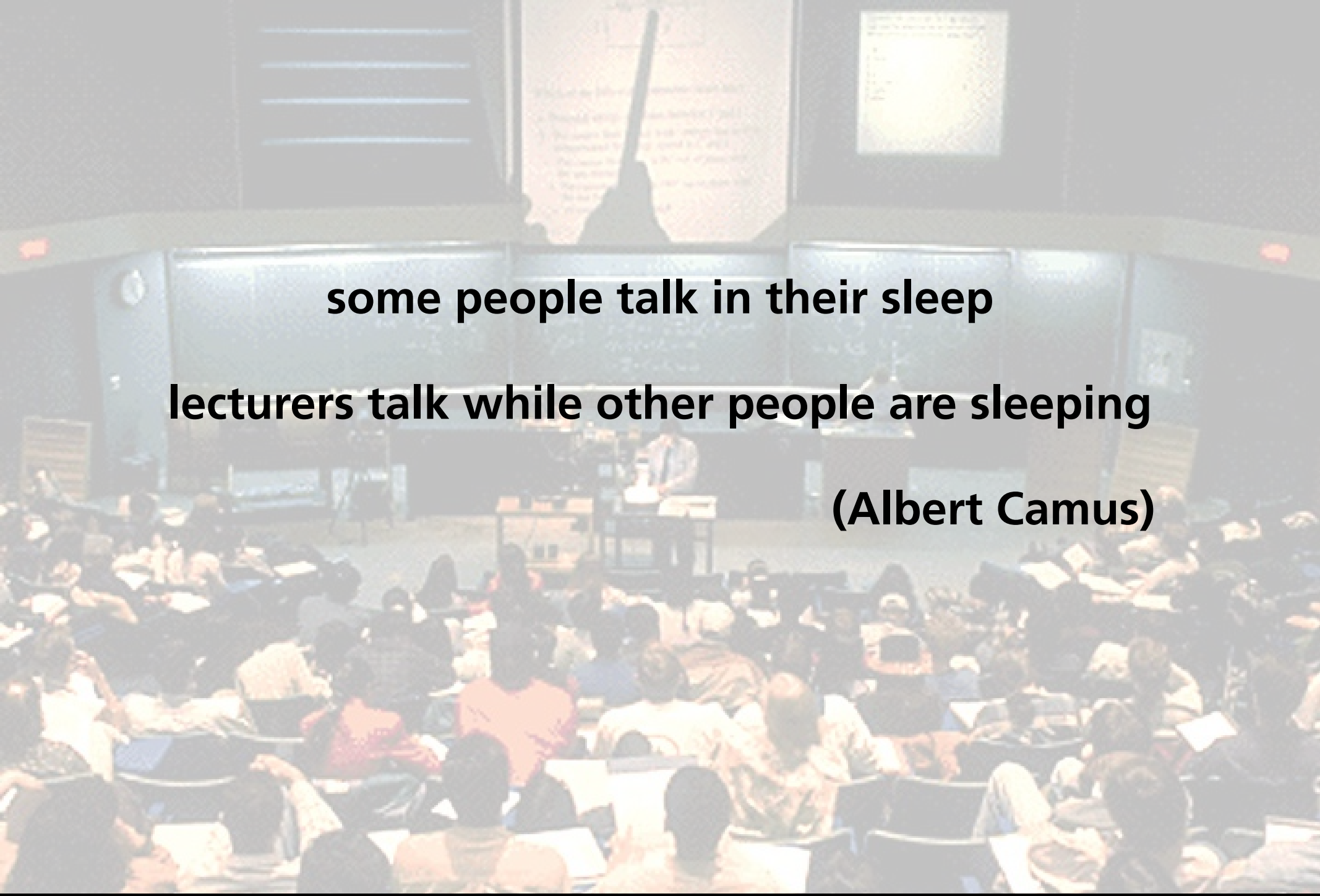
1 education 2 PI 3 test

What happens
in a lecture?



1 education

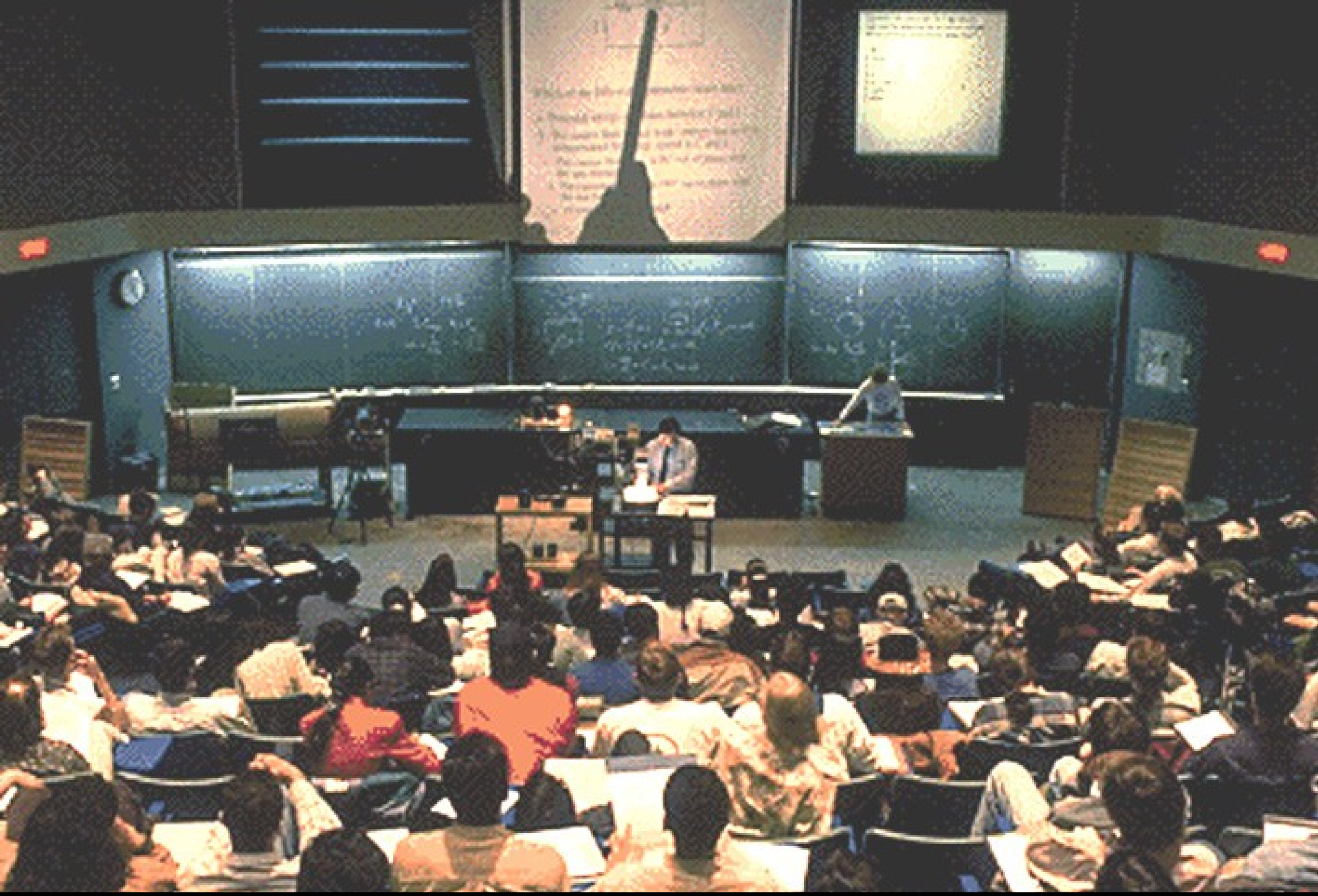
some people talk in their sleep



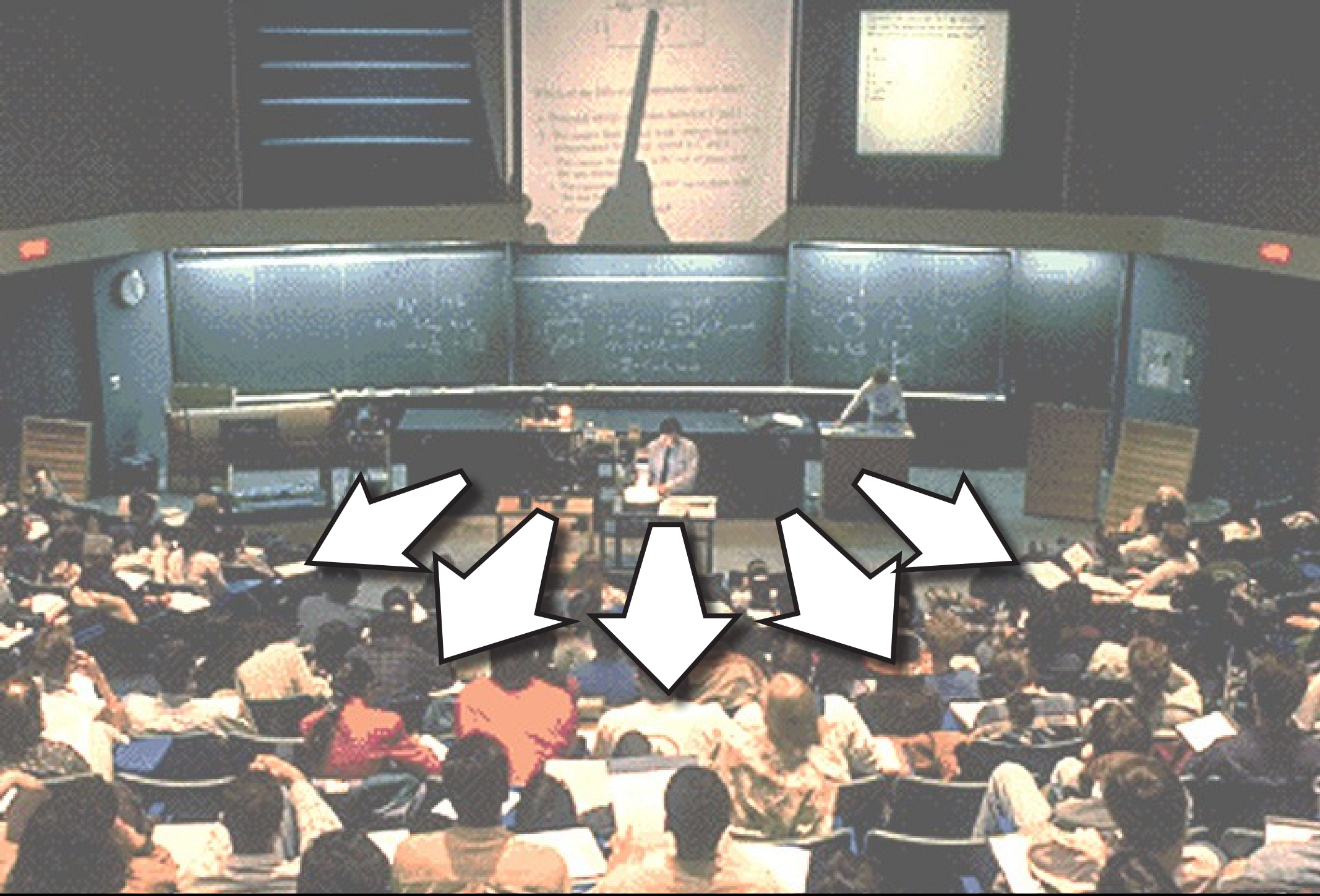
some people talk in their sleep

lecturers talk while other people are sleeping

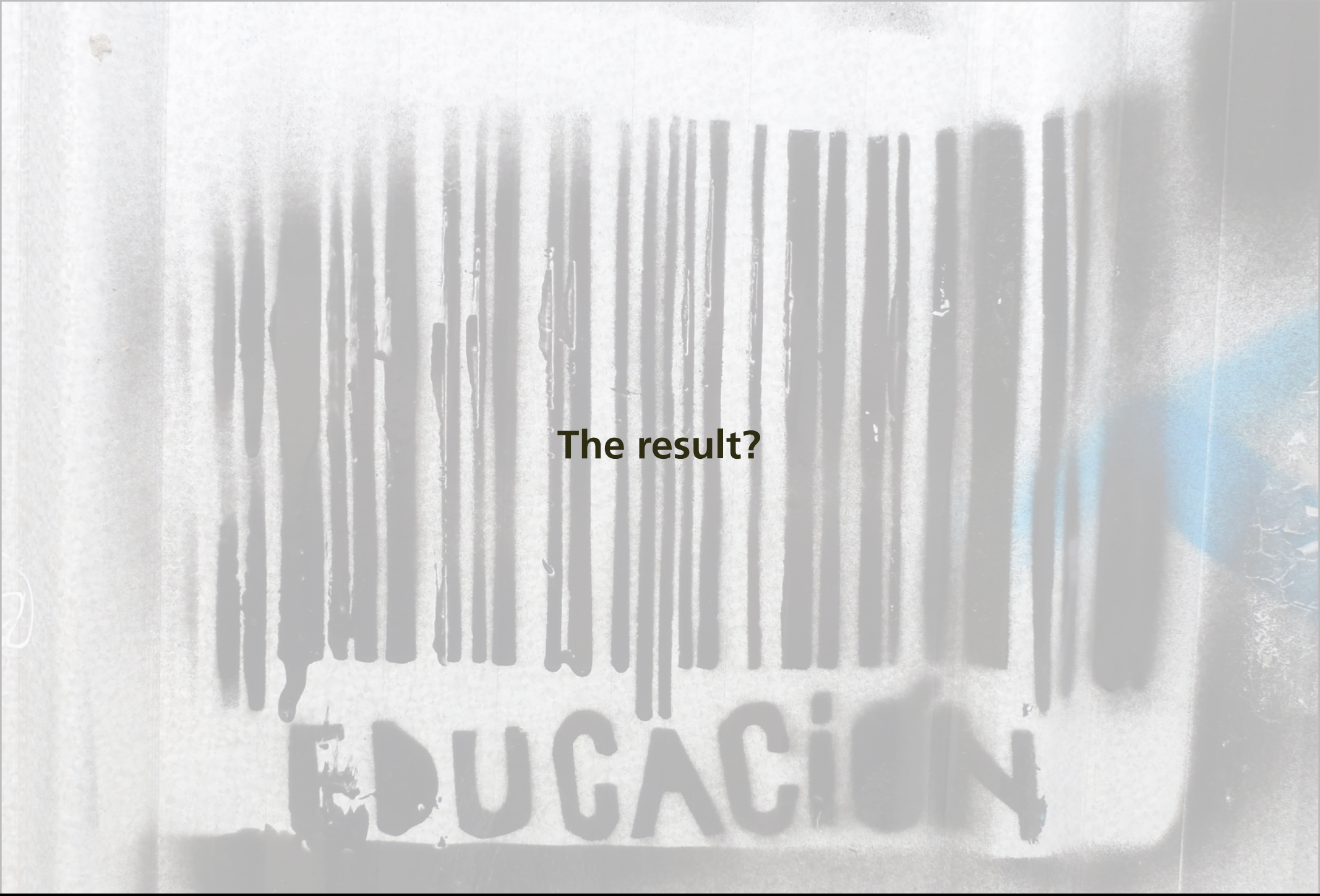
(Albert Camus)



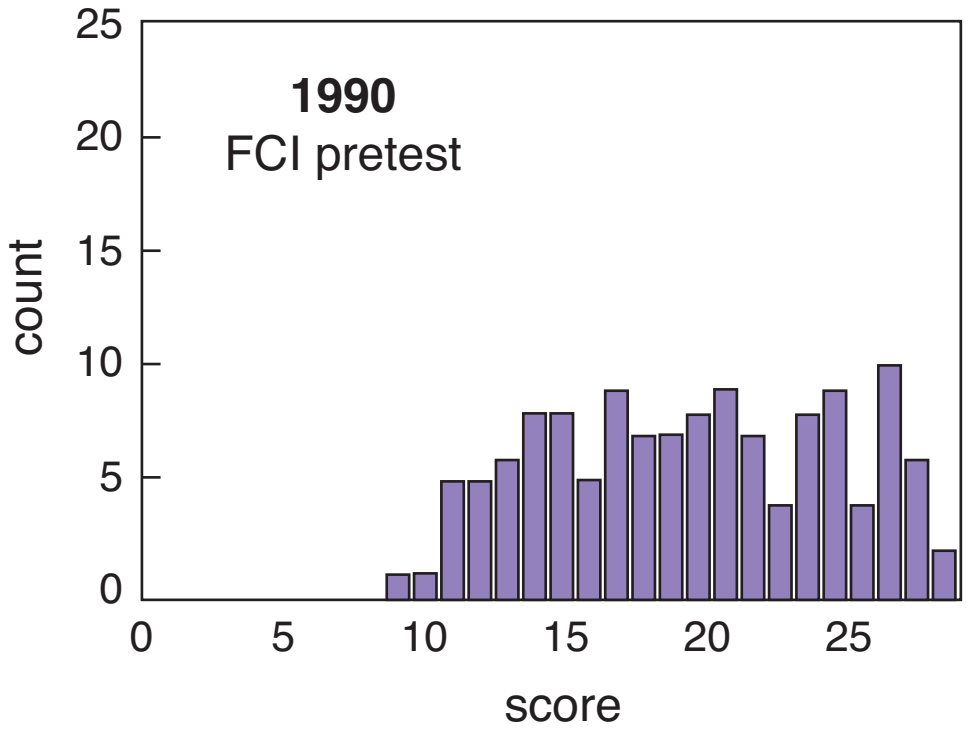
1 education



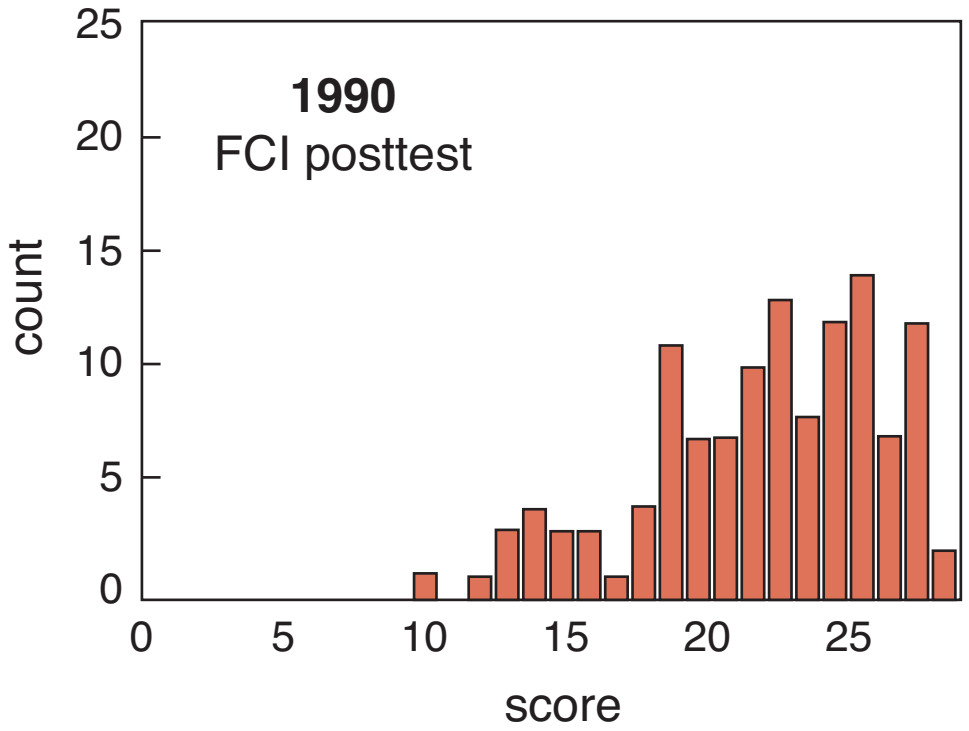
1 education


The result?
EDUCACION

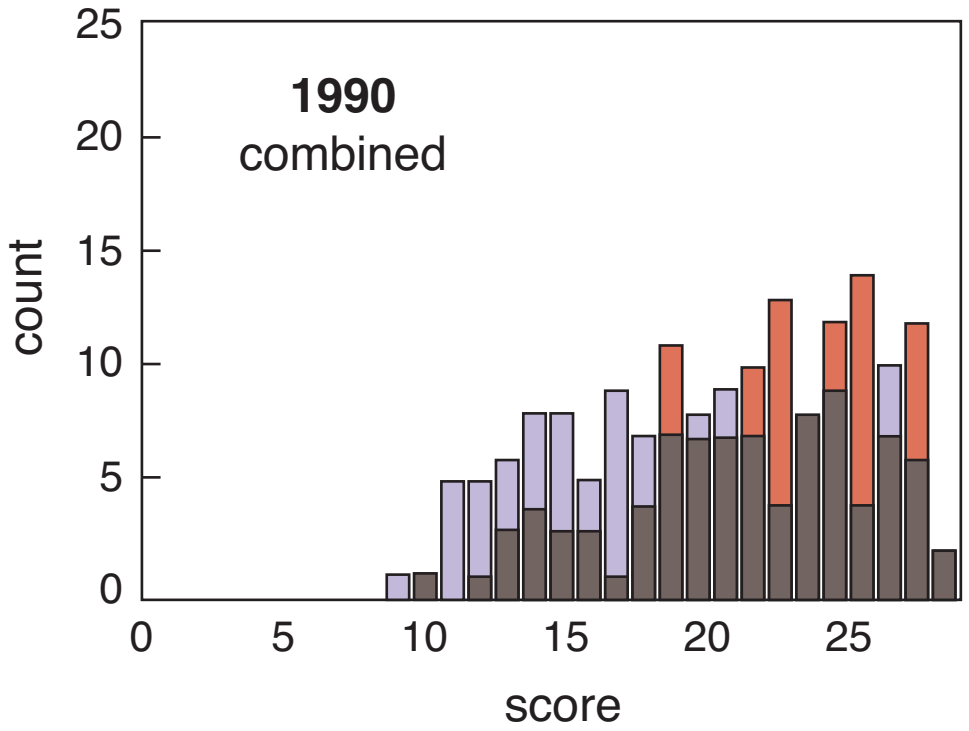
education is not just information transfer

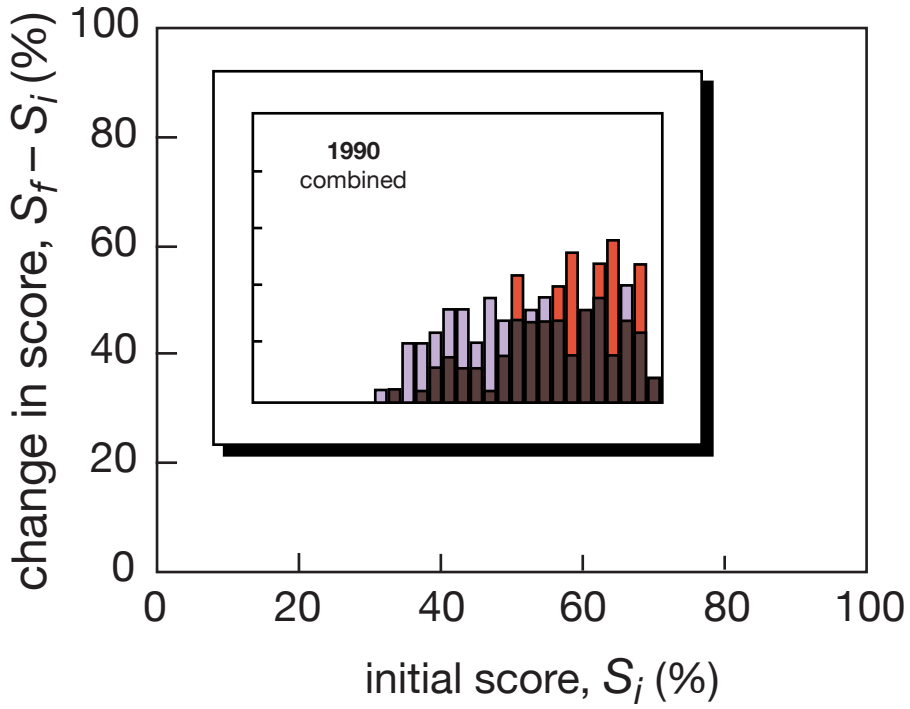


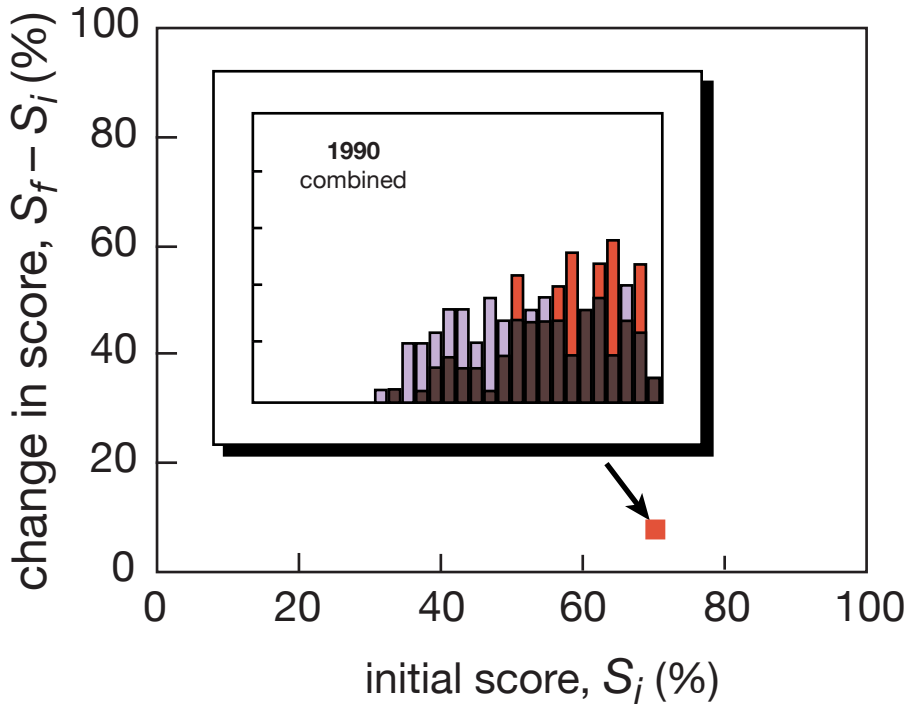
education is not just information transfer

