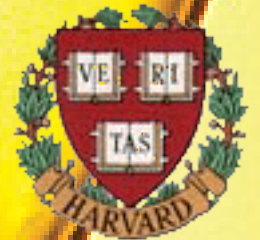


# Educating the innovators of the 21st century



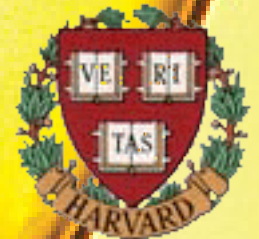
Dell Solution Center  
Limerick, Ireland, 8 April 2016





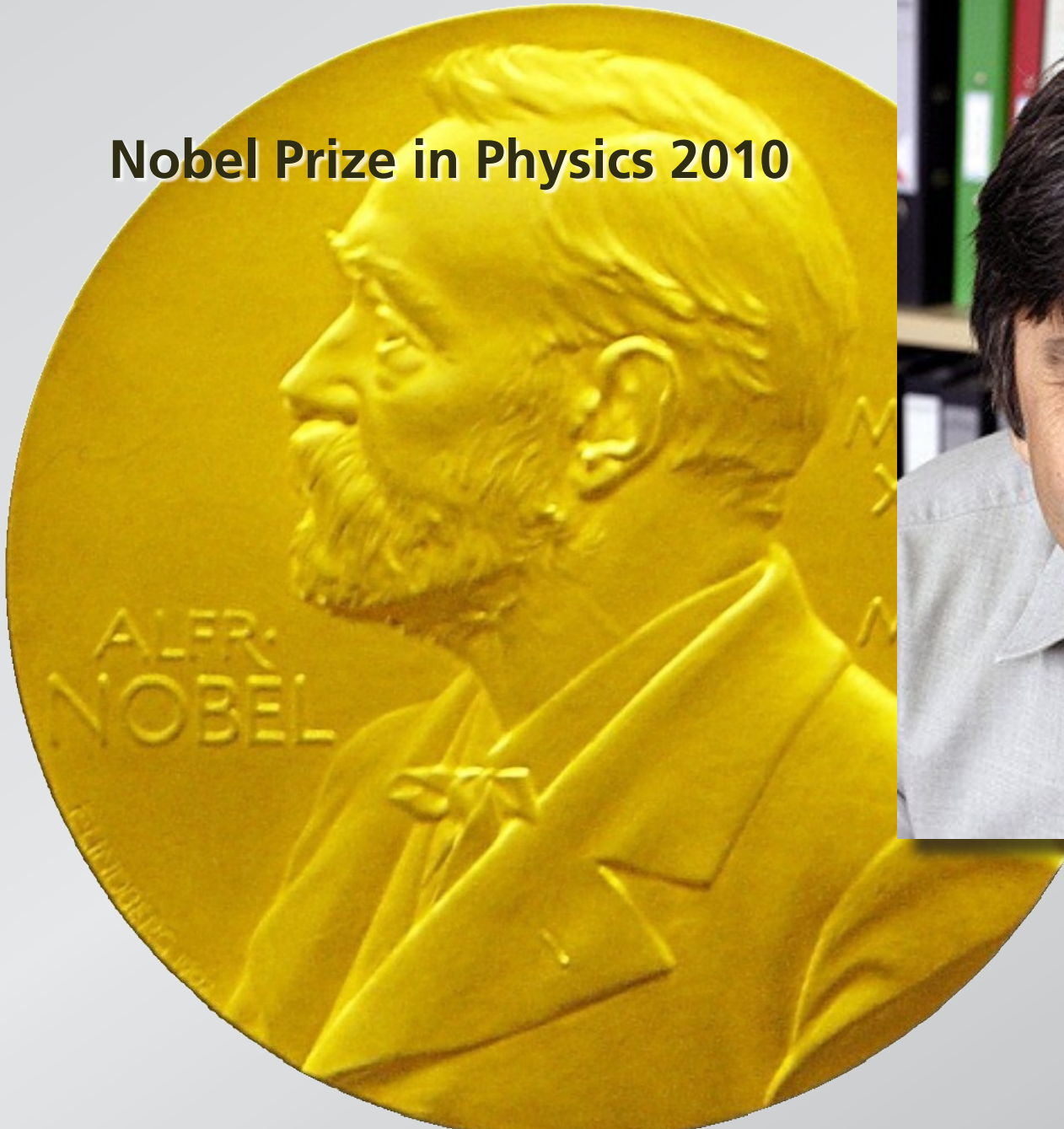
**@eric\_mazur**

Dell Solution Center  
Limerick, Ireland, 8 April 2016



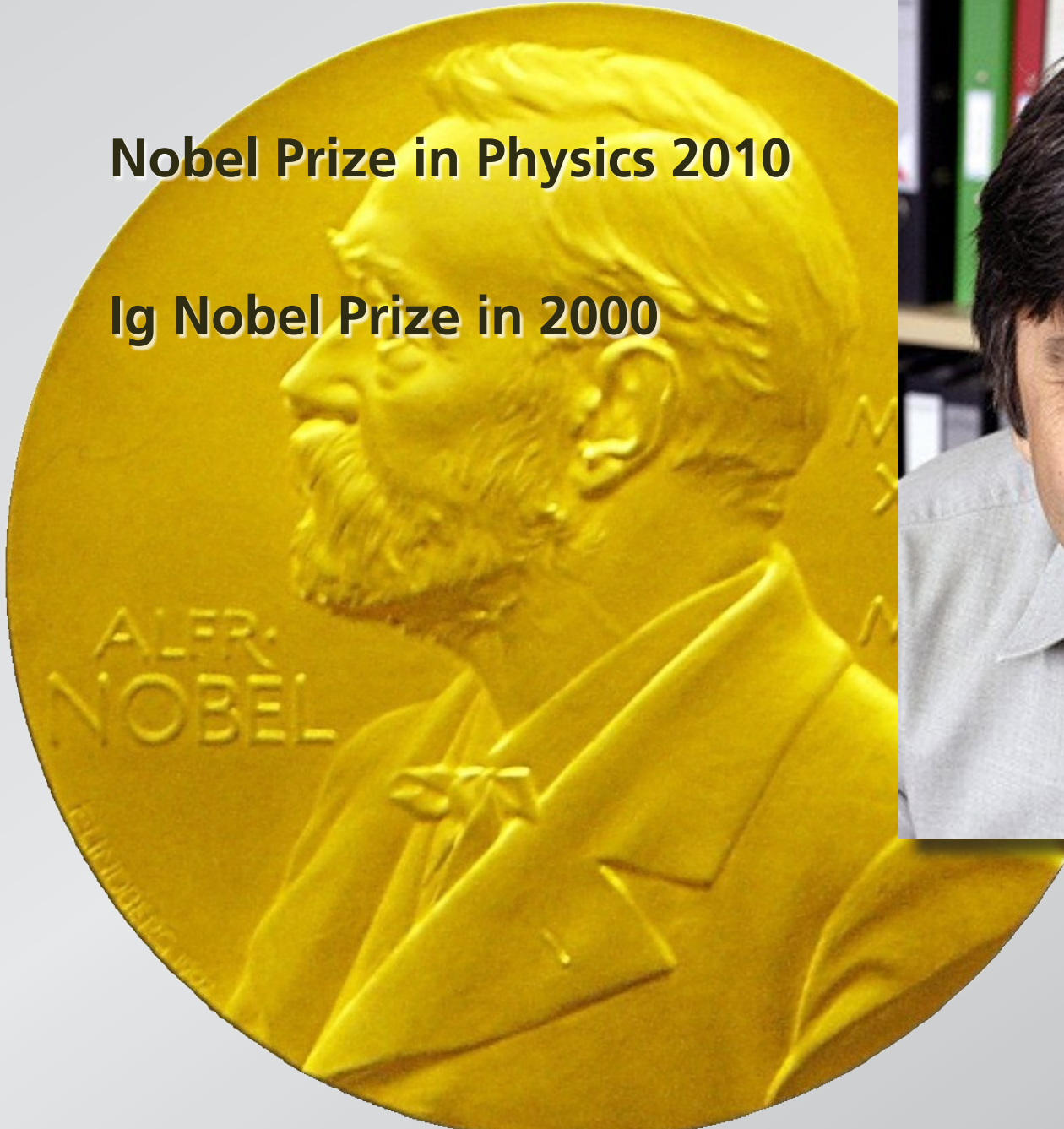
**Innovation**

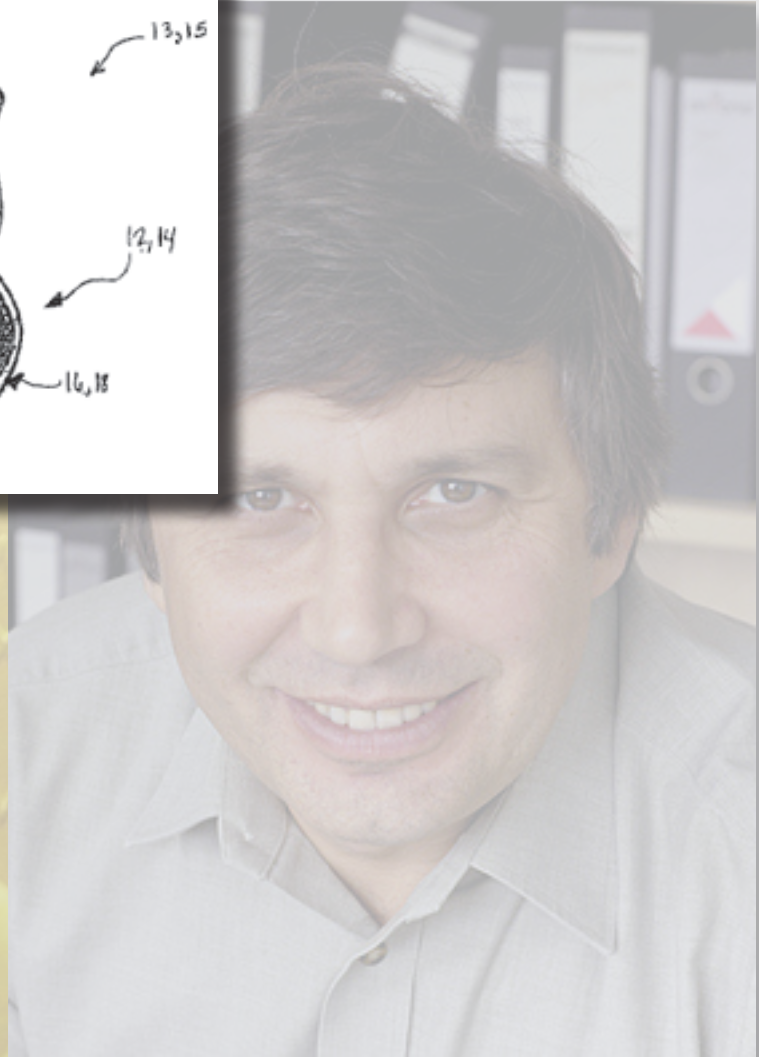