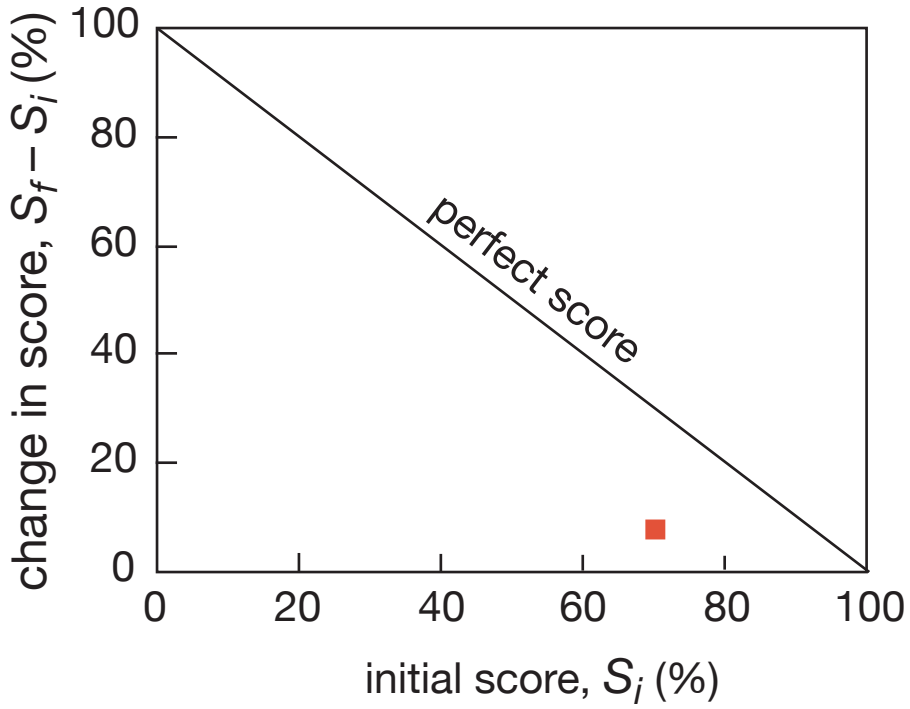


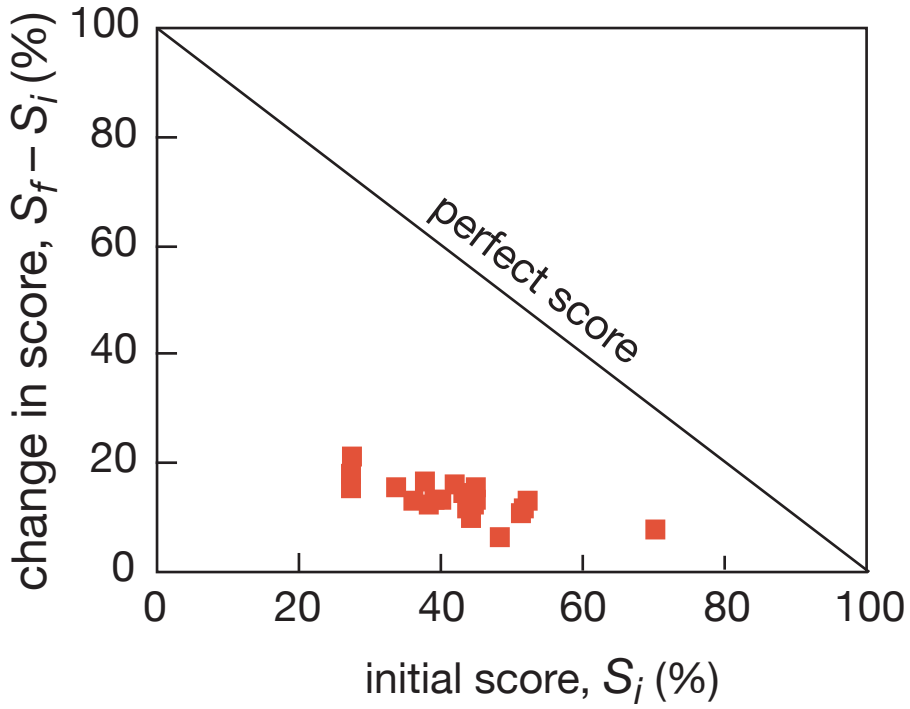
education is not just information transfer




1990
combined
change in score, $S_f - S_i$ (%)
initial score, S_i (%)
0
20
40
60
80
100

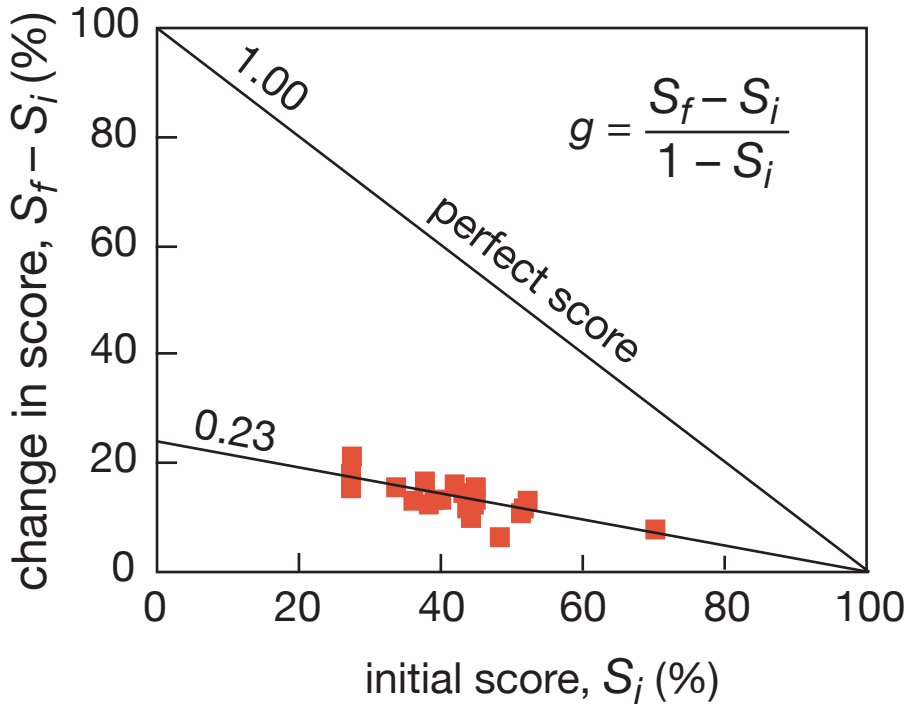

1990
combined
change in score, $S_f - S_i$ (%)
initial score, S_i (%)
0
20
40
60
80
100


change in score, $S_f - S_i$ (%)
100
80
60
40
20
0
0
20
40
60
80
100
perfect score
initial score, S_i (%)

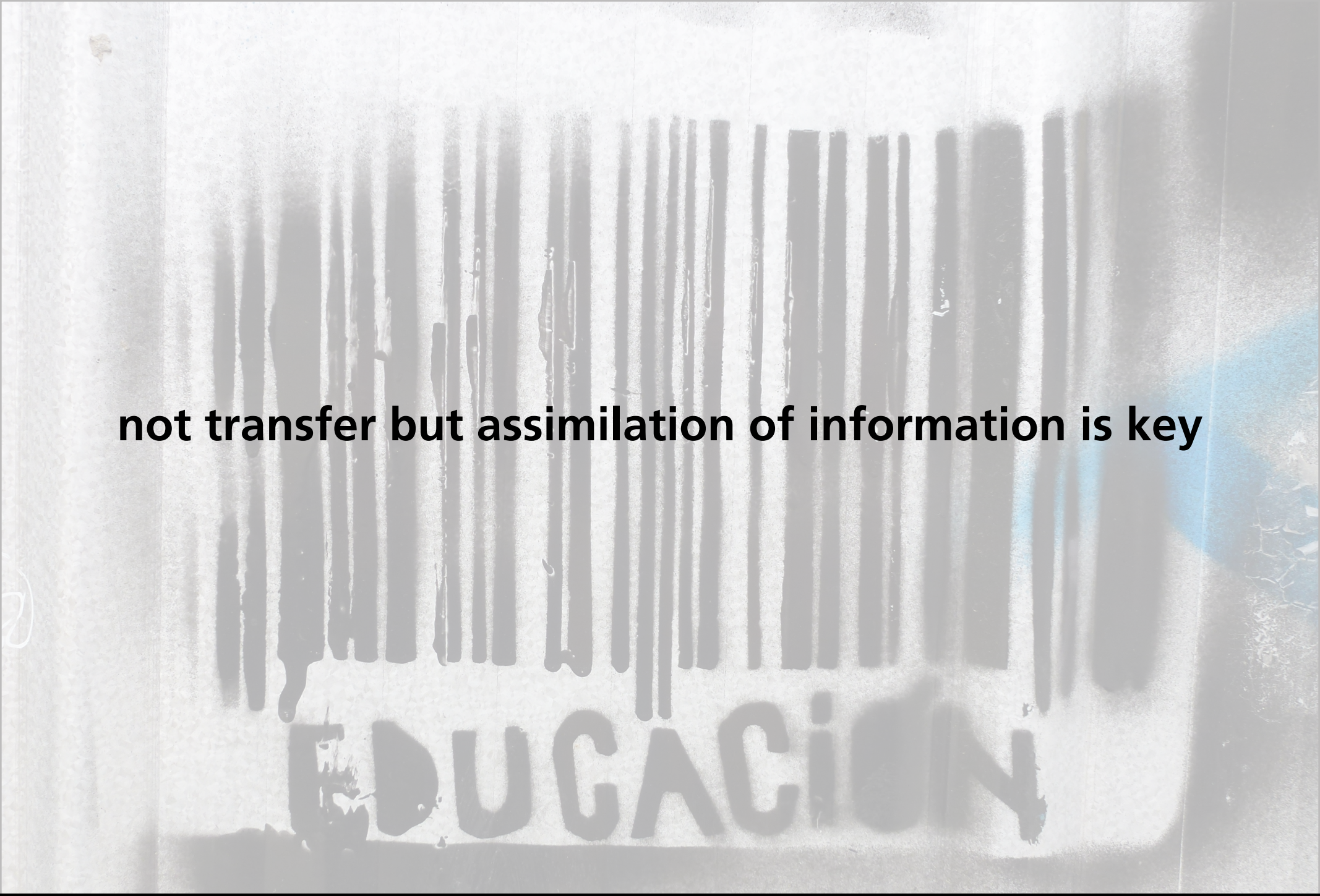


R.R. Hake, *Am. J. Phys.* 66, 64 (1998)

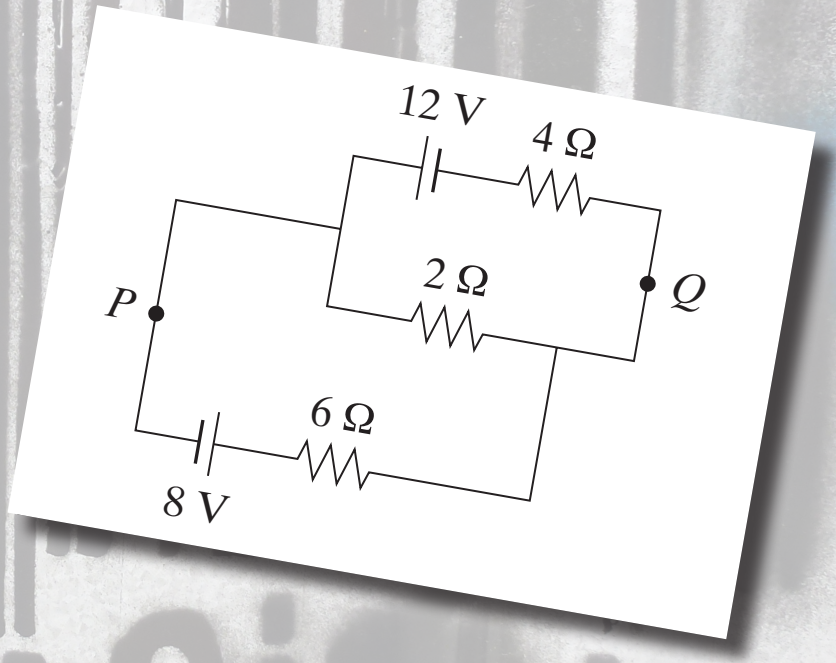
only one quarter of maximum gain realized



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


not transfer but assimilation of information is key
EDUCACION

conventional problems misleading



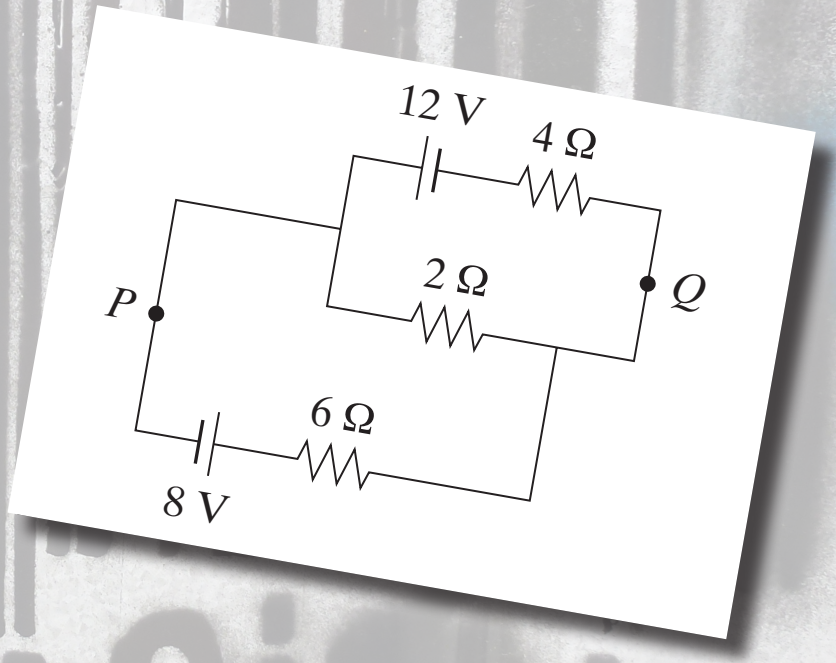
conventional problems misleading

Calculate:

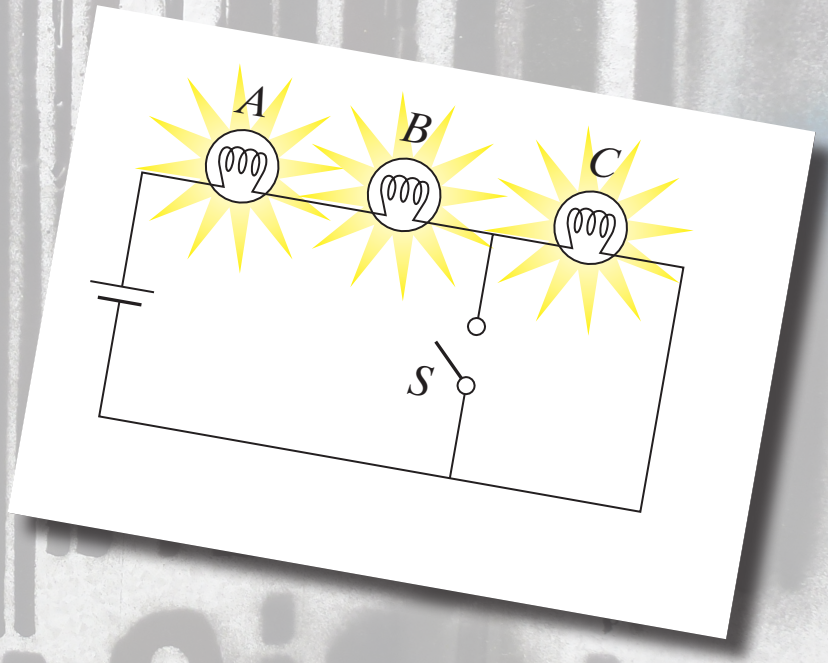
(*a*) current in 2-Ω resistor

(*b*) potential difference

between *P* and *Q*



are the basic principles understood?



are the basic principles understood?

When *S* is closed, what happens to:

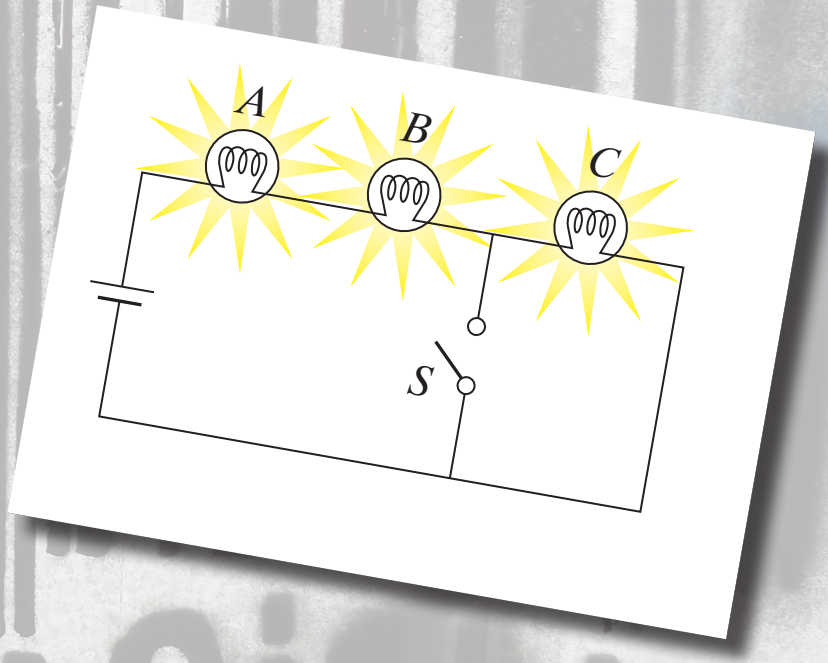
(*a*) intensities of A and B?

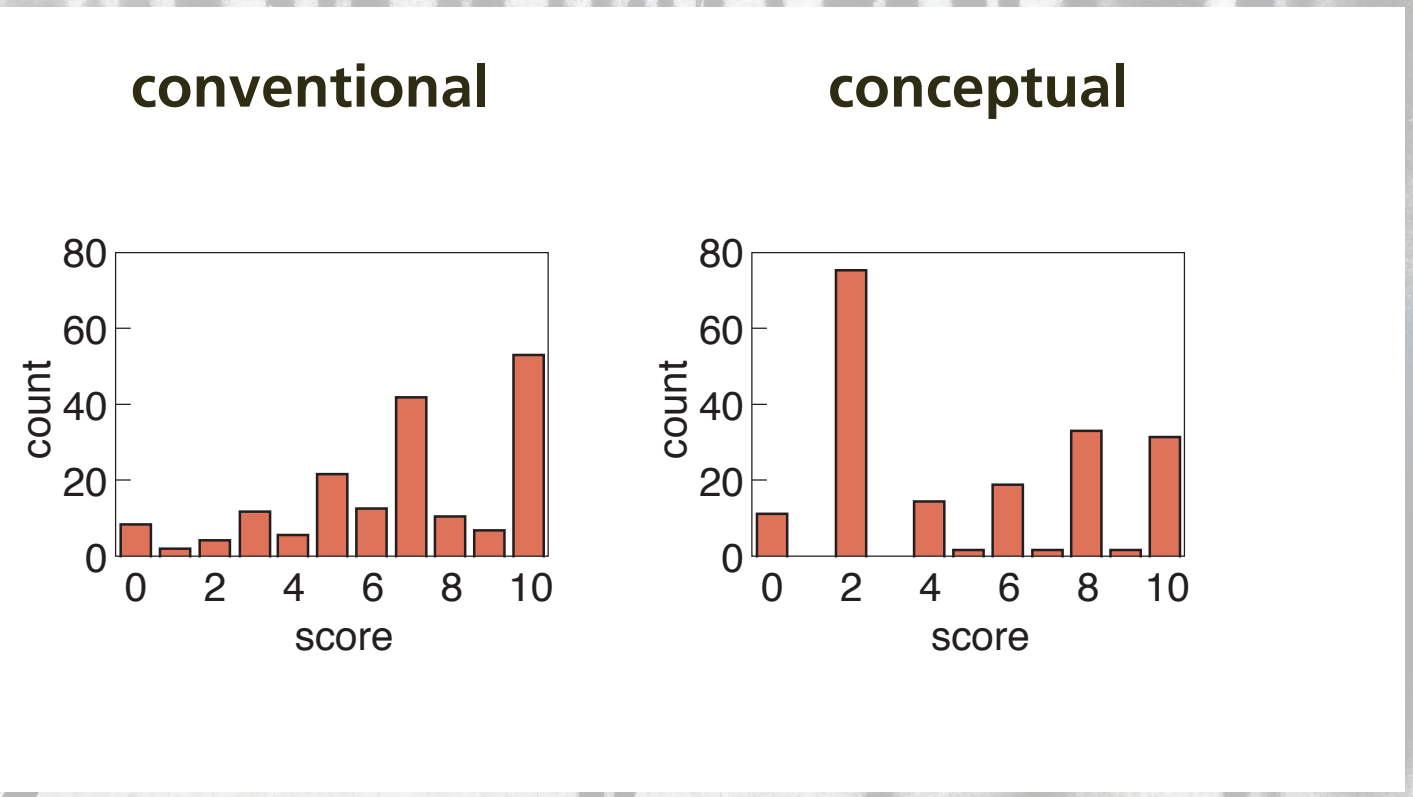
(*b*) intensity of C?

(*c*) current through battery?

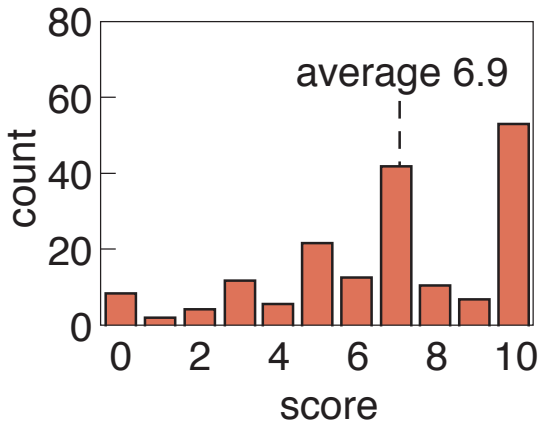
(*d*) potential difference across *A*, *B*, and *C*?

(*e*) the total power dissipated?

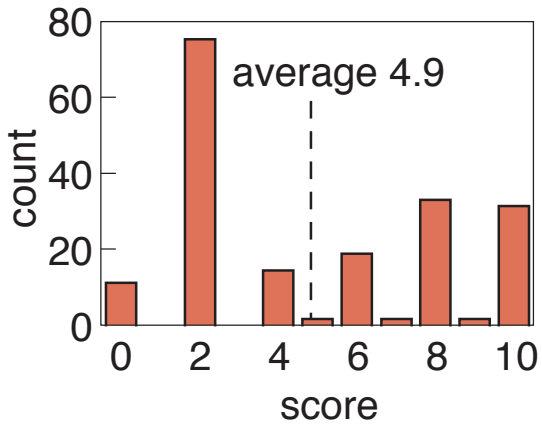


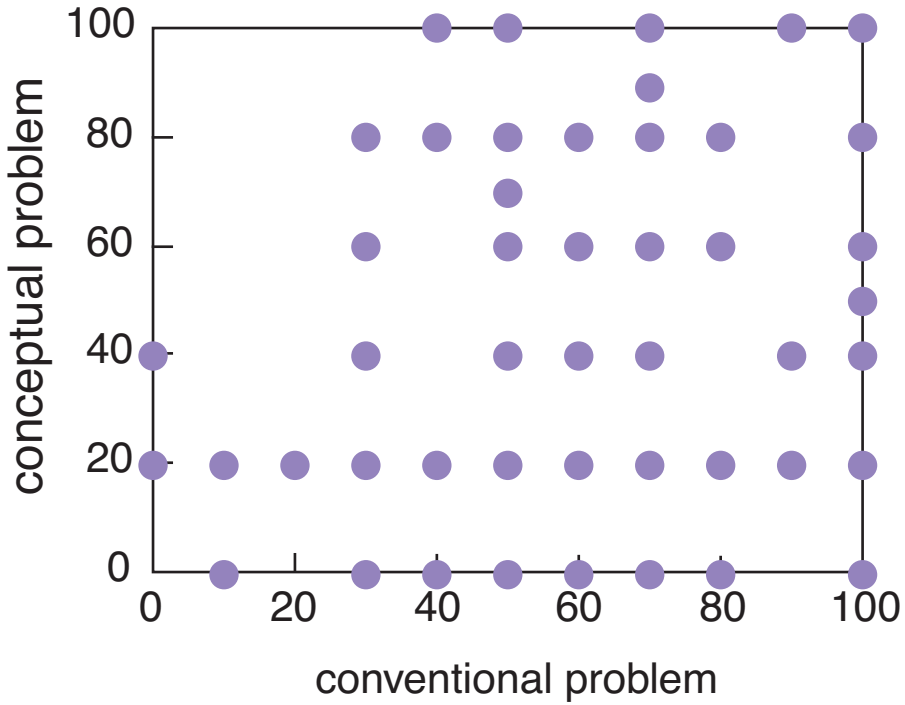

conventional
conceptual
count
score
0
20
40
60
80
0
2
4
6
8
10

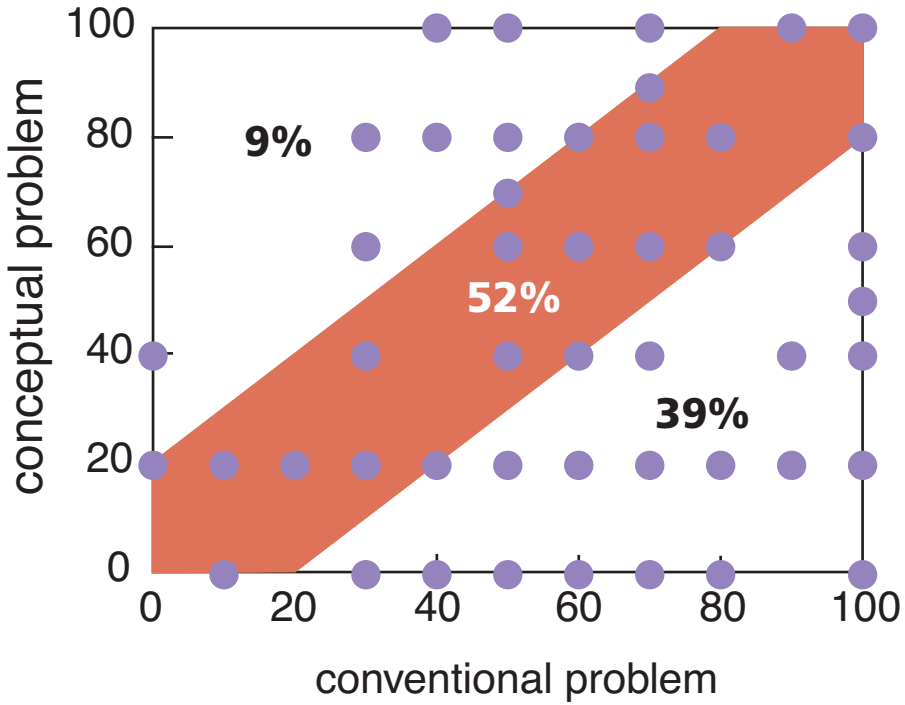
conventional



conceptual



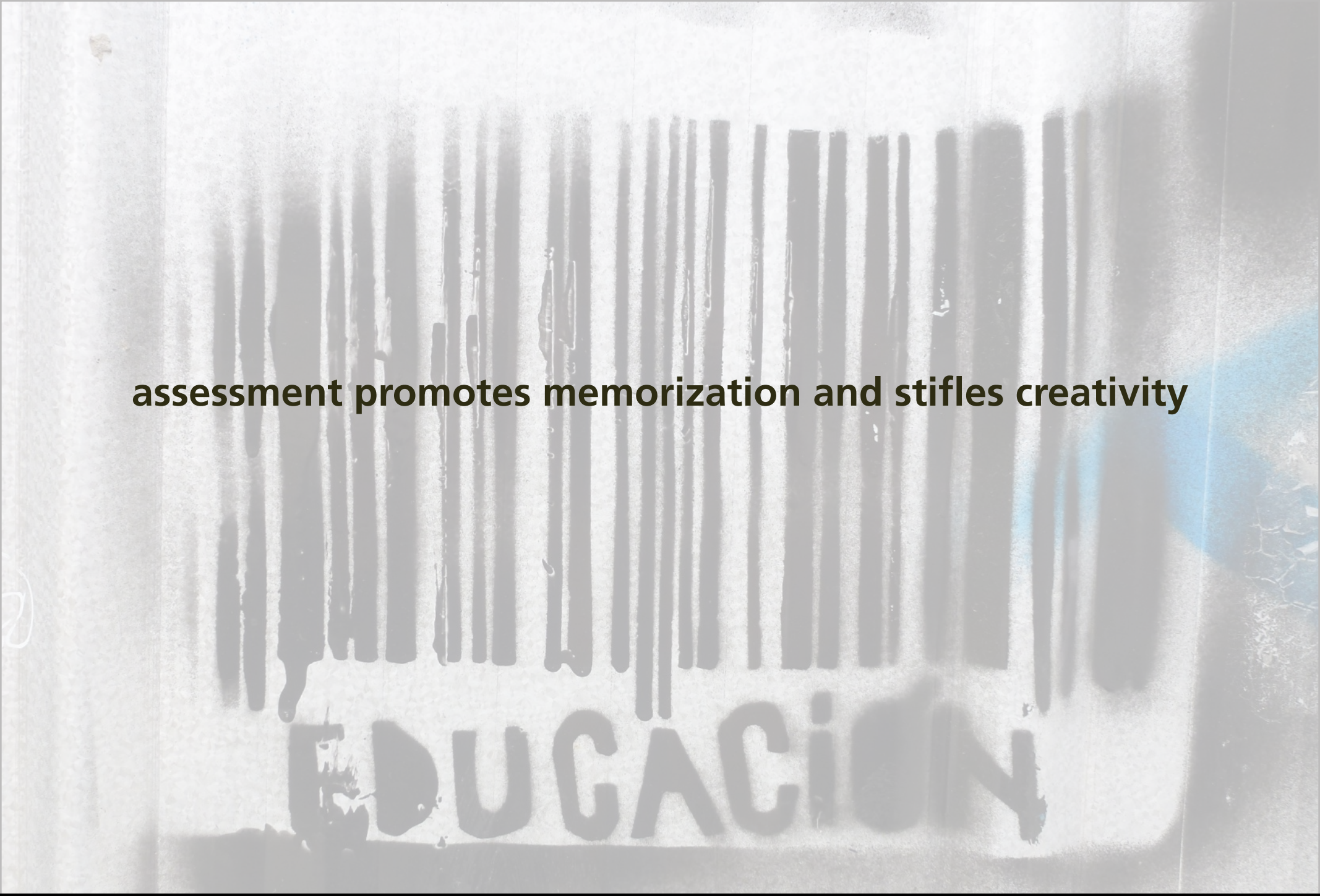

100
80
60
40
20
0
conceptual problem
0
20
40
60
80
100
conventional problem


100
80
60
40
20
0
conceptual problem
9%
52%
39%
0
20
40
60
80
100
conventional problem

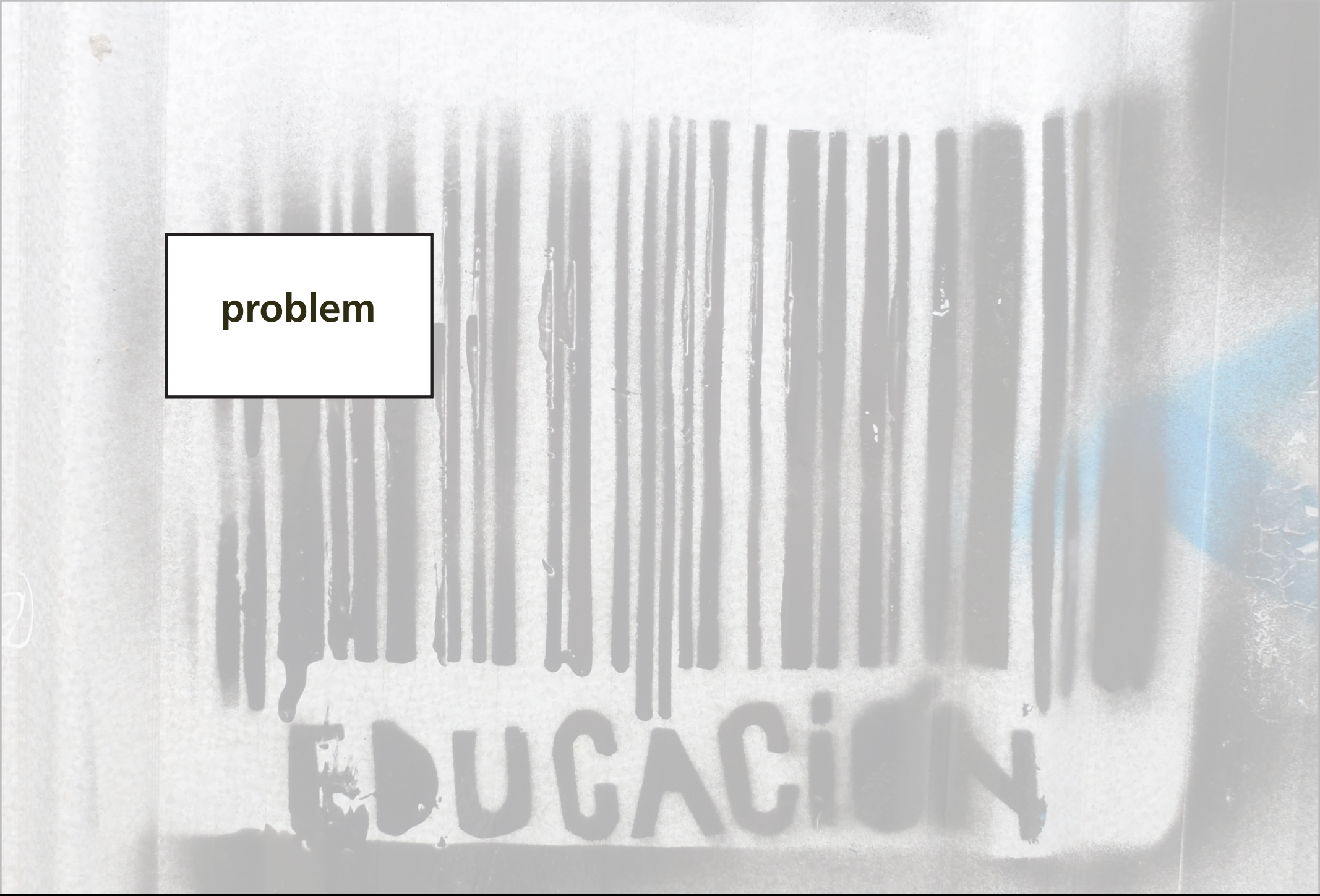
1 education

1 education

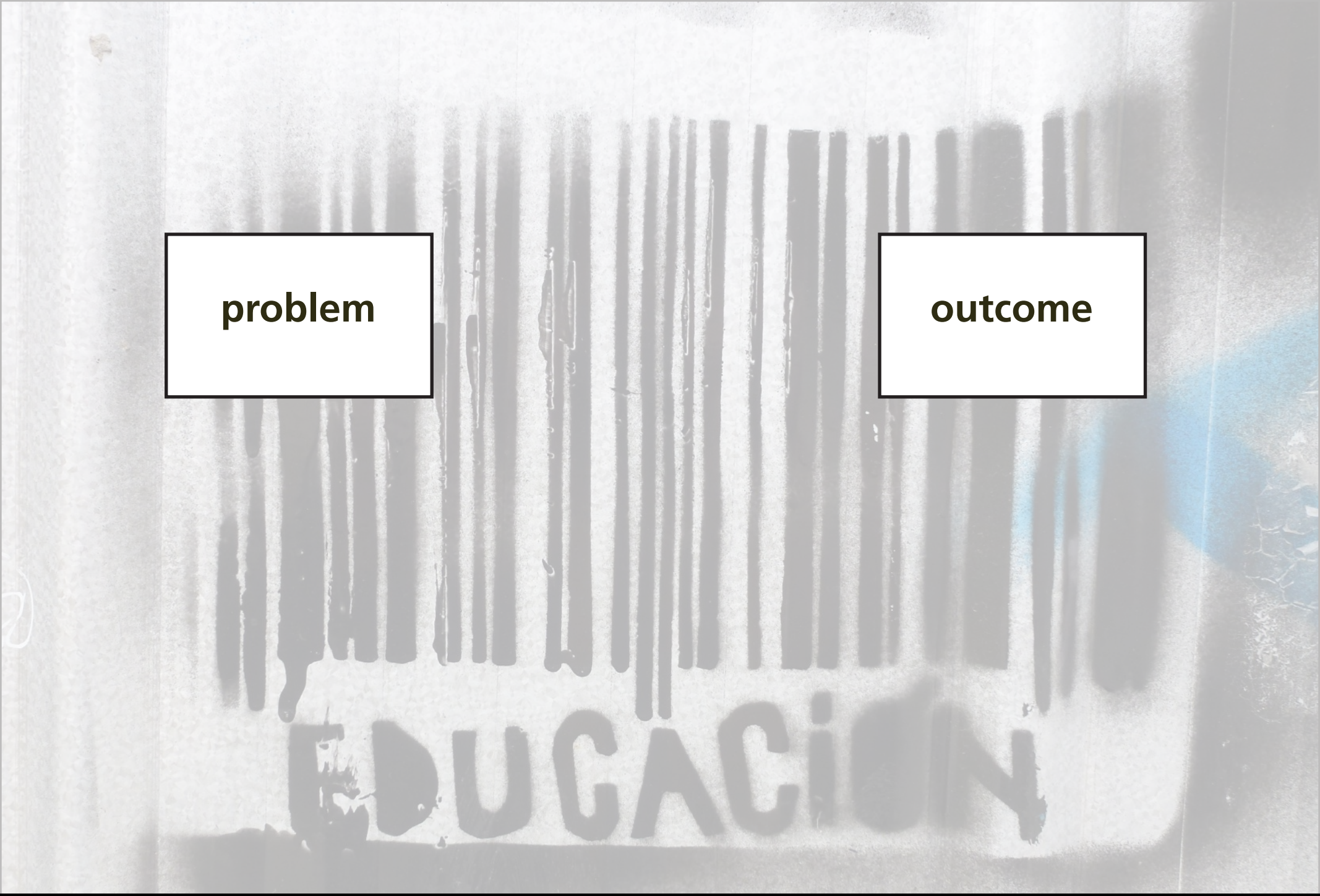
1 lecture



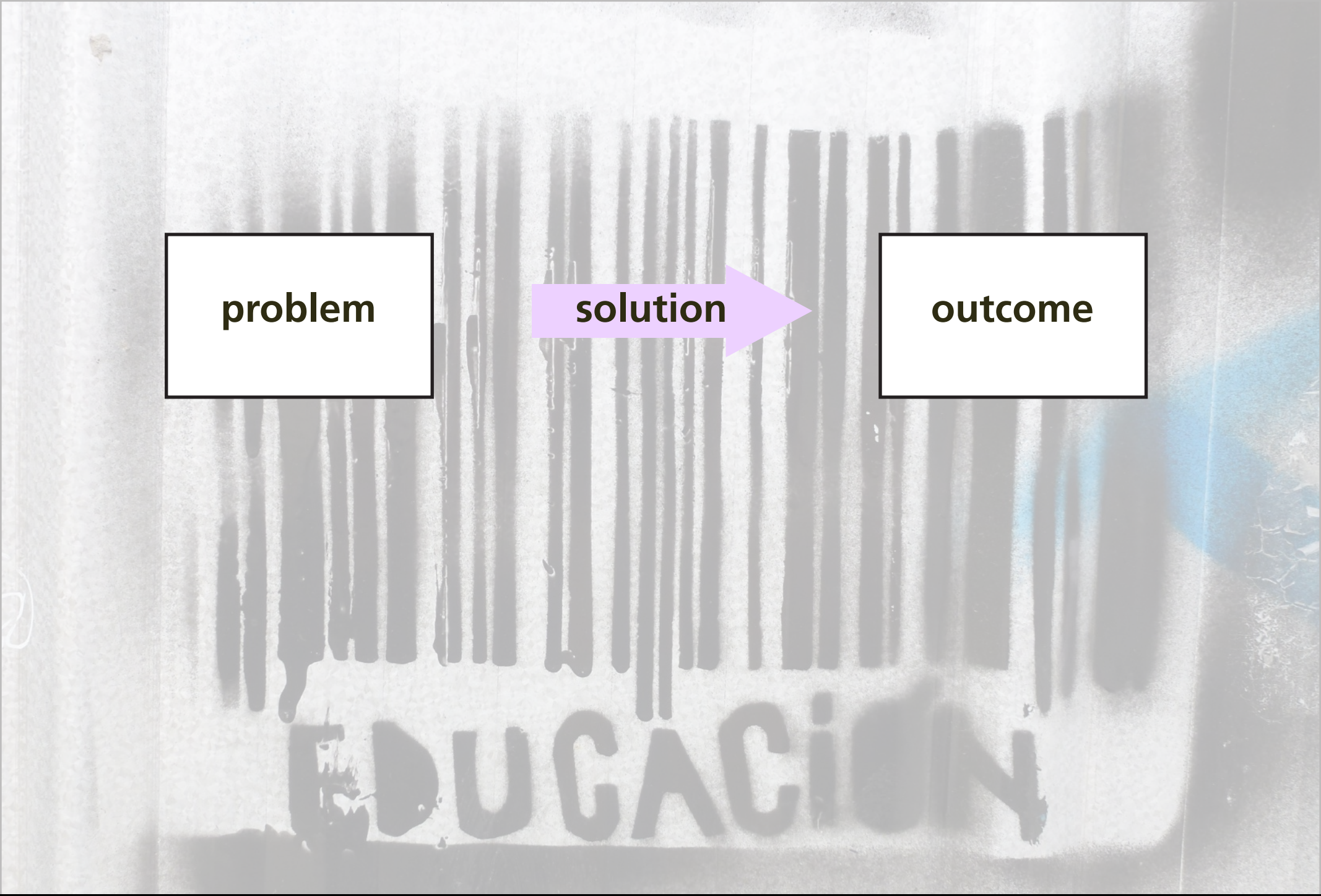
assessment promotes memorization and stifles creativity



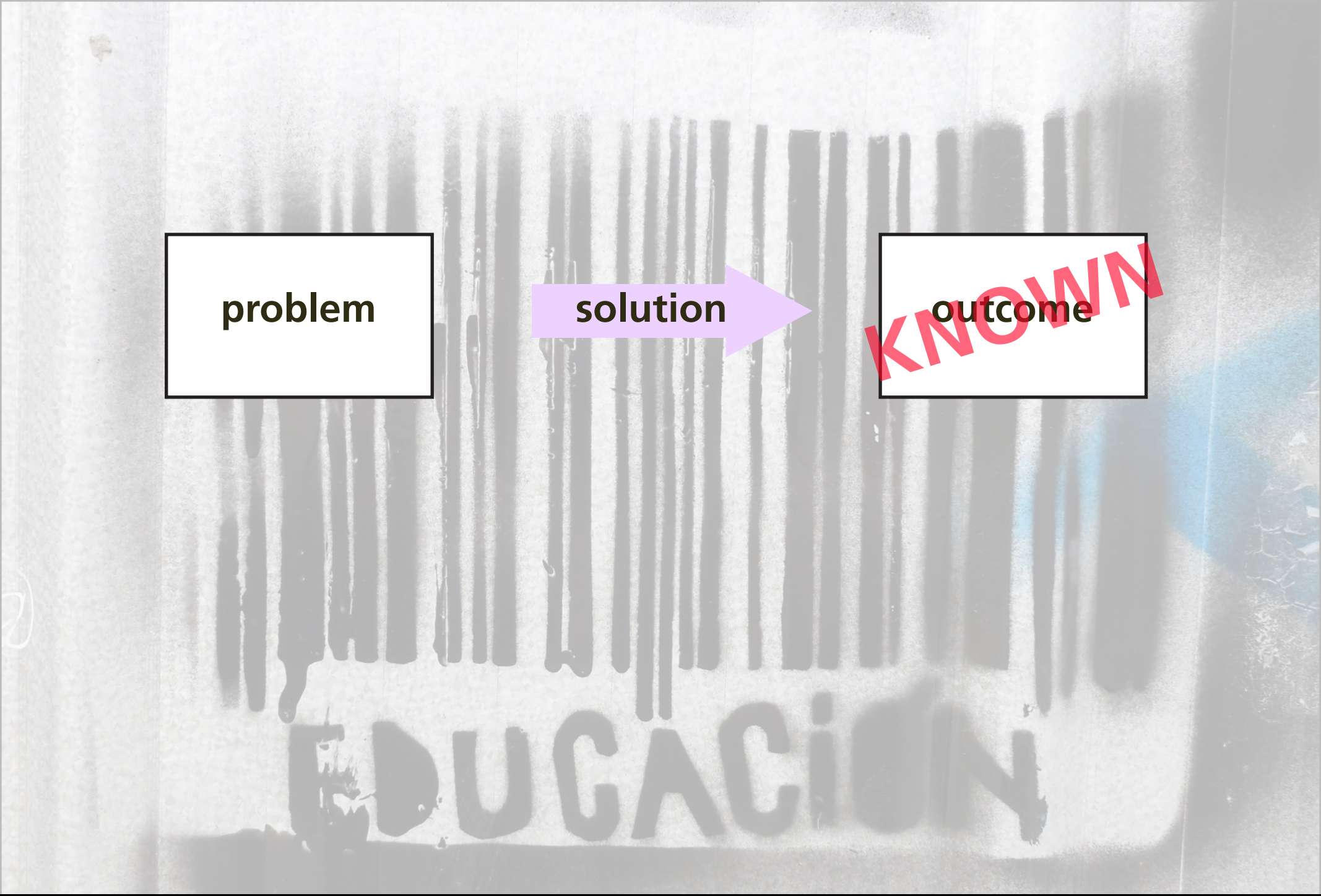
1 education



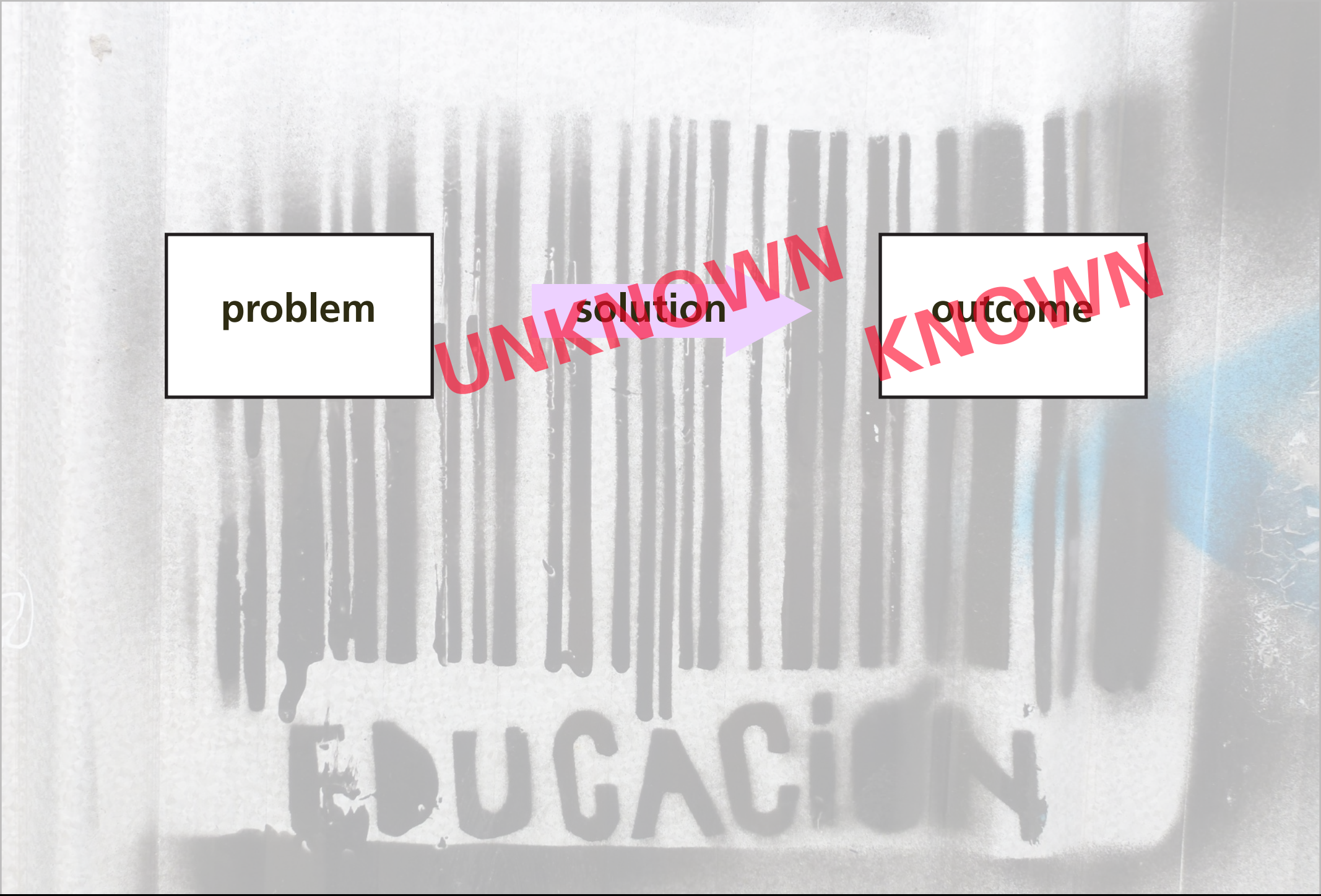
1 education



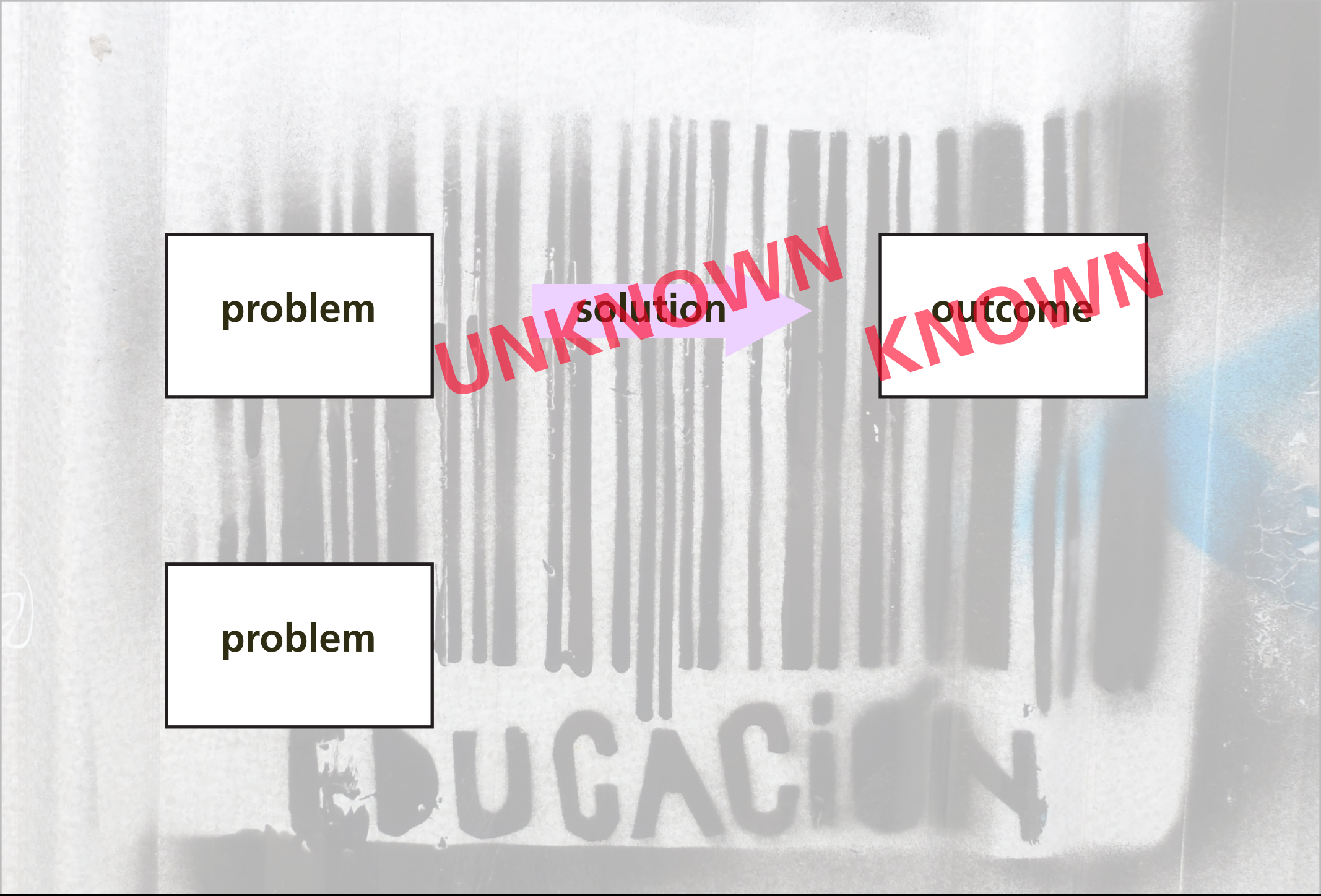
1 education



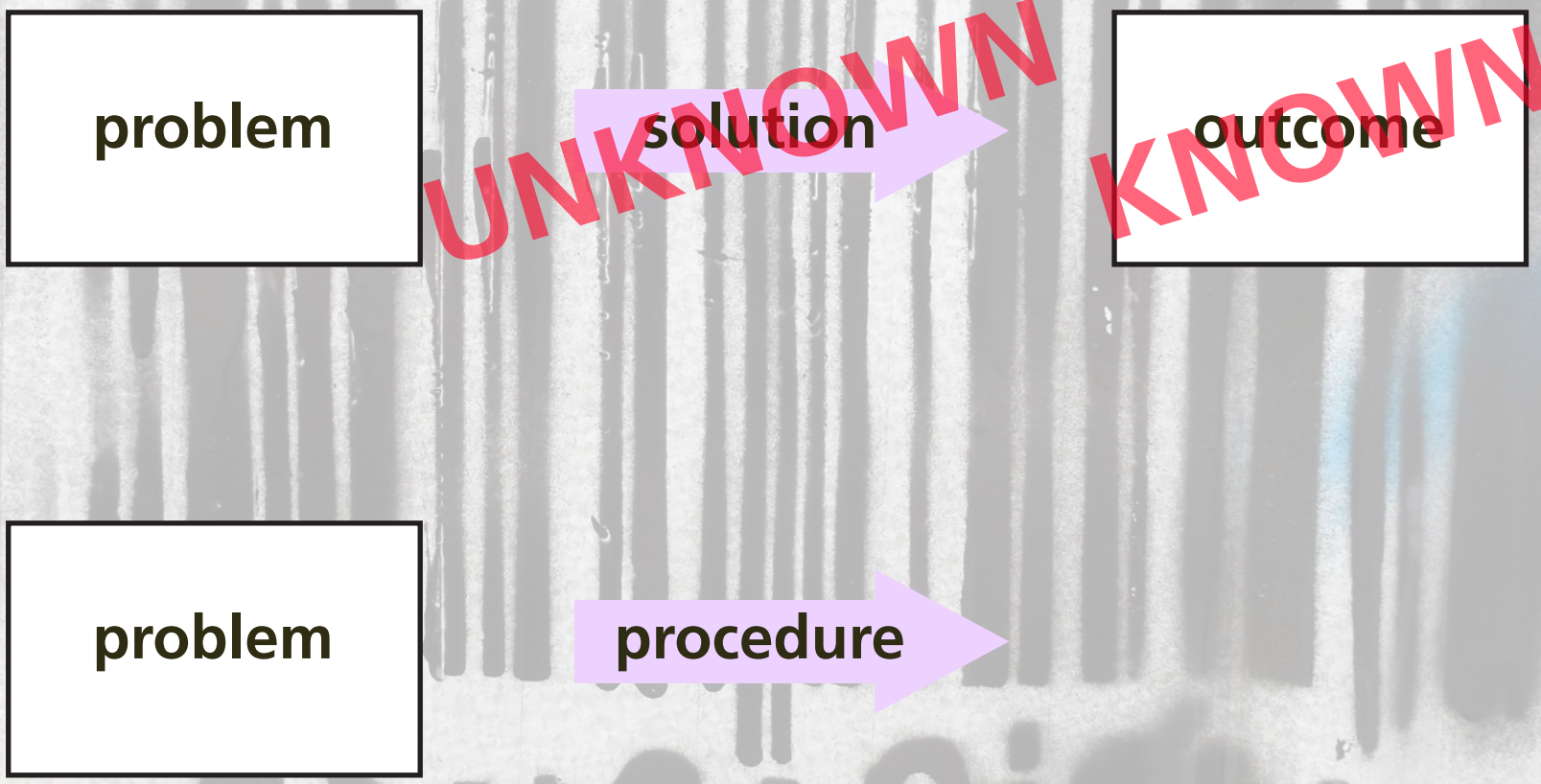
1 education

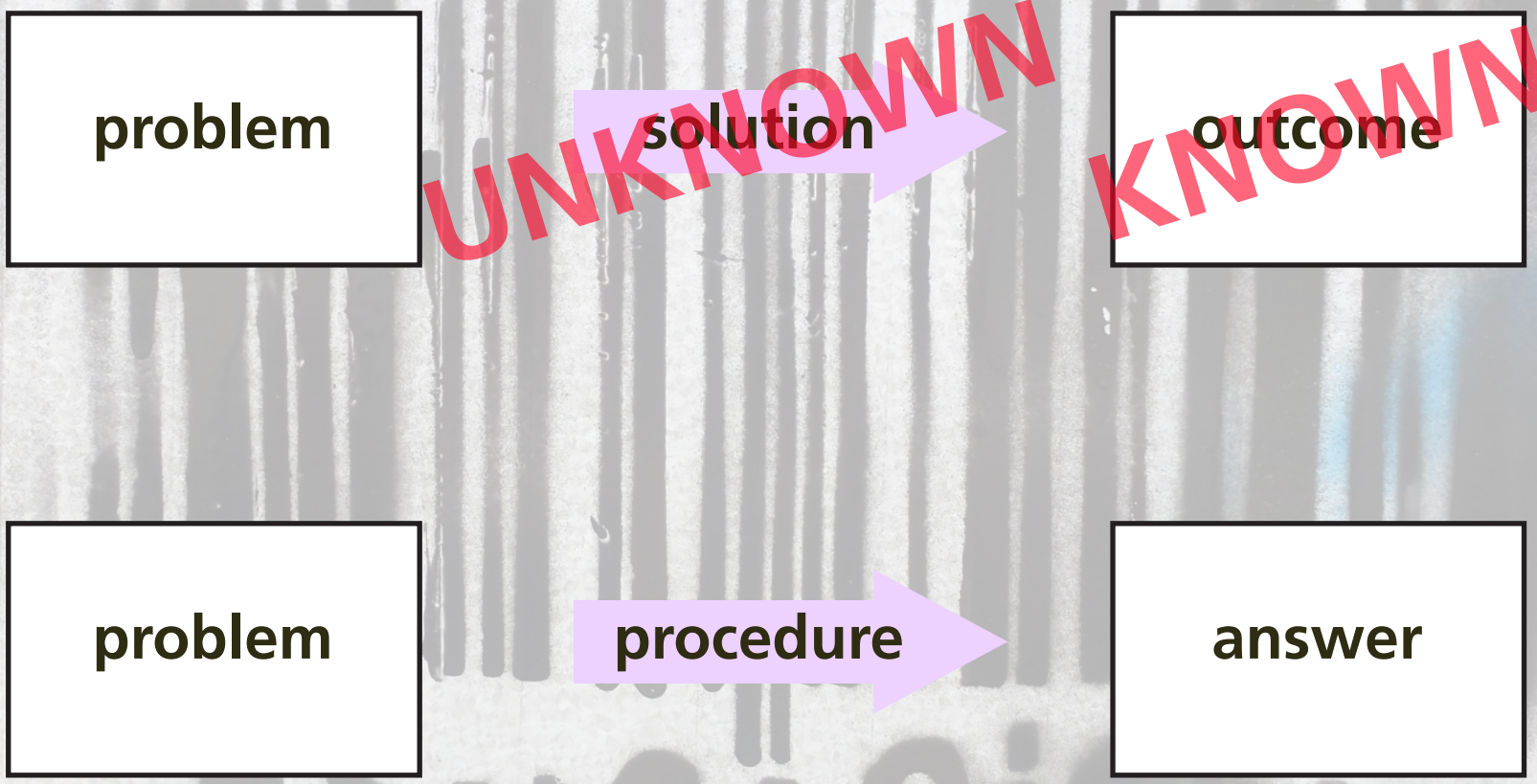


1 education

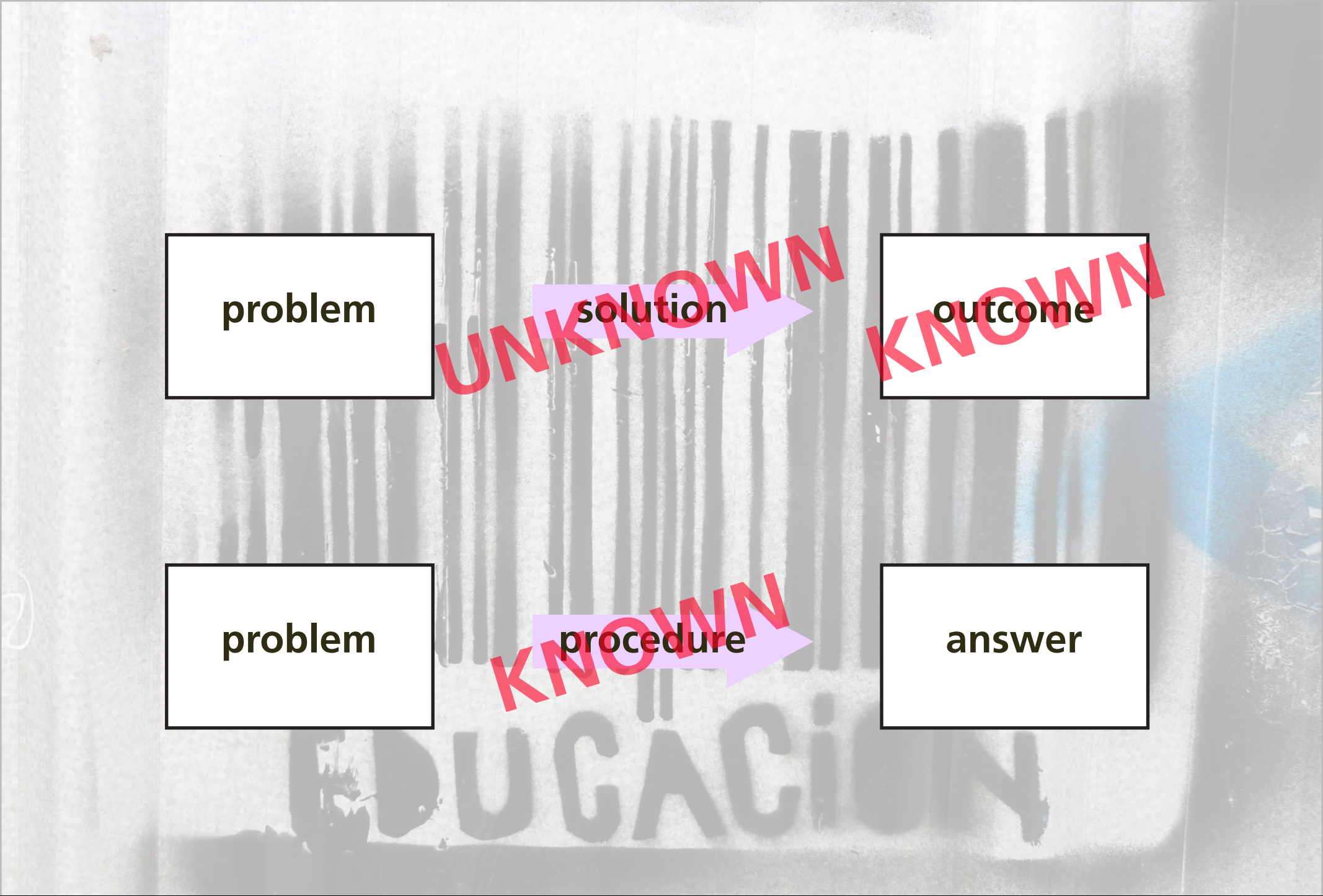


1 education


problem
solution
outcome
UNKNOWN
KNOWN
problem
procedure

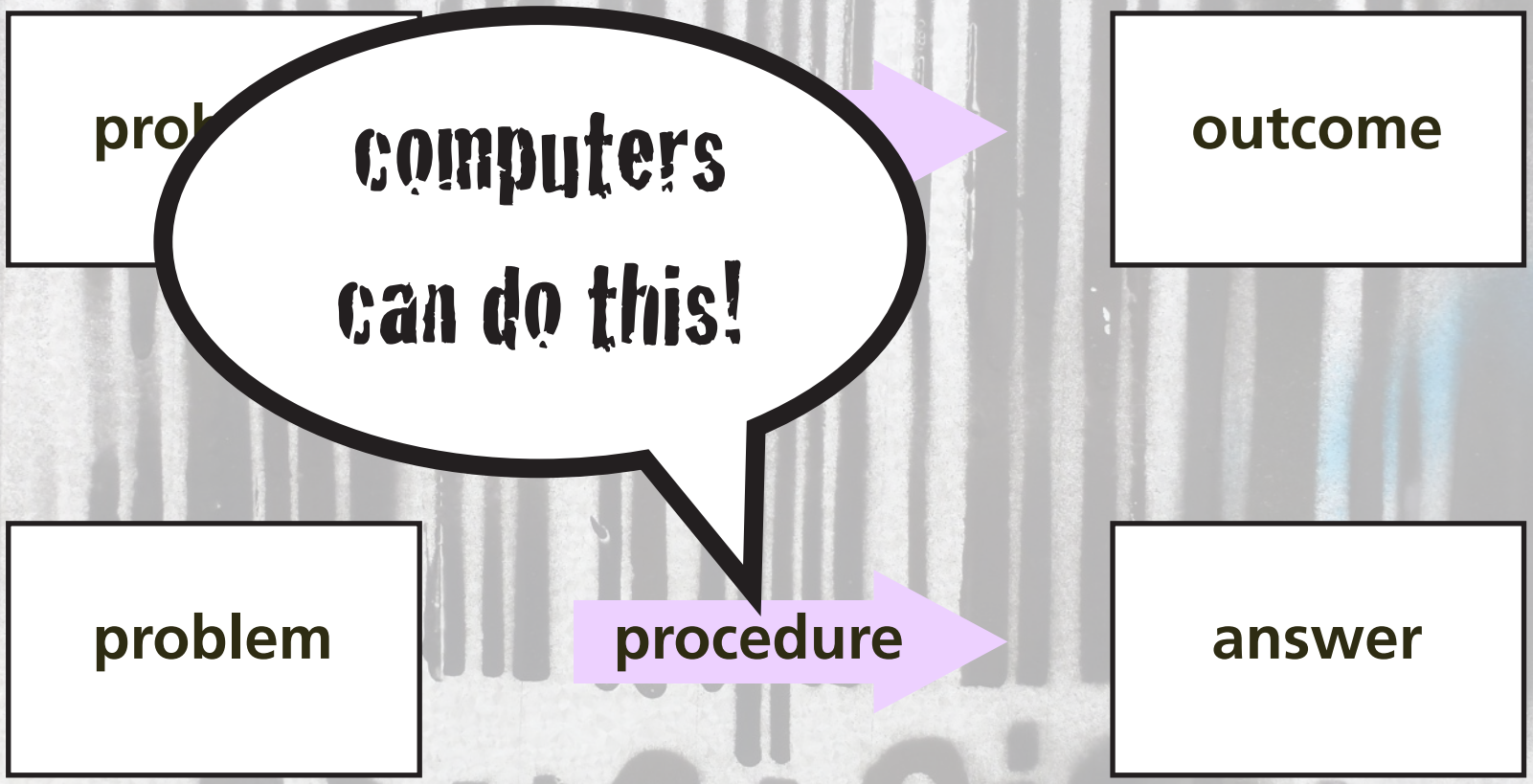

problem
solution
outcome
UNKNOWN
KNOWN
problem
procedure
answer

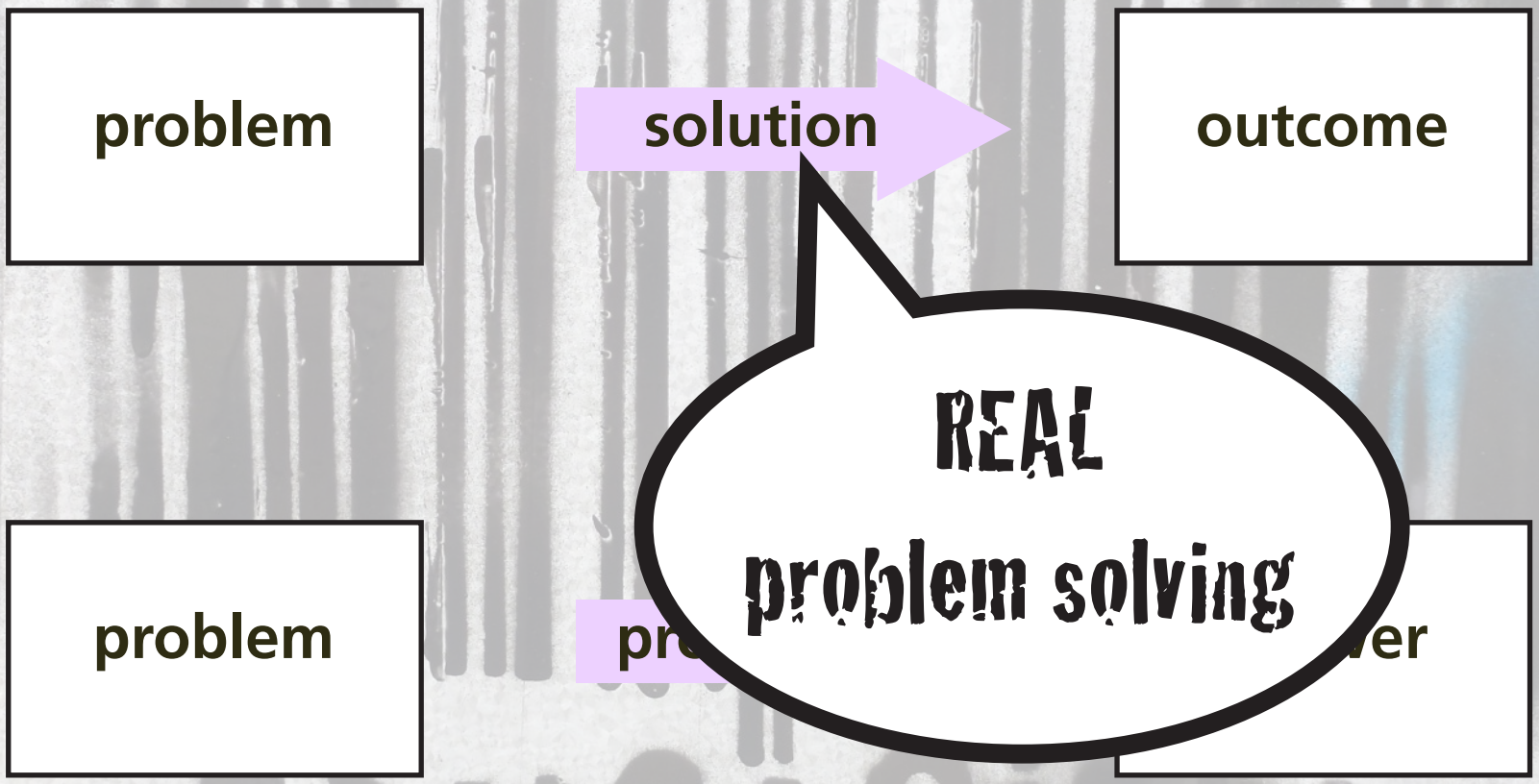
1 education

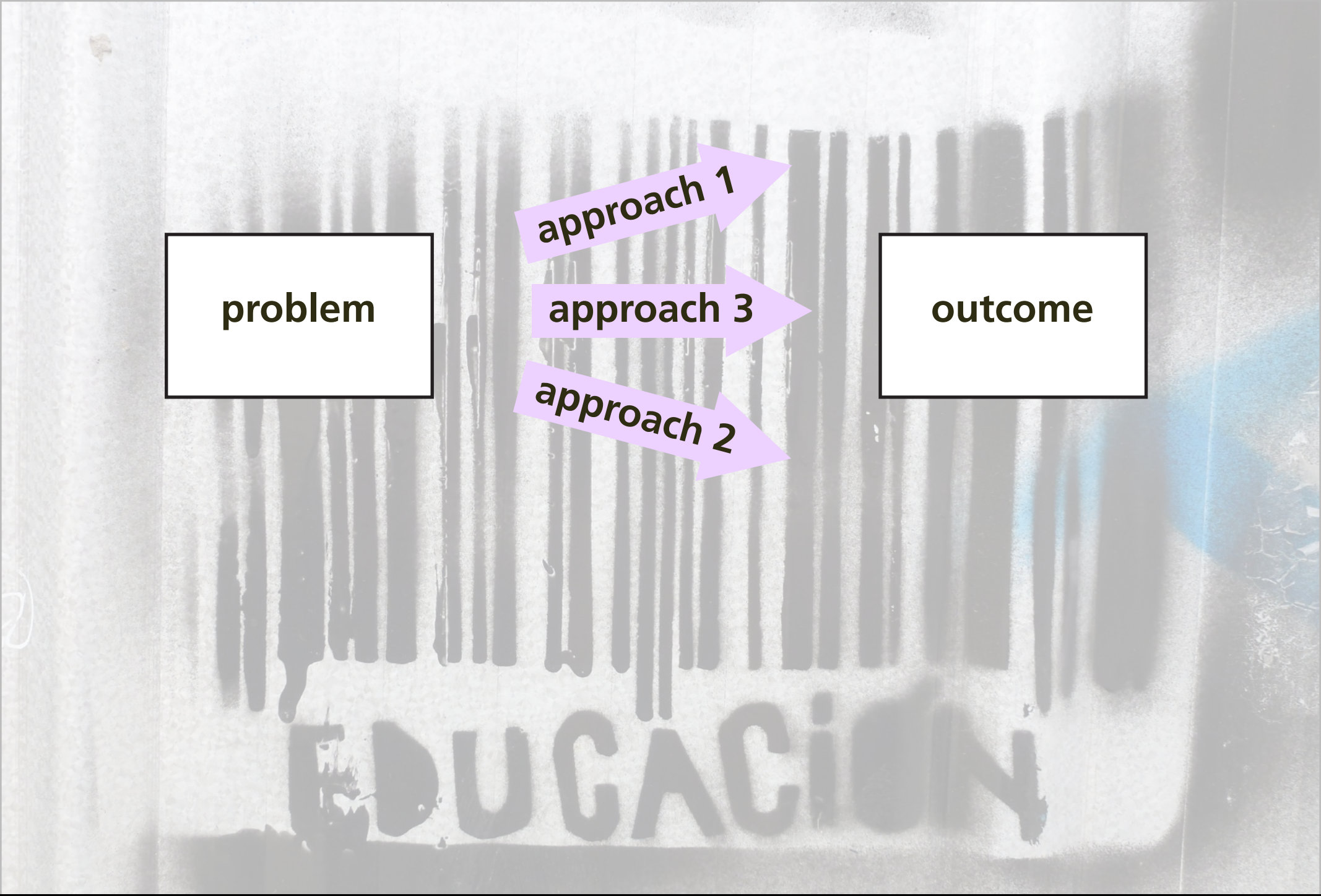

problem
solution
outcome
UNKNOWN
KNOWN
problem
procedure
answer
KNOWN

problem
solution
outcome
UNKNOWN
KNOWN
problem
procedure
answer
KNOWN
UNKNOWN

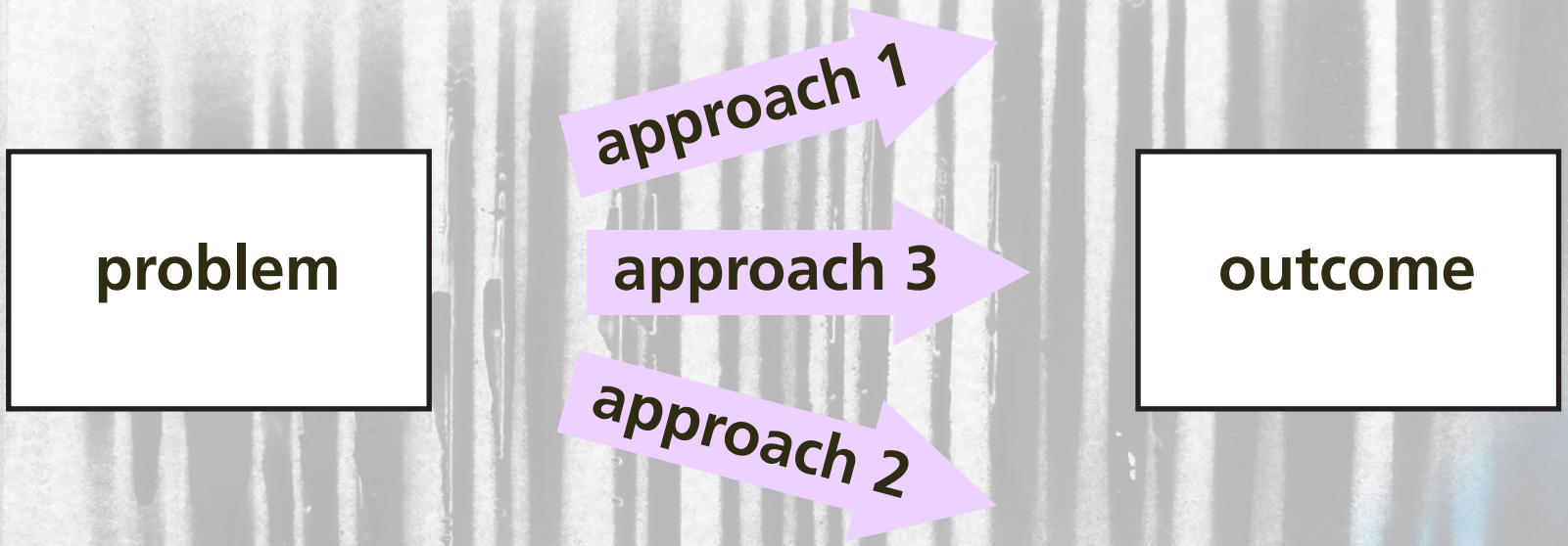
1 education


prob
computers
can do this!
outcome
problem
procedure
answer


problem
solution
outcome
REAL
problem solving
problem



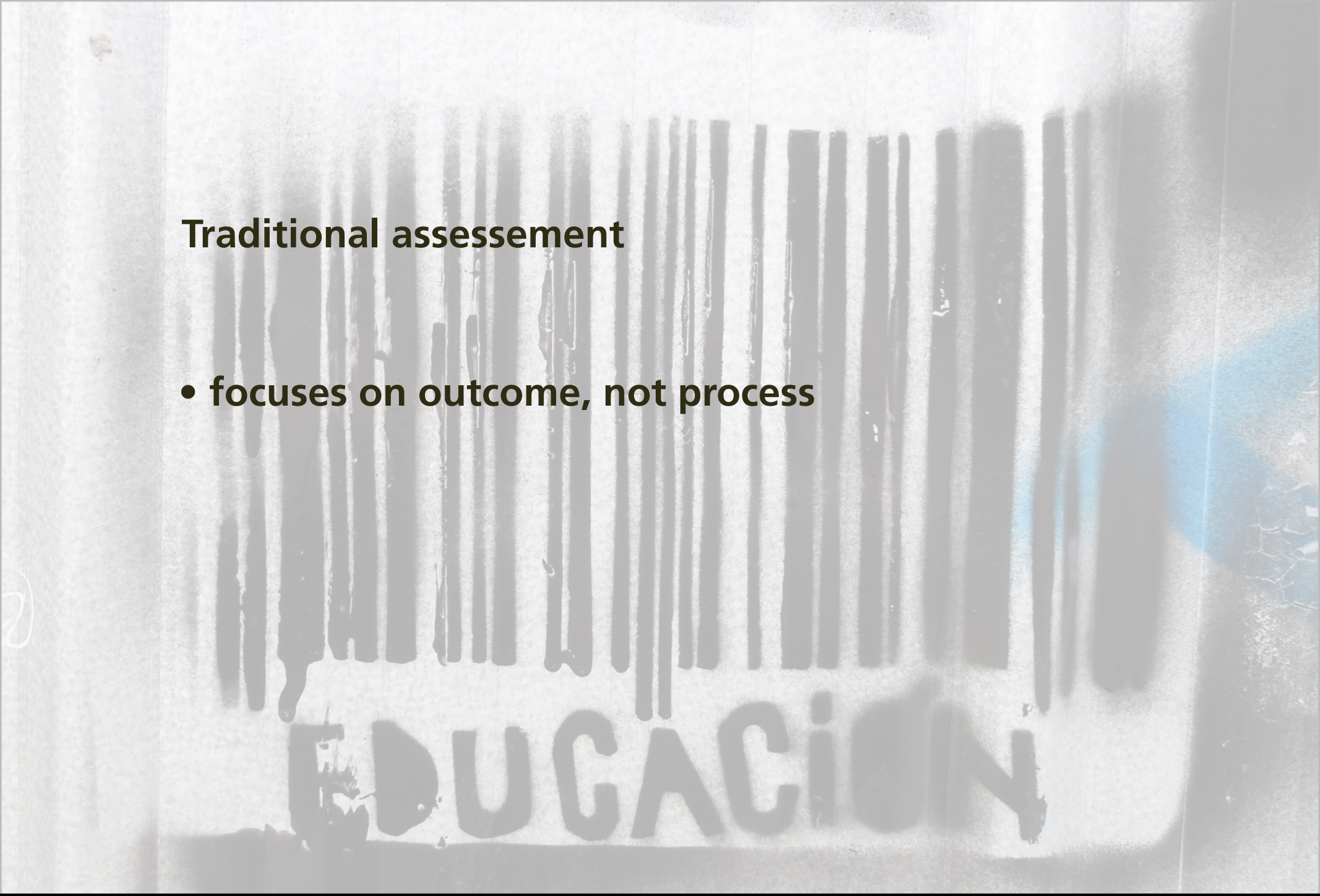
1 education



assessment incompatible with real problem solving

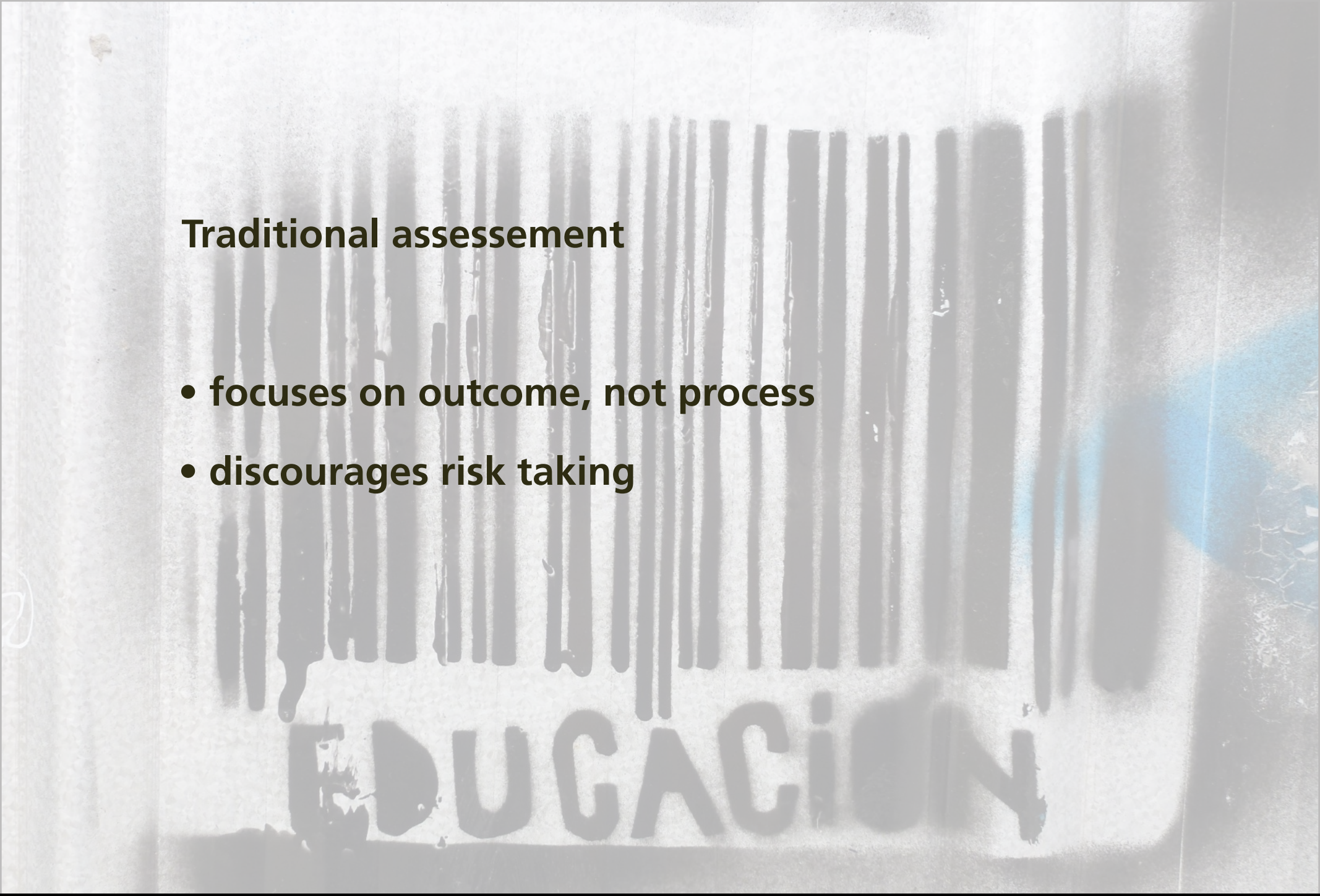
Traditional assessement

- focuses on outcome, not process



Traditional assessement

- focuses on outcome, not process
- discourages risk taking



Traditional assessement

- focuses on outcome, not process
- discourages risk taking
- focuses on individual, not group

Traditional assessement

- focuses on outcome, not process
- discourages risk taking
- focuses on individual, not group
- does not mirror future work environment

1 education

2 PI

1. transfer of information

1. transfer of information

2. assimilation of that information

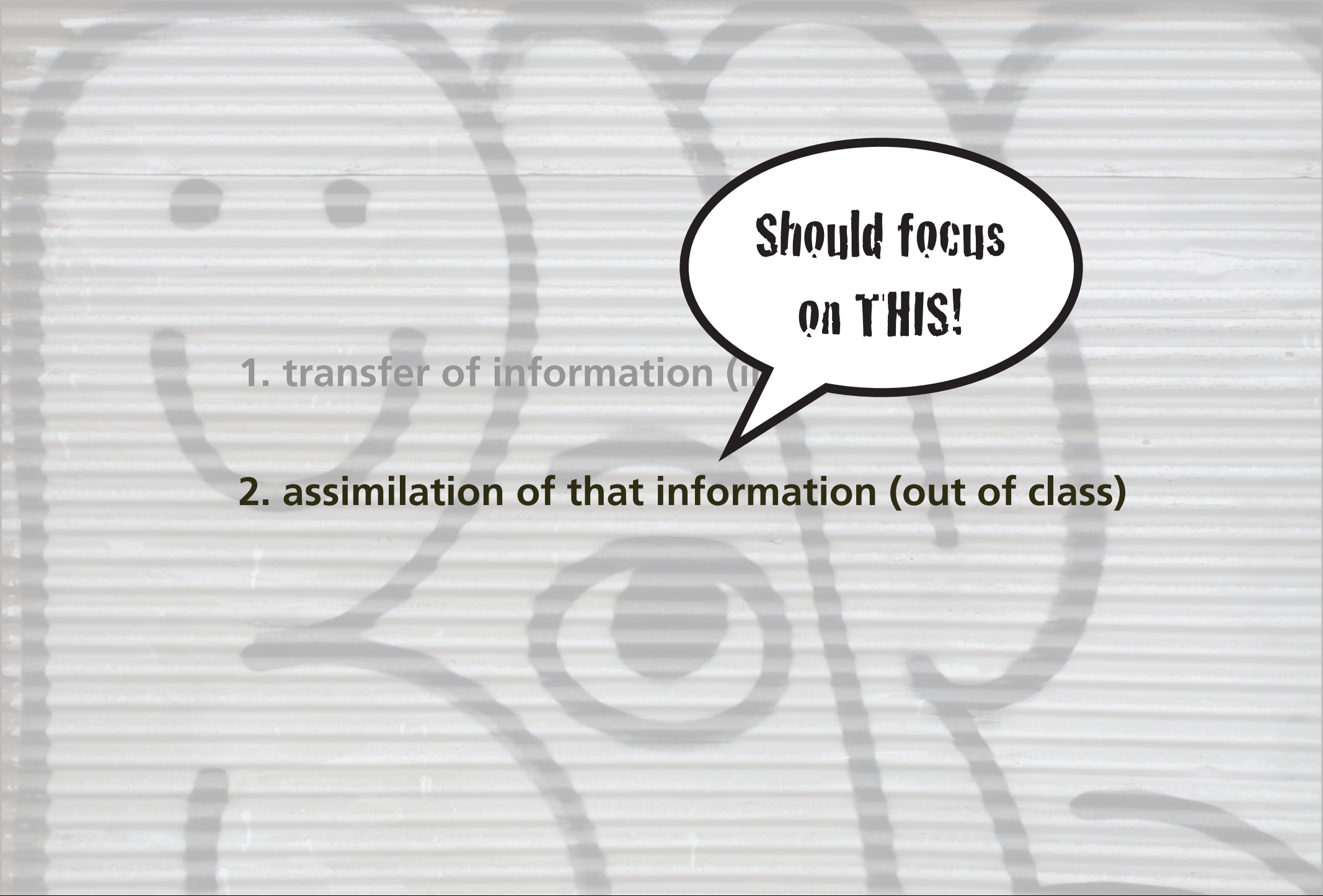
1 education 2 PI

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)



1 education 2 PI

1. transfer of information (in class)

2. assimilation of that information (out of class)

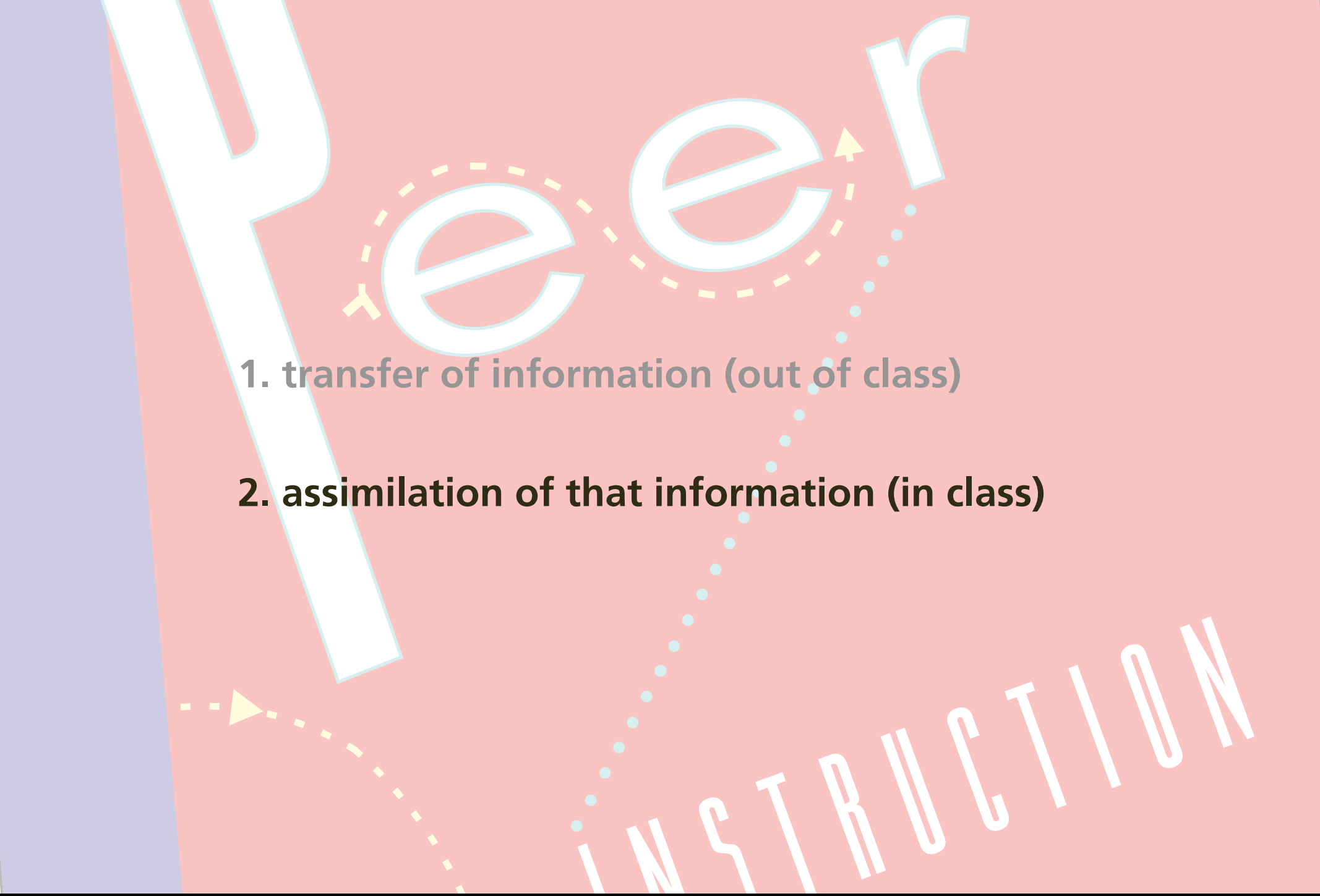
1 education

2 PI

1. transfer of information (out of class)

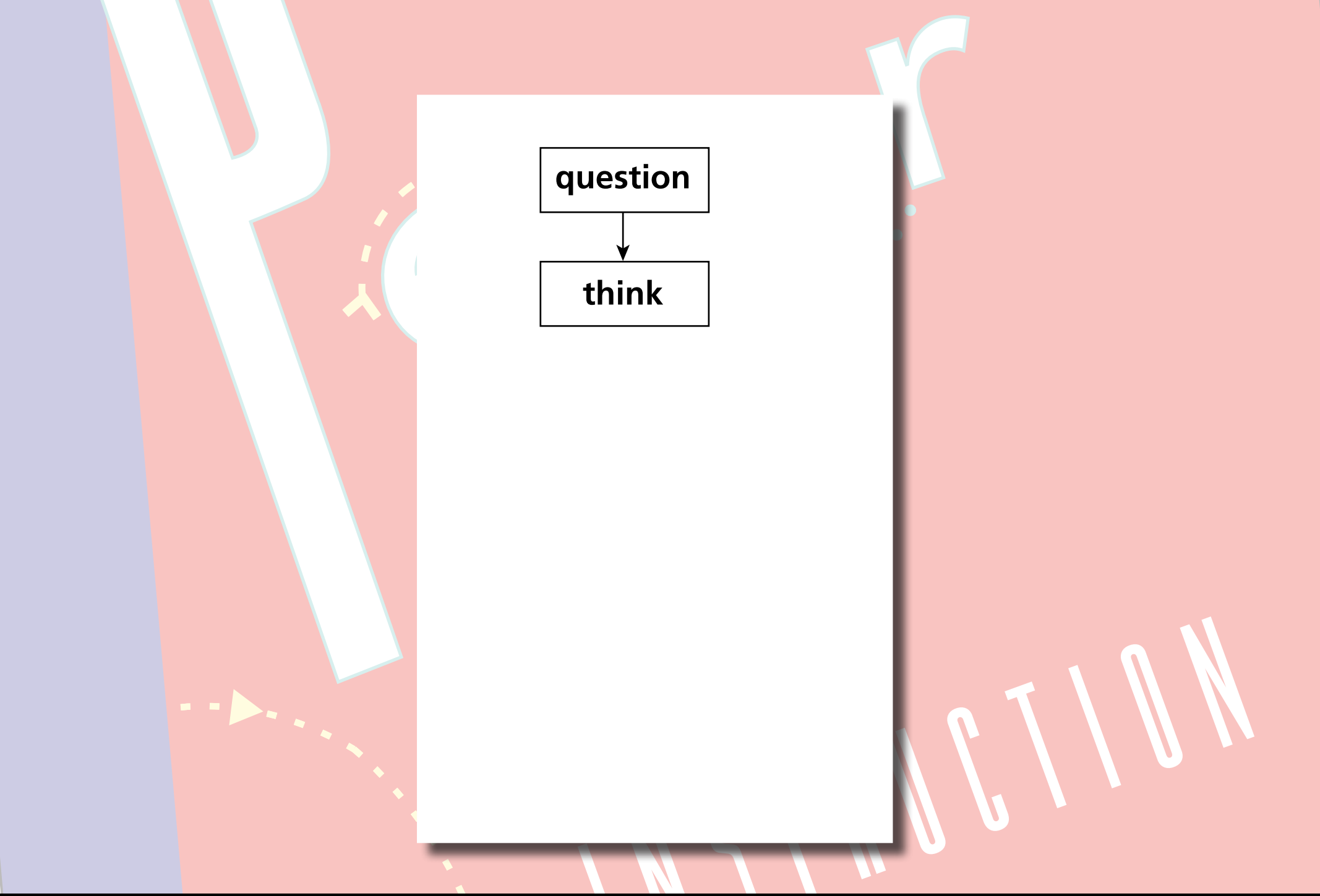
2. assimilation of that information (in class)

1 education 2 PI



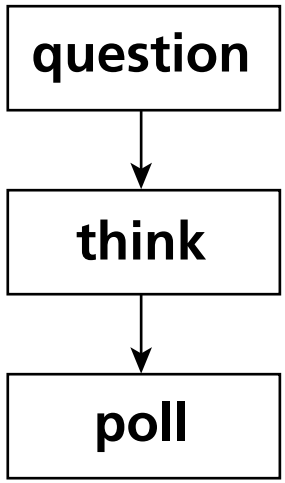
1 education 2 PI

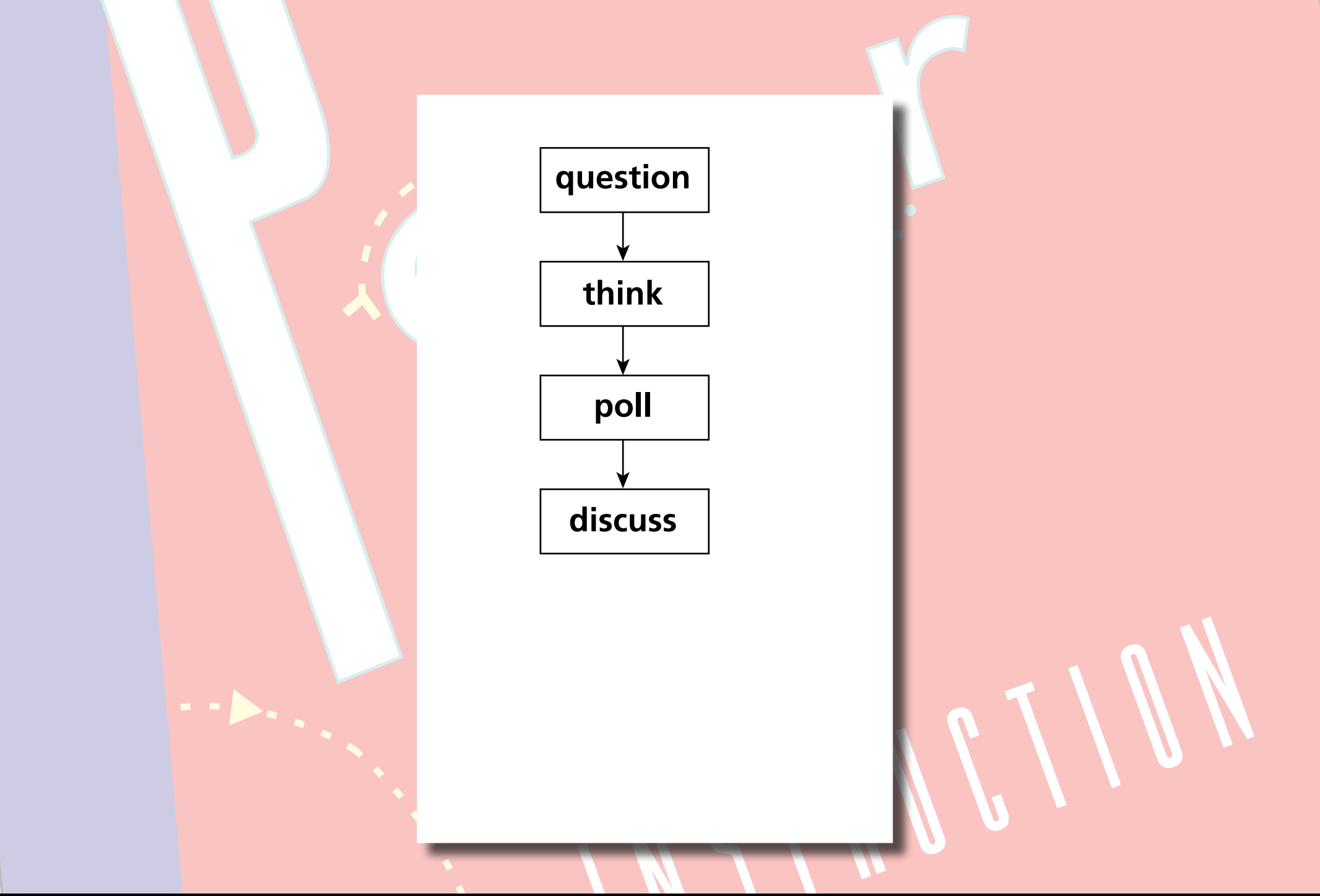
1 education 2 PI



1 education

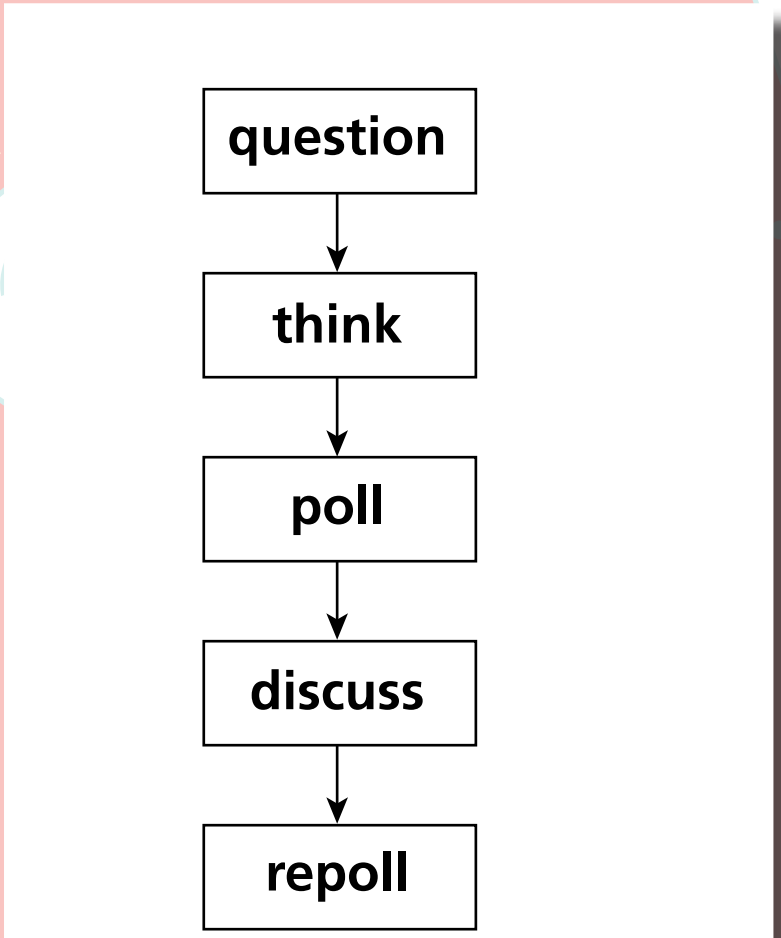
2 PI

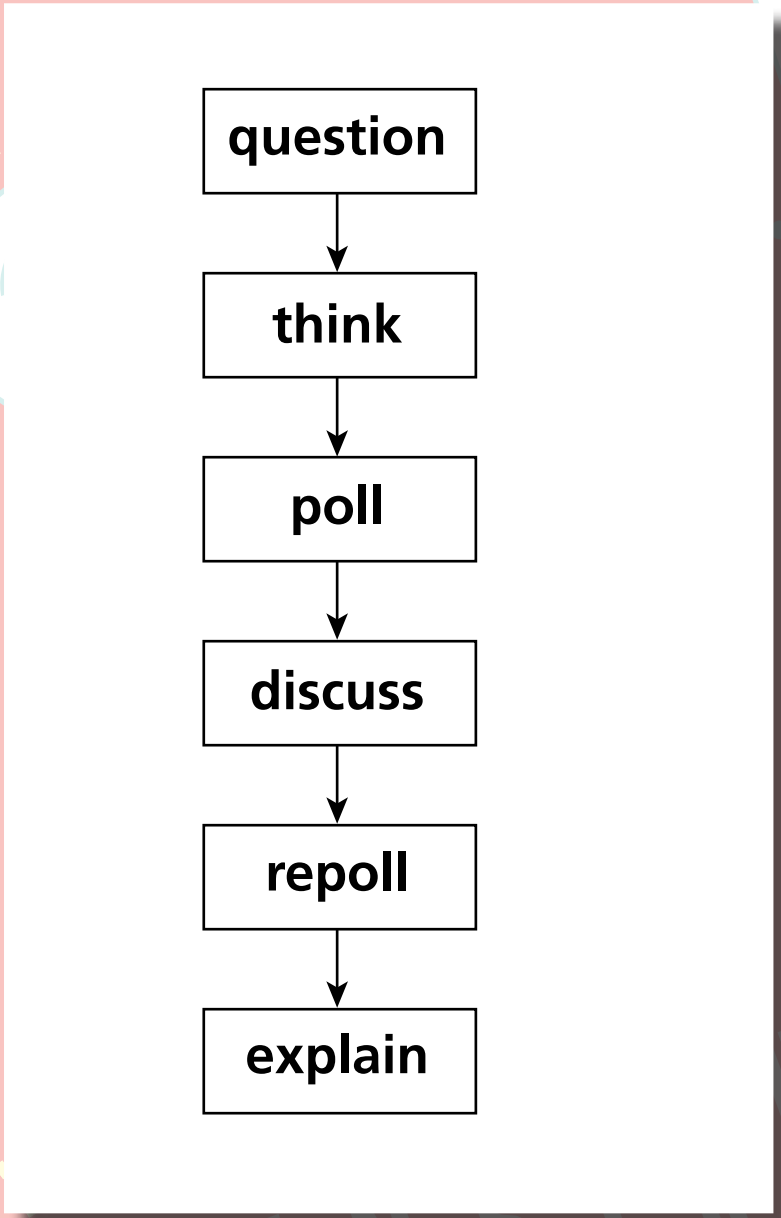

question
think
poll

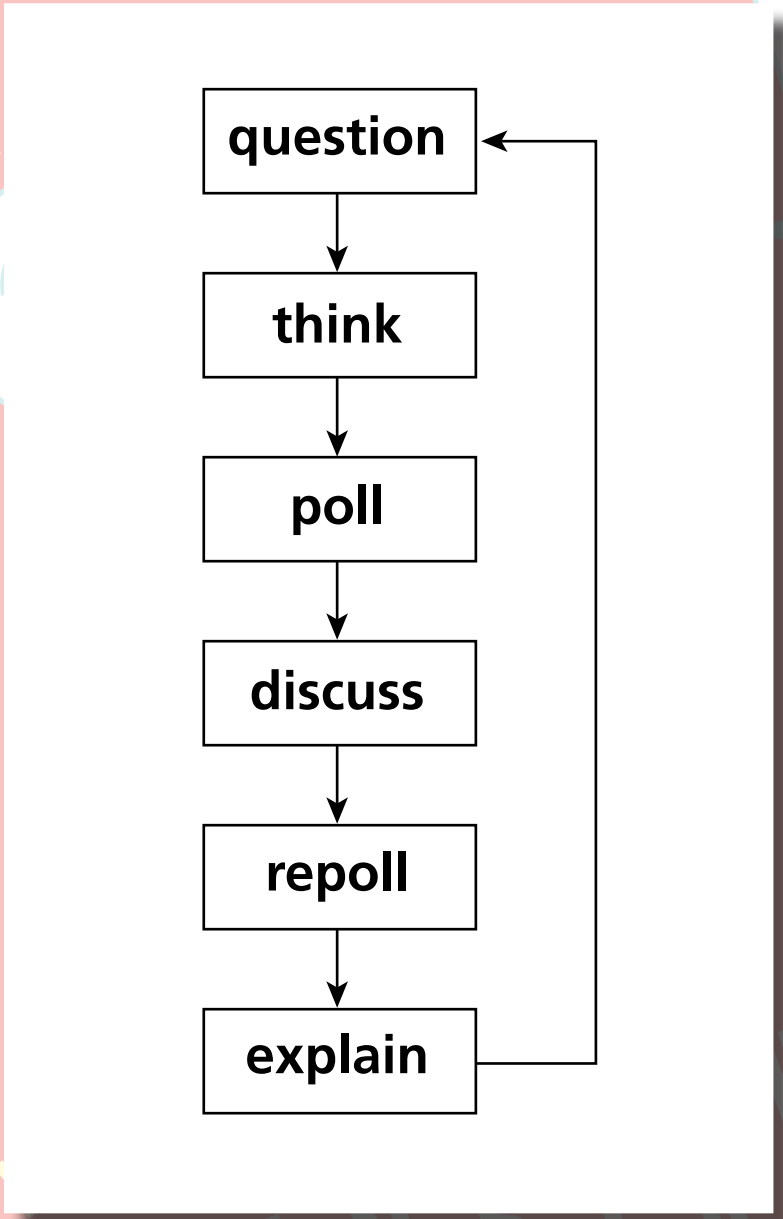


1 education

2 PI


question
think
poll
discuss
repoll


question
think
poll
discuss
repoll
explain


question
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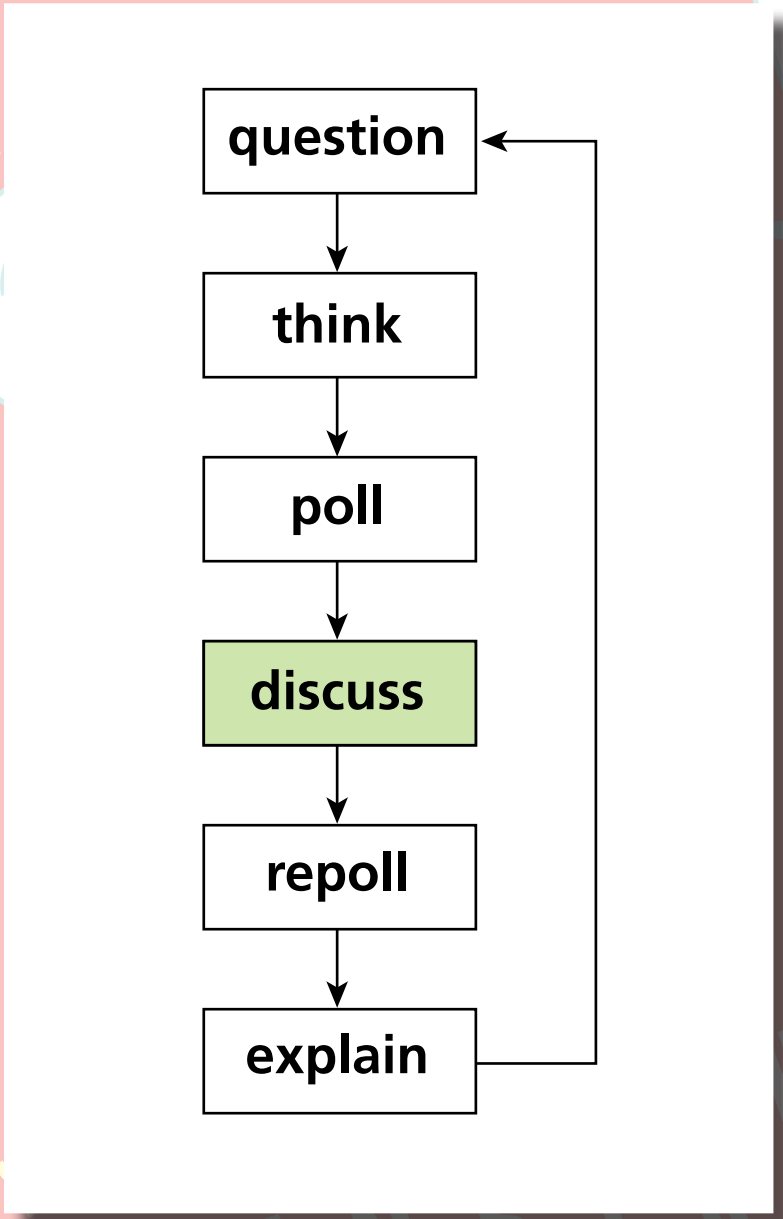
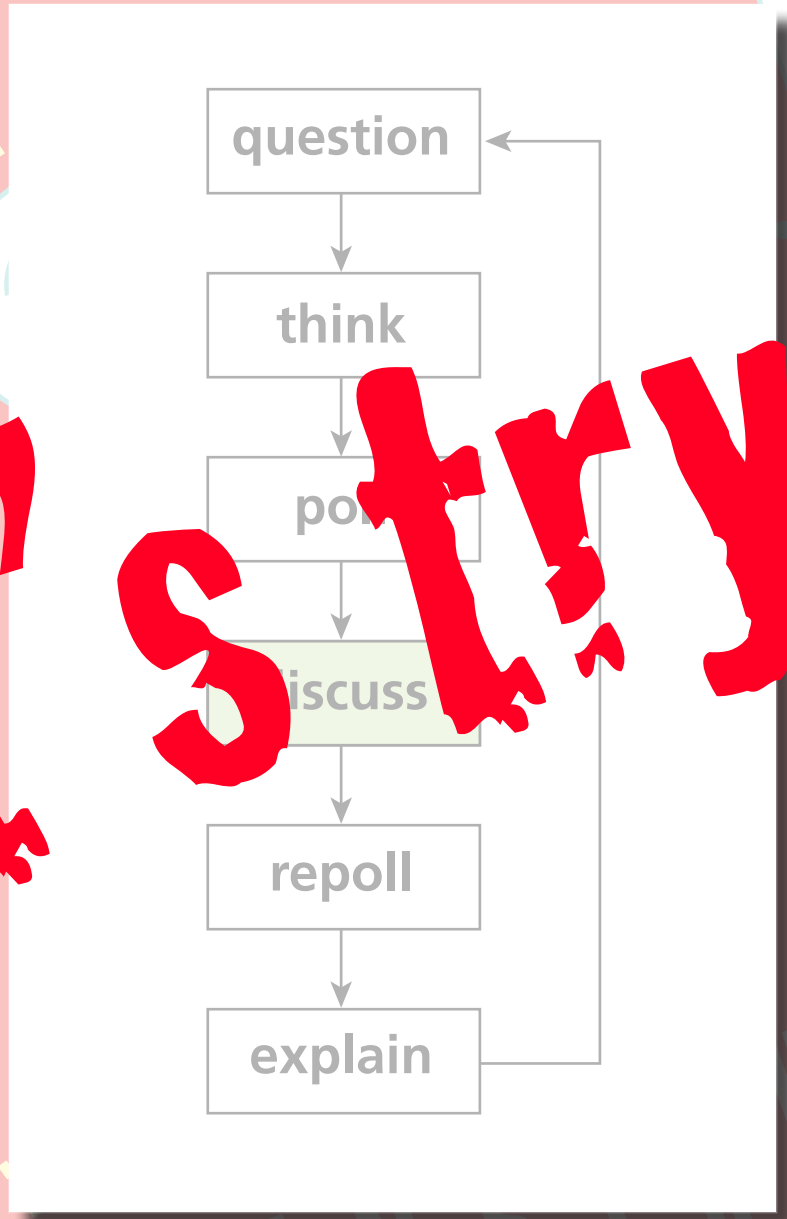


1 education

2 PI

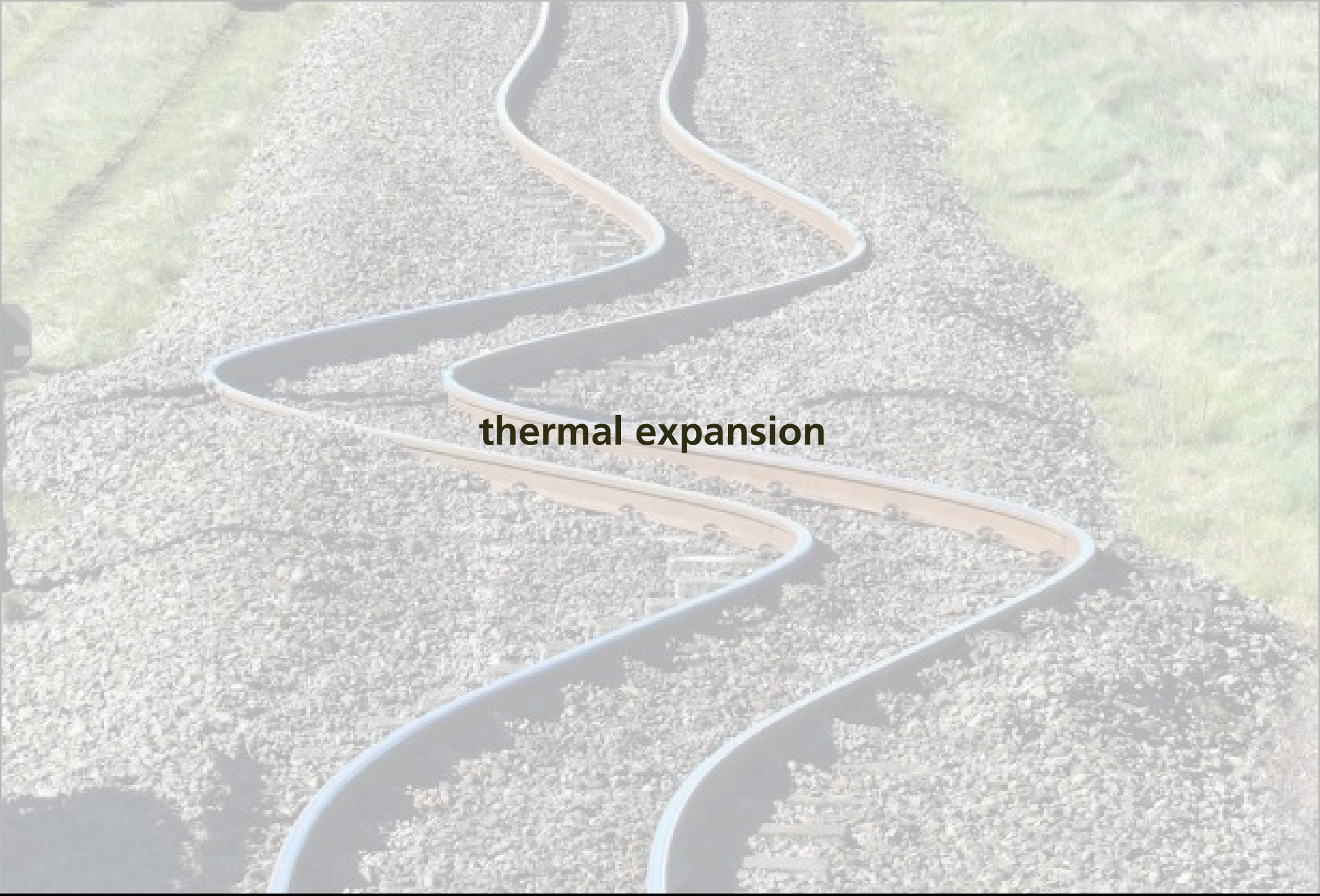
1. lecture
2. PI



Let's try it!

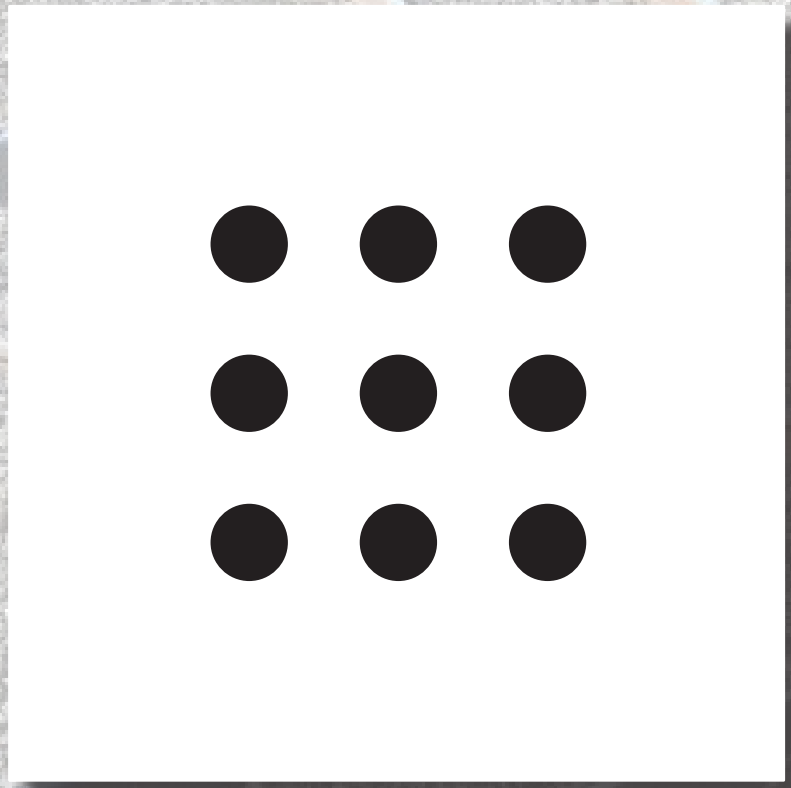
1 education

2 PI



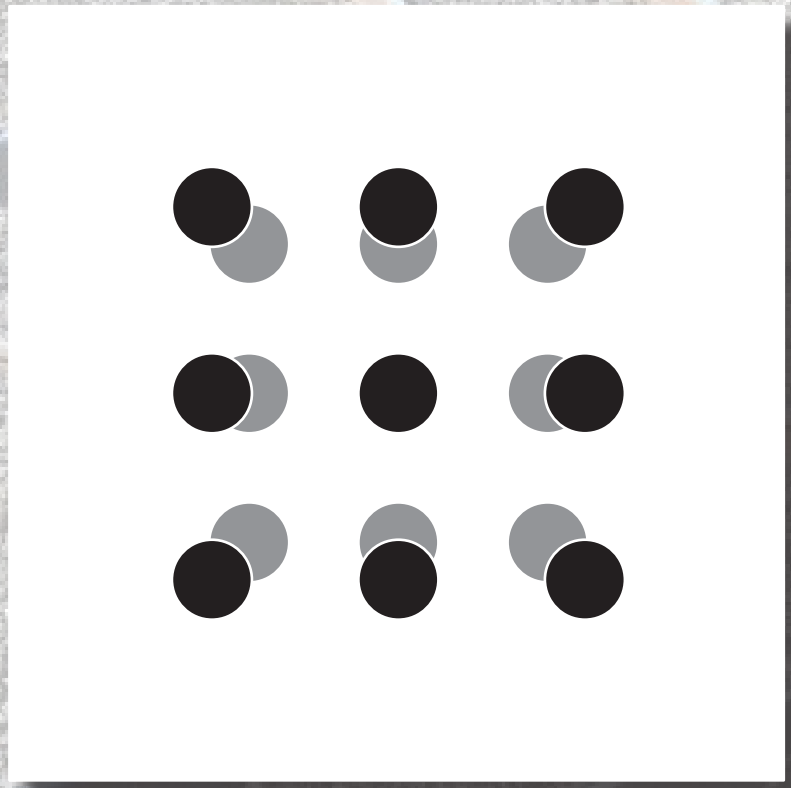
1 education

2 PI



1 education

2 PI



1 education

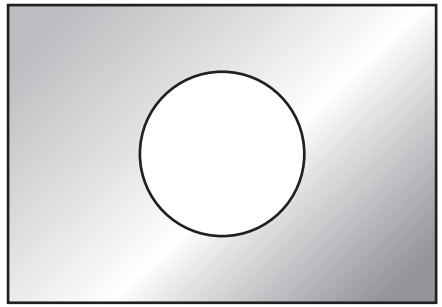
2 PI

1 education

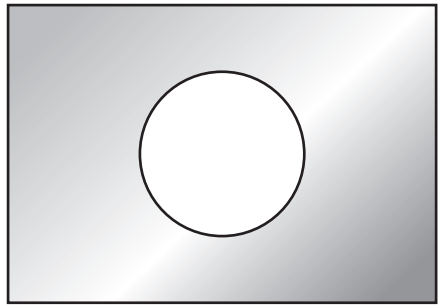
2 PI

1 education 2 PI 3 test?

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



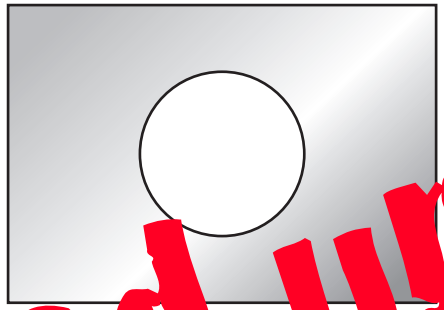
Consider a rectangular metal plate with a circular hole in it.



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.



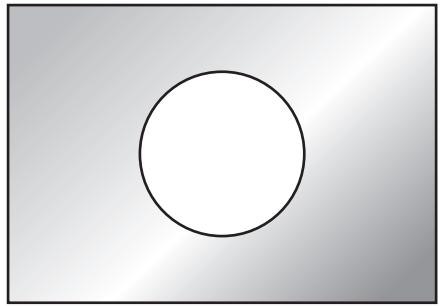
When the plate is uniformly heated, the diameter of the hole

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

you got all fired up!

1 education 2 PI 3 test

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…

1 education

2 PI

3 test

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

1 education 2 PI 3 test

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…

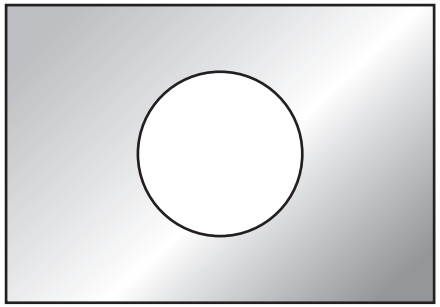
1. made a commitment
2. externalized your answer
3. moved from the answer/fact to reasoning

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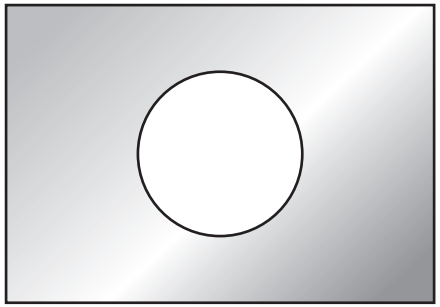
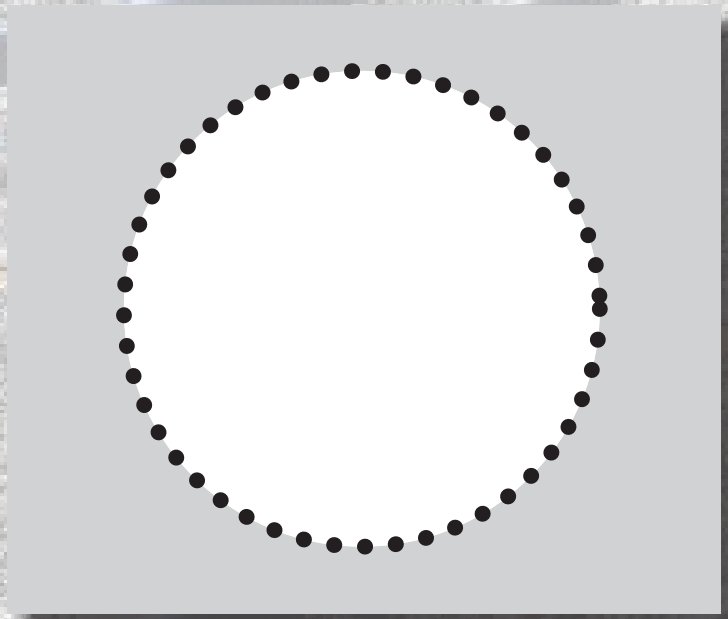
Consider a rectangular metal plate with a circular hole in it.



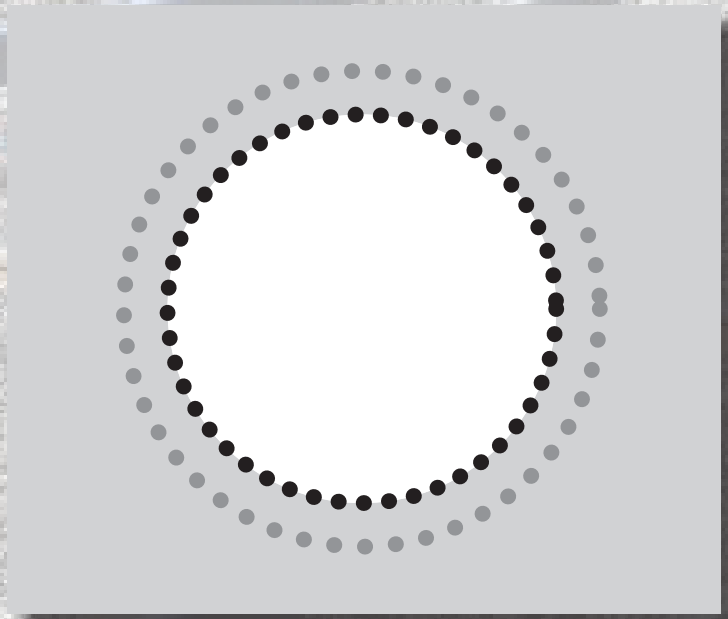
When the plate is uniformly heated, the diameter of the hole

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

consider atoms at rim of hole

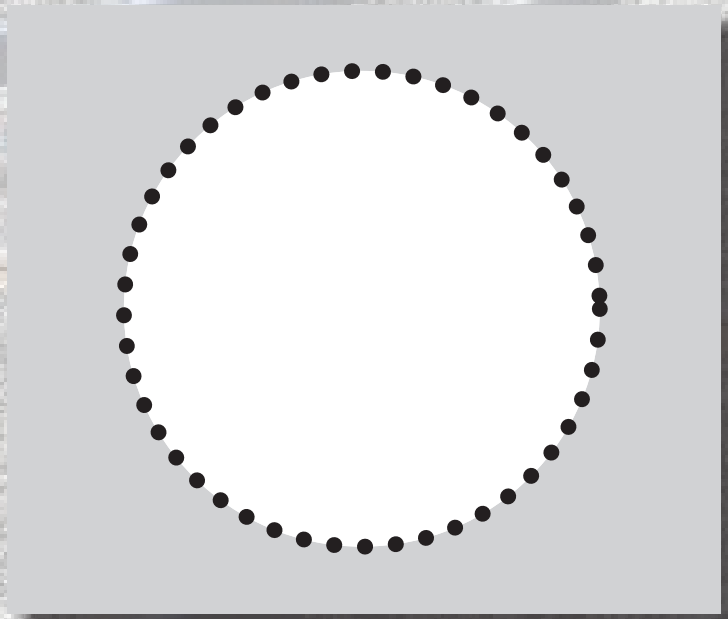


consider atoms at rim of hole

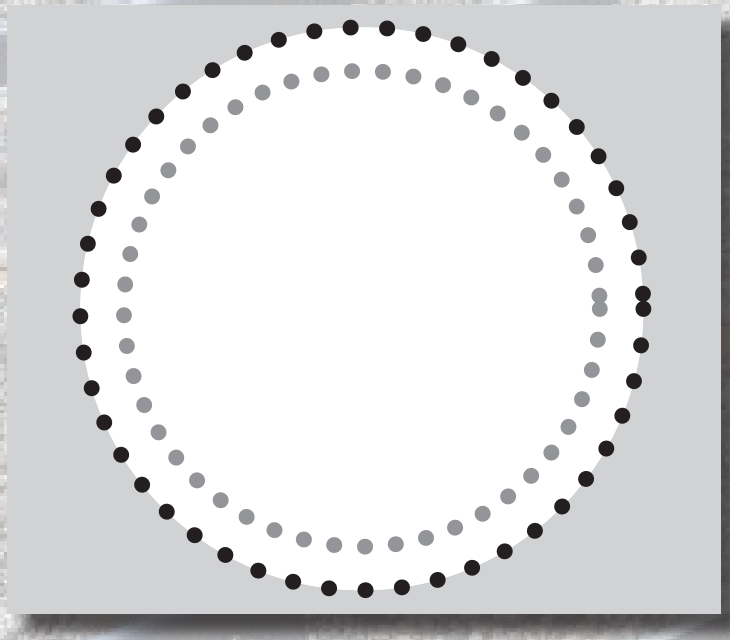


1 education 2 PI 3 test

consider atoms at rim of hole



consider atoms at rim of hole



consider atoms at rim of hole

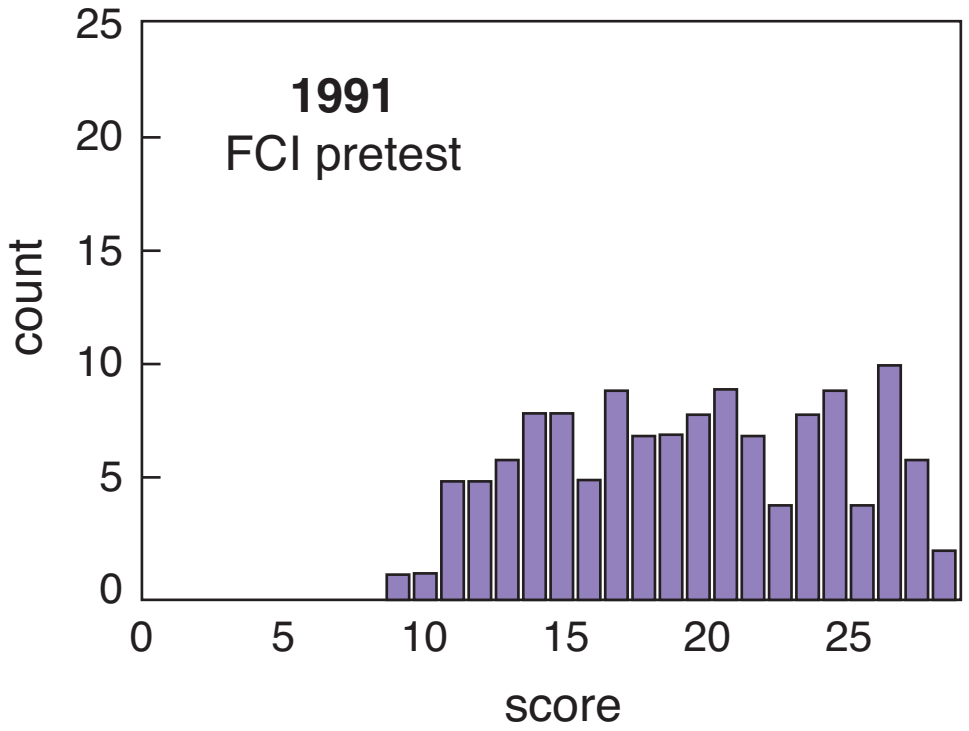
you won't forget this

1 education 2 PI 3 test

1 education 2 PI 3 test

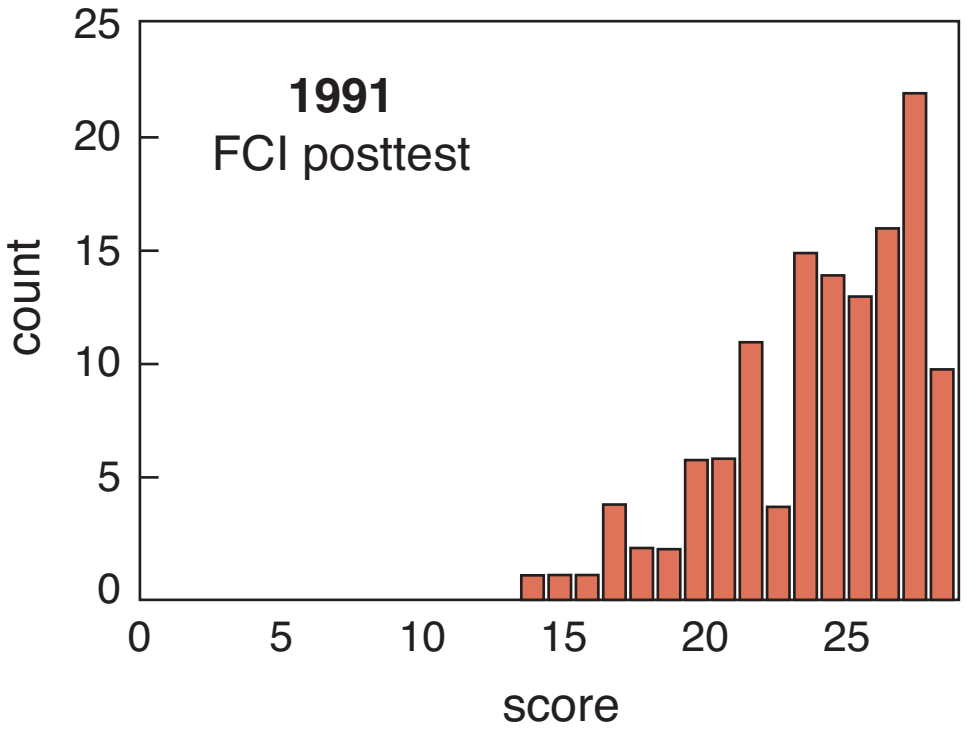
1 education 2 PI 3 test

first year of implementing PI



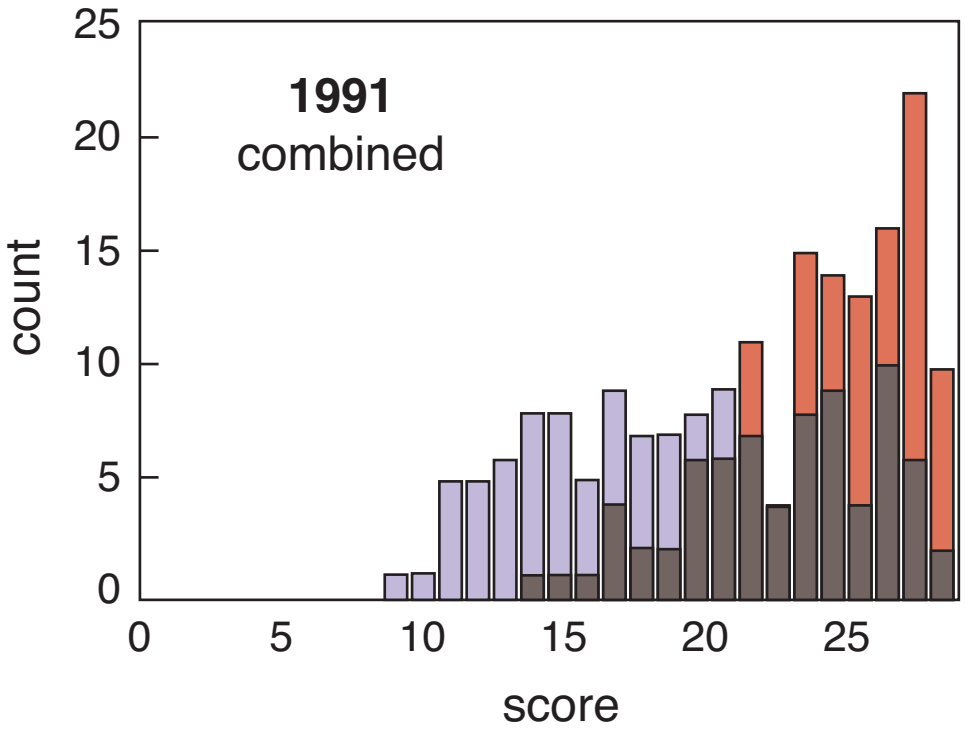
1 education 2 PI 3 test

first year of implementing PI



1 education 2 PI 3 test

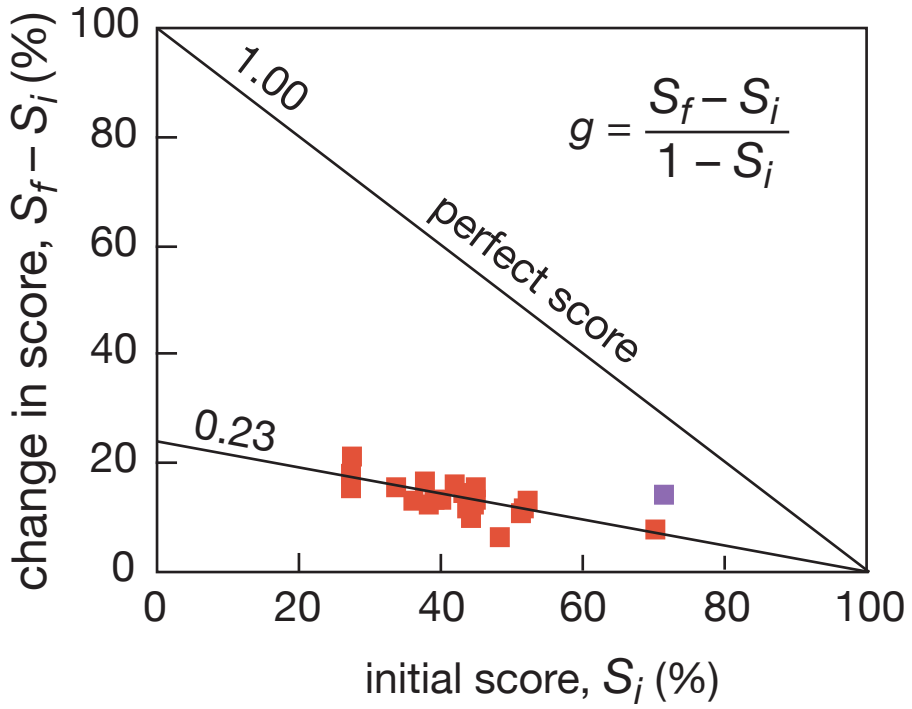
first year of implementing PI



1 education

2 PI

3 test



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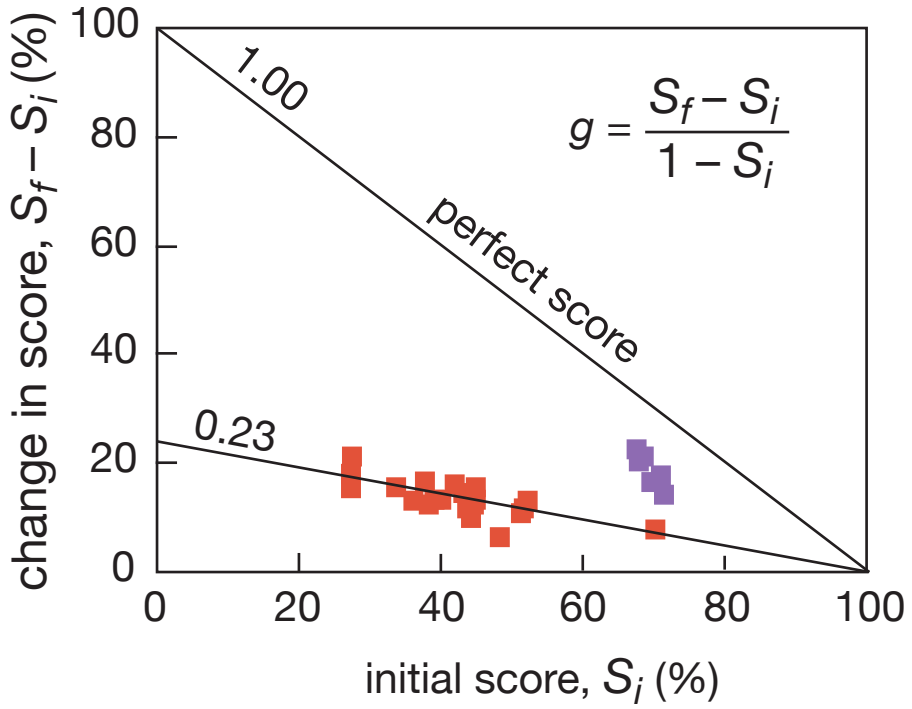

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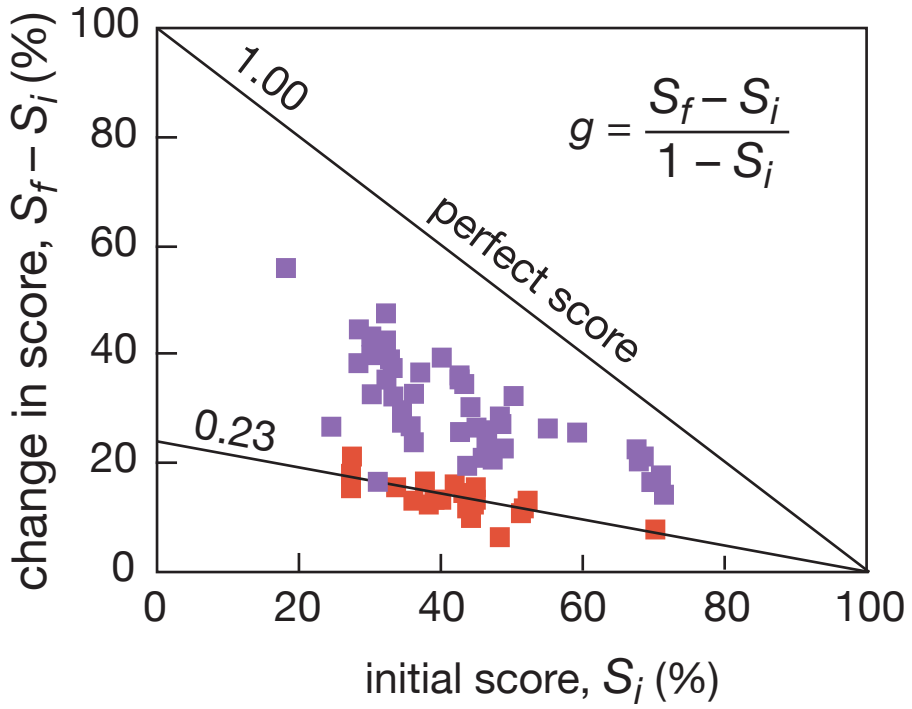
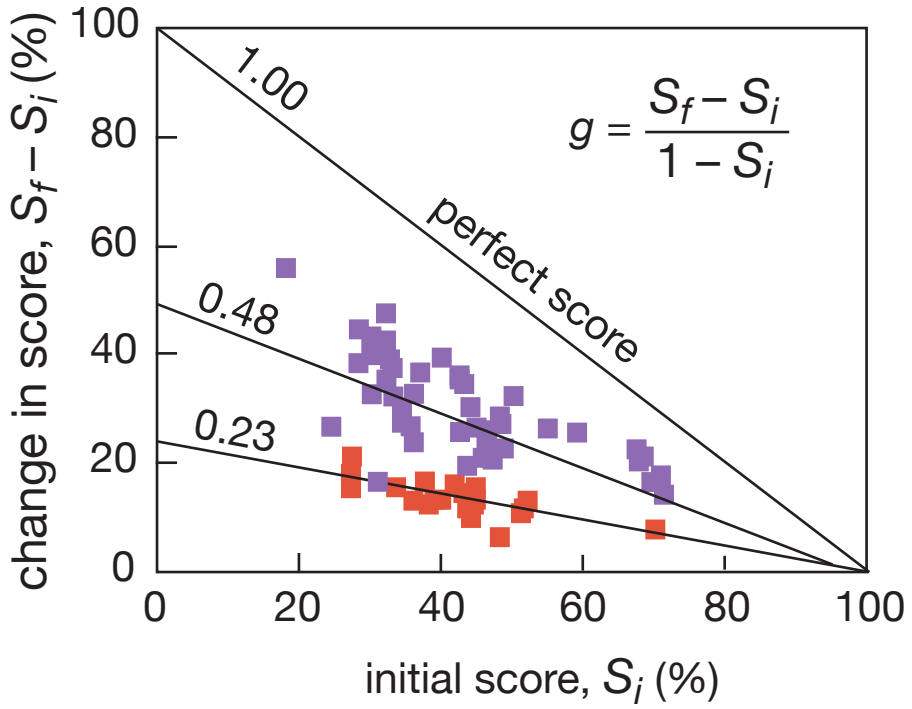


R.R. Hake, *Am. J. Phys.* 66, 64 (1998)

1 education 2 PI 3 test



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1 education 2 PI 3 test

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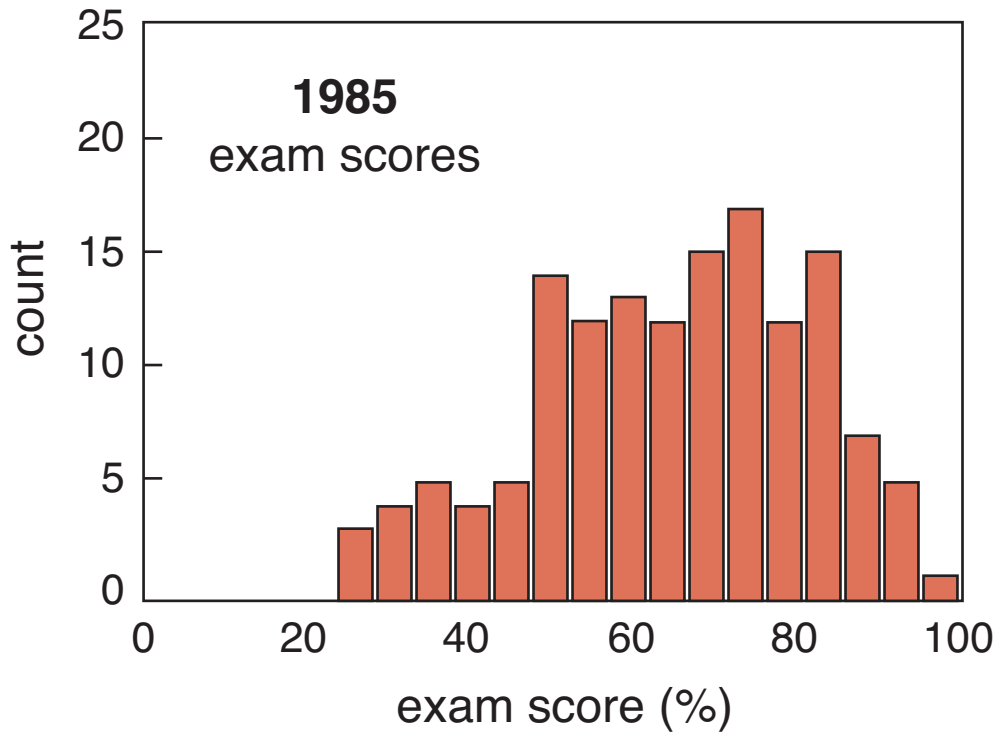

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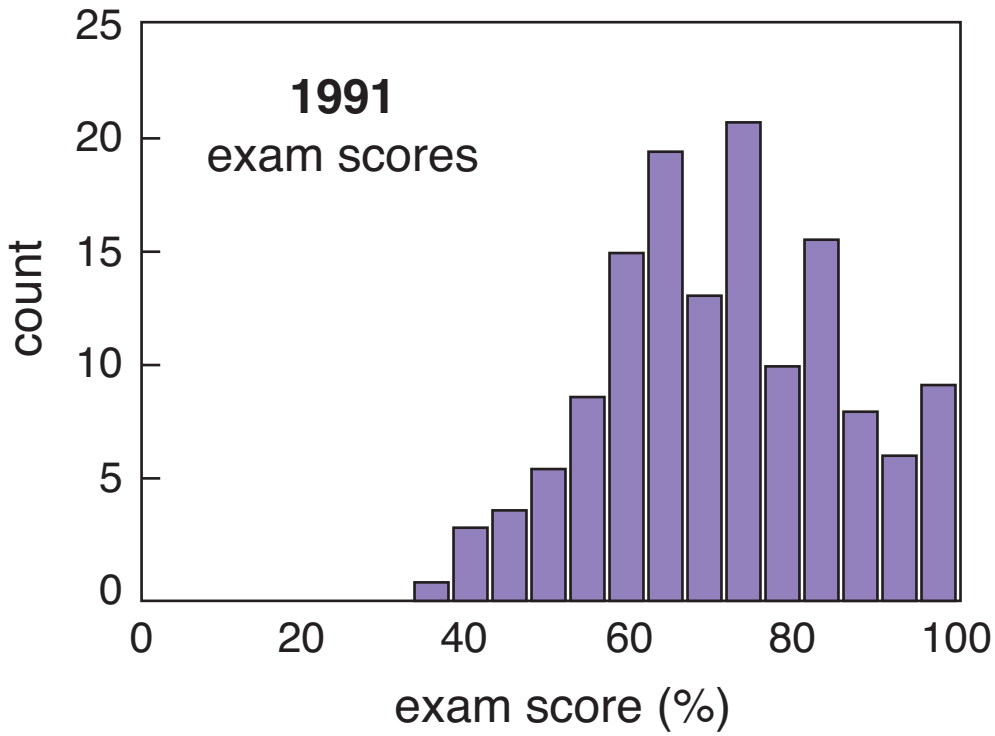

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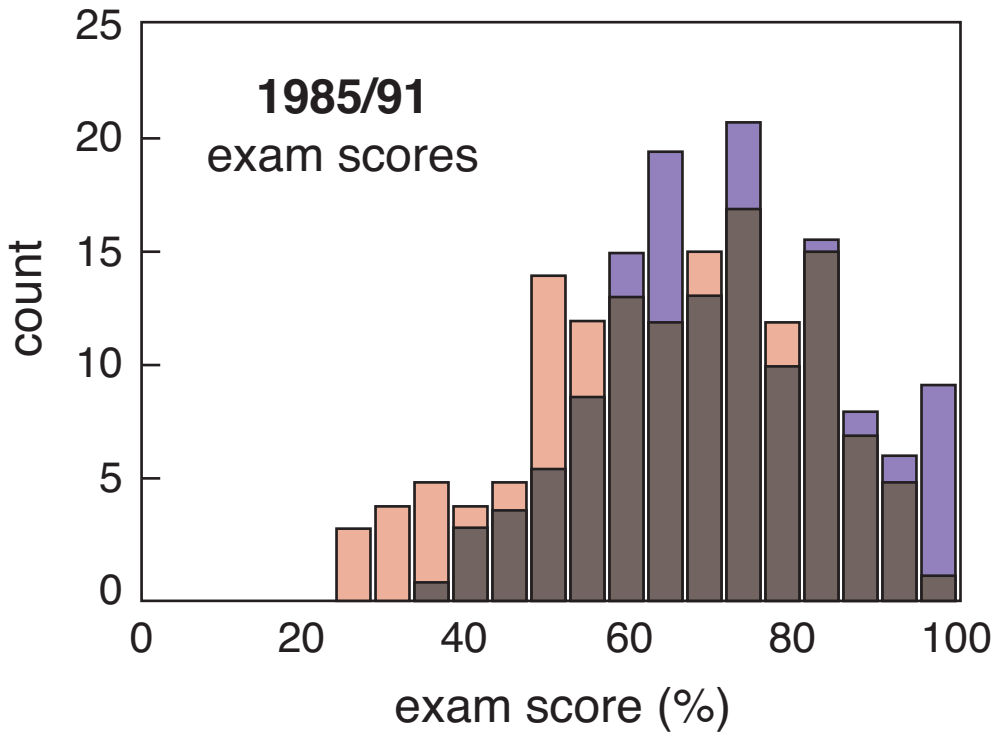

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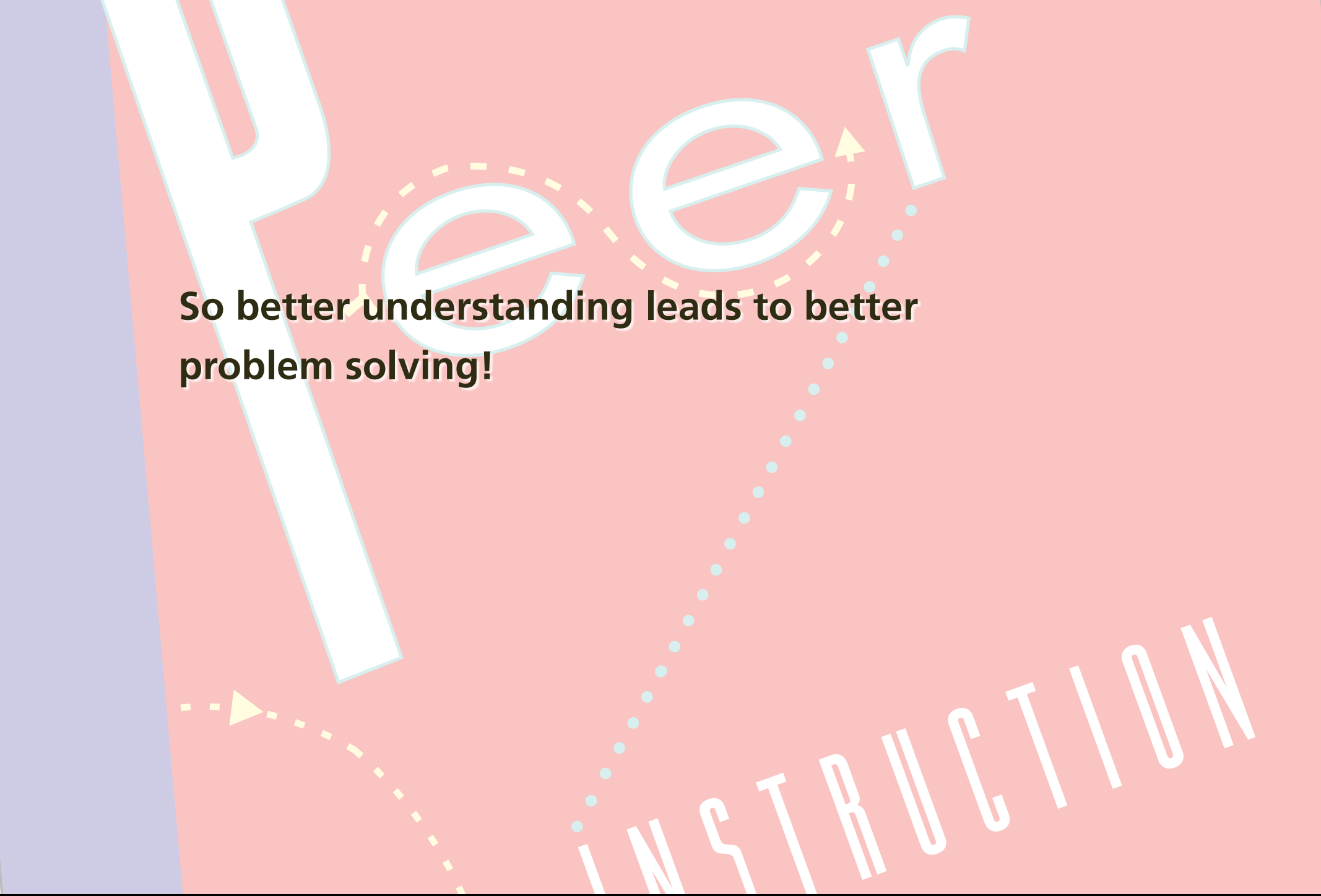


So better understanding leads to better problem solving!

1 education 2 PI 3 test

So better understanding leads to better problem solving!

(but “good” problem solving doesn’t always indicate understanding!)

1 education 2 PI 3 test

Peer
Higher learning gains
INSTRUCTION
1 education
2 PI
3 test

Peer
Higher learning gains
Better retention
INSTRUCTION
1 education
2 PI
3 test

1 education

2 PI

3 test

in a lecture, students…

1 education

2 PI

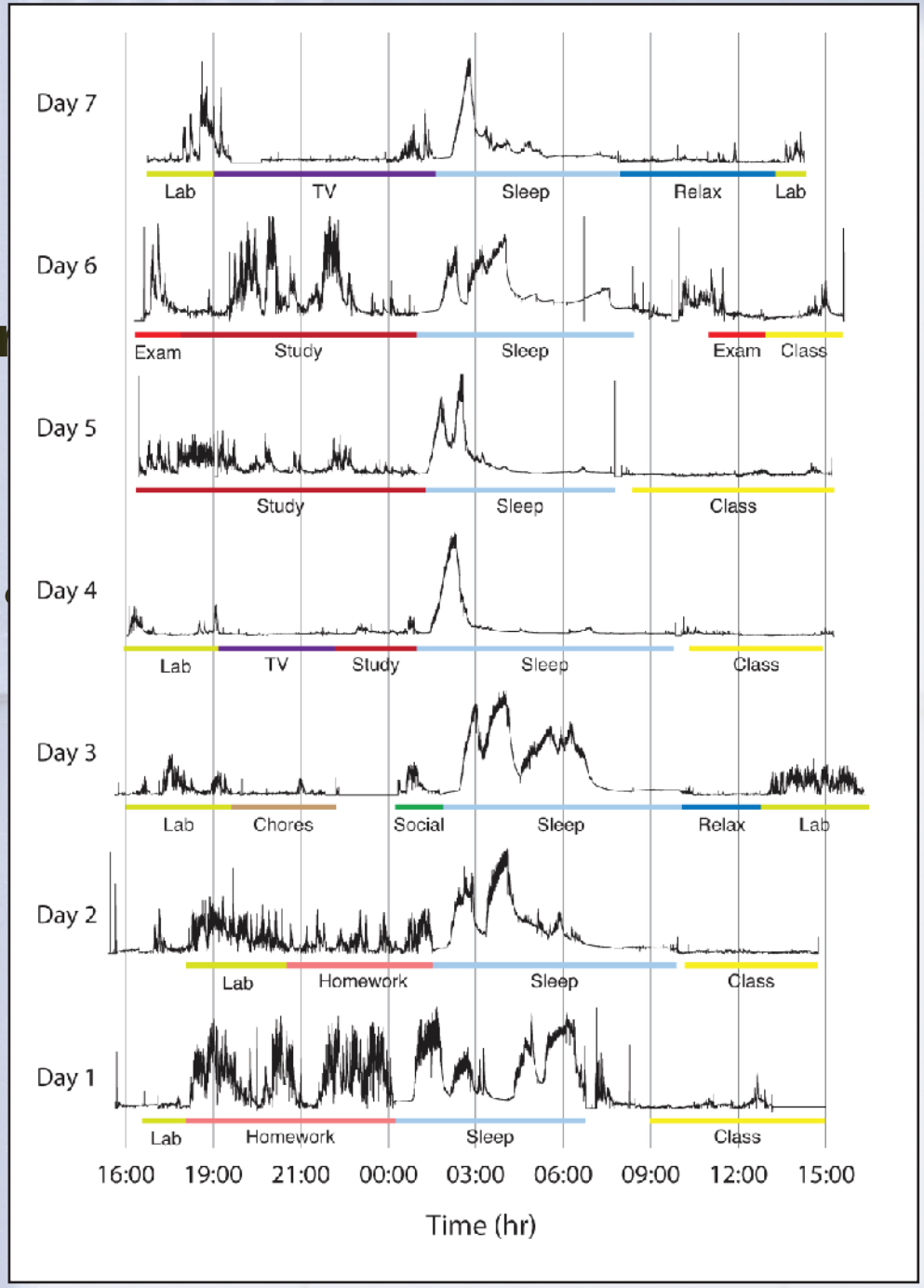
3 test

in a lecture, students…

1. don’t pay utmost attention

in a lectur

1. don’t pay utmost

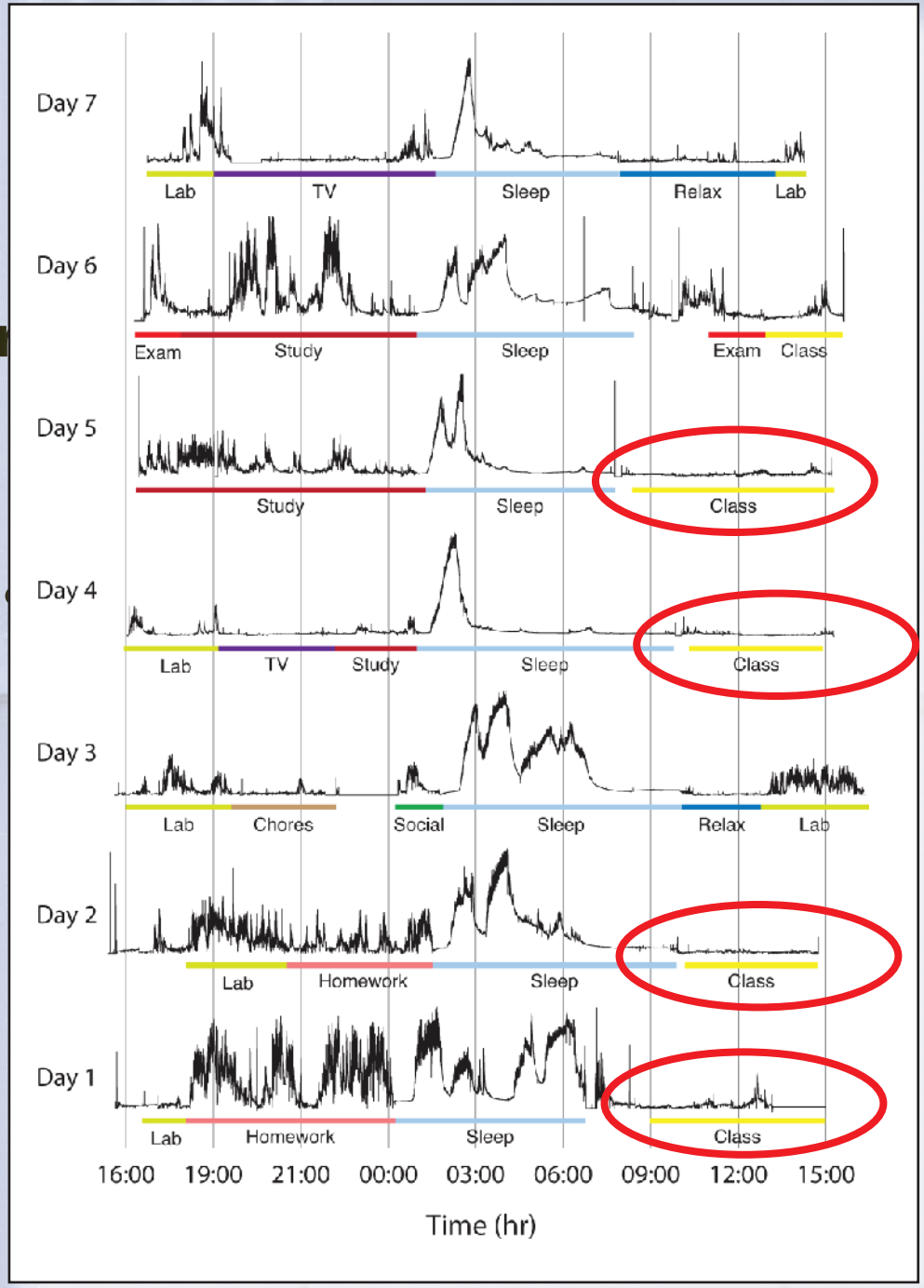


doi: 10.1109/TBME.2009.2038487

1 education 2 PI 3 test

in a lectur

1. don’t pay utmost



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1 education 2 PI 3 test

in a lectur

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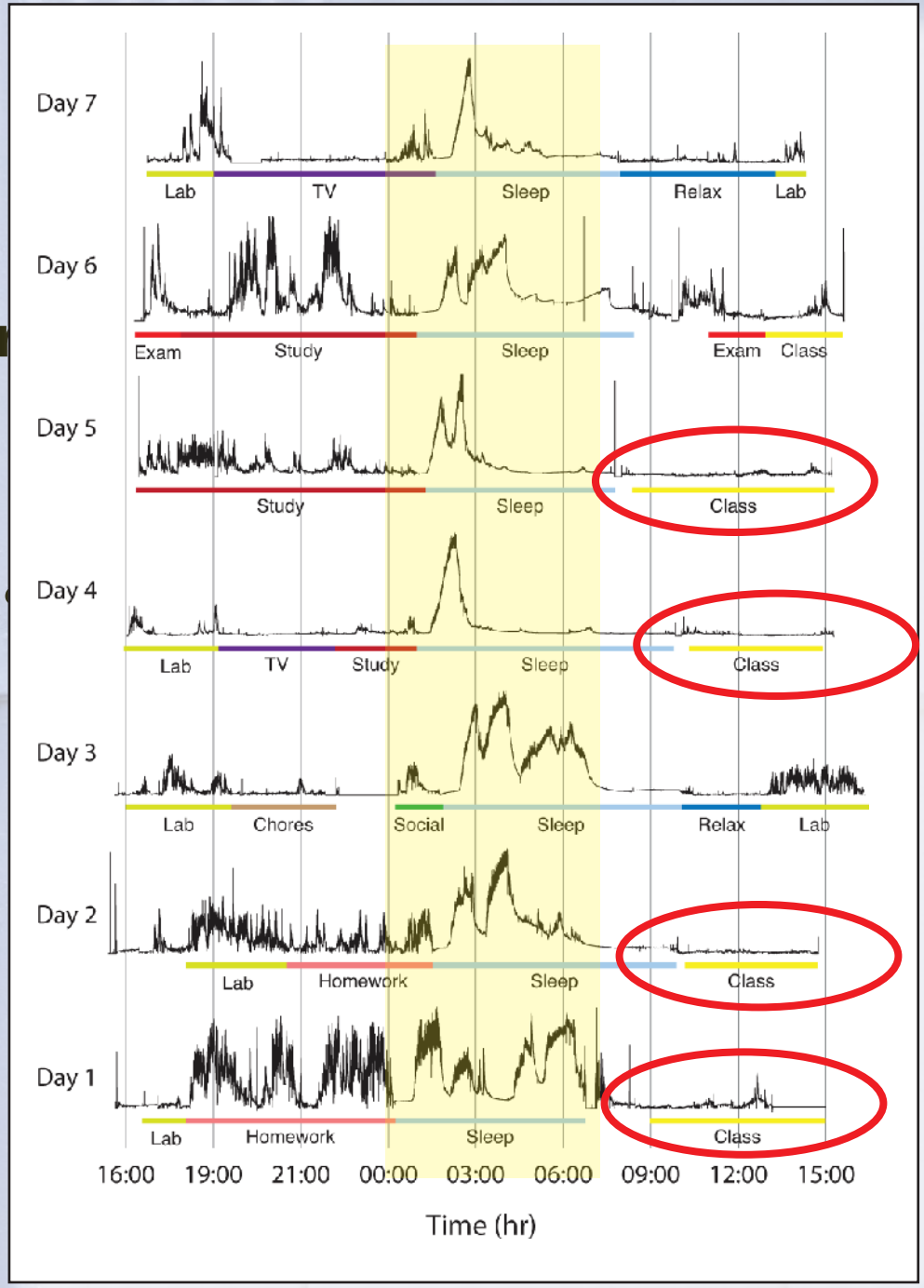

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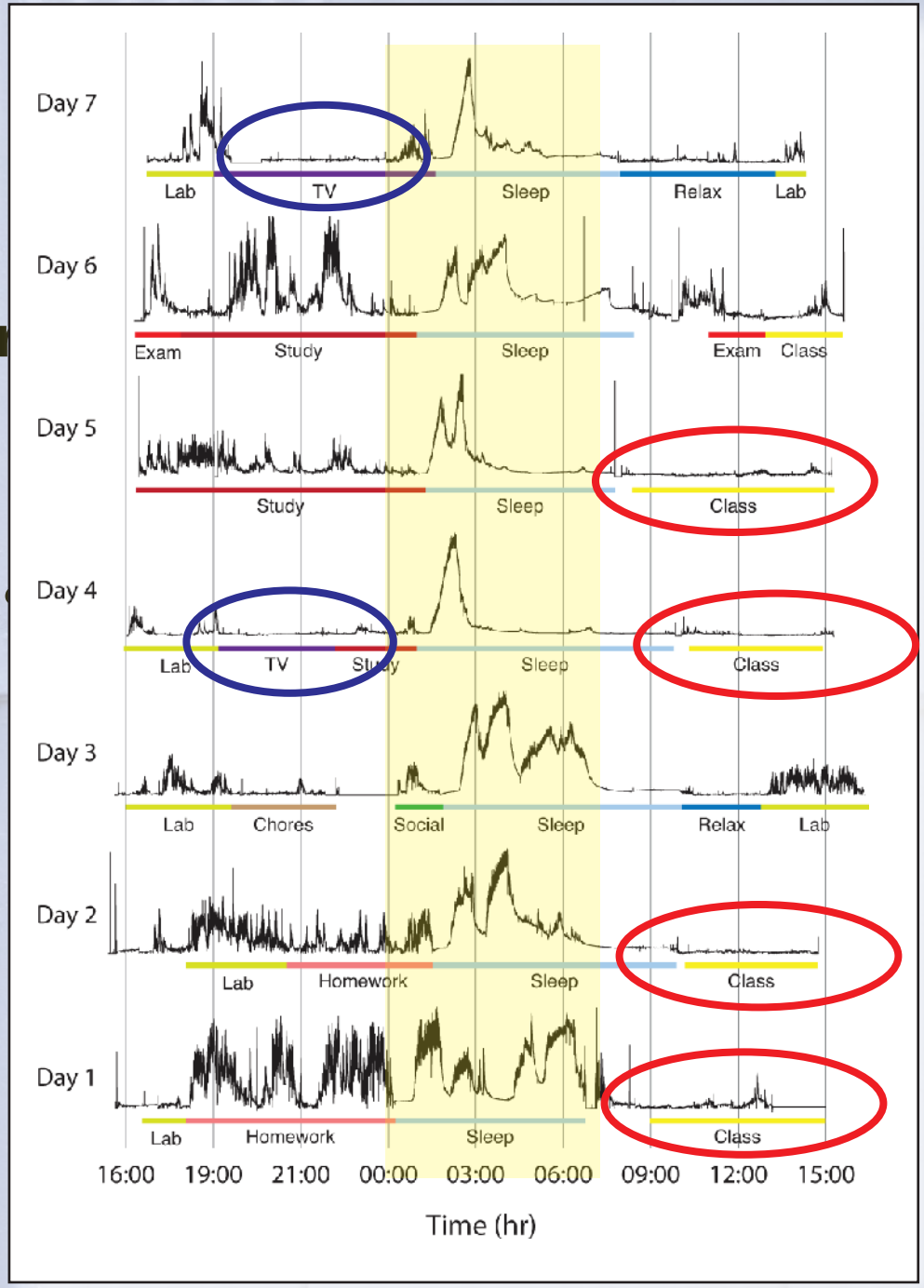
1 education 2 PI 3 test

in a lectur

1. don’t pay utmost



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1 education 2 PI 3 test

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

1 education 2 PI 3 test

1 education 2 PI 3 test

Education is not just about:

- transferring information
- getting students to do what we do

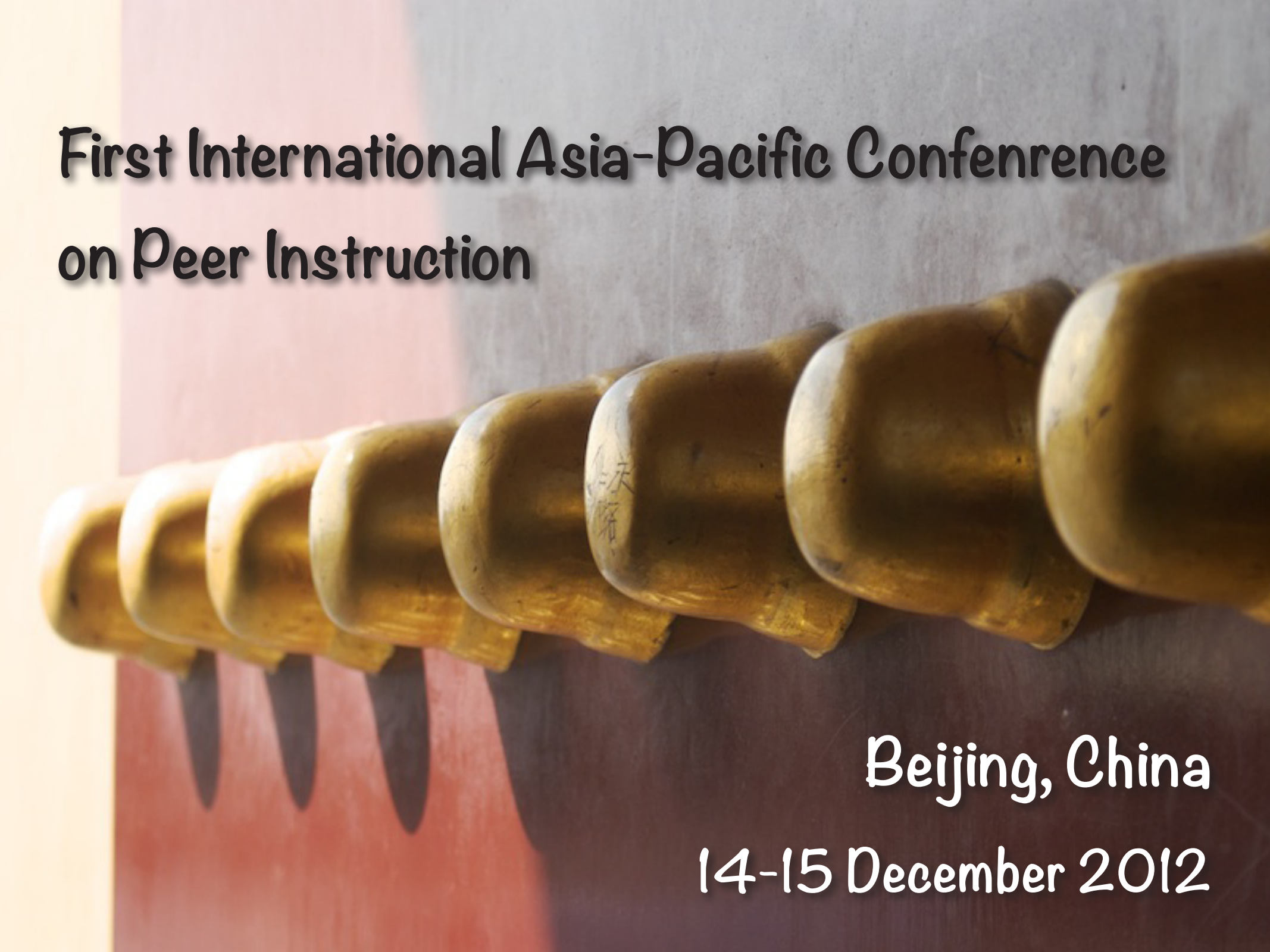
Education is not just about:

- transferring information
- getting students to do what we do

active participation a must!

With a simple change, Peer Instruction…

- teaches *real* problem solving
- encourages risk taking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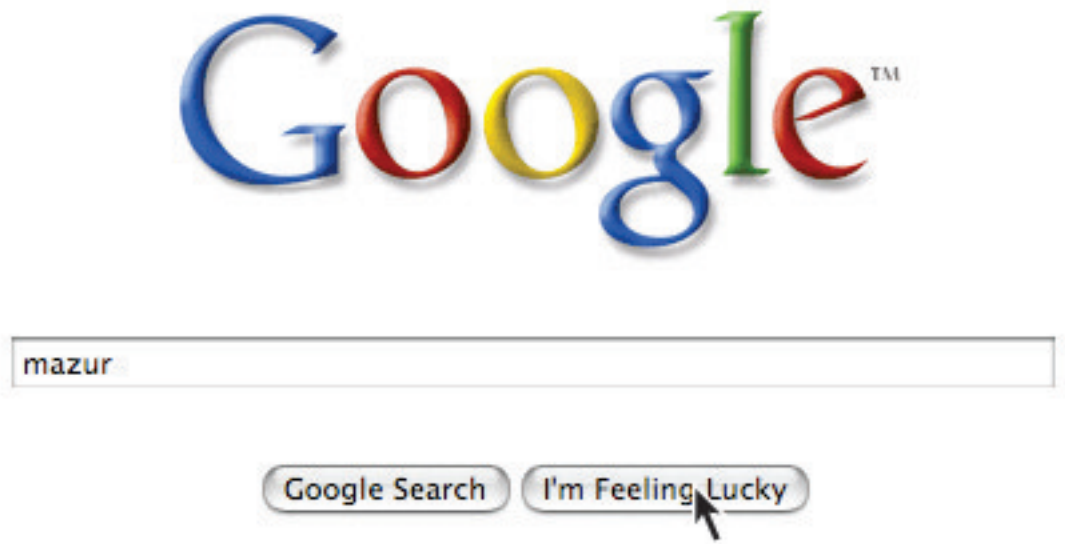
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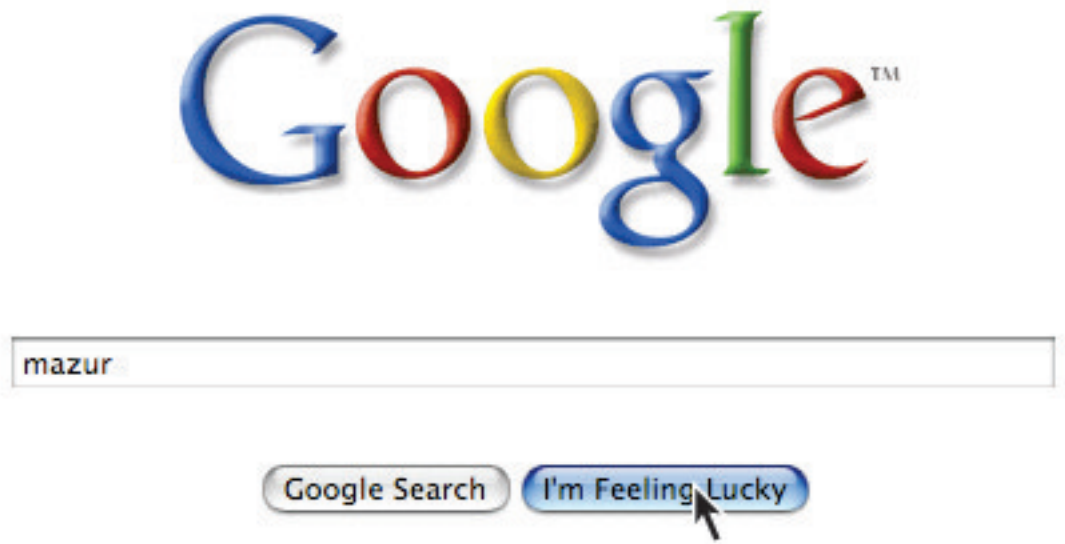
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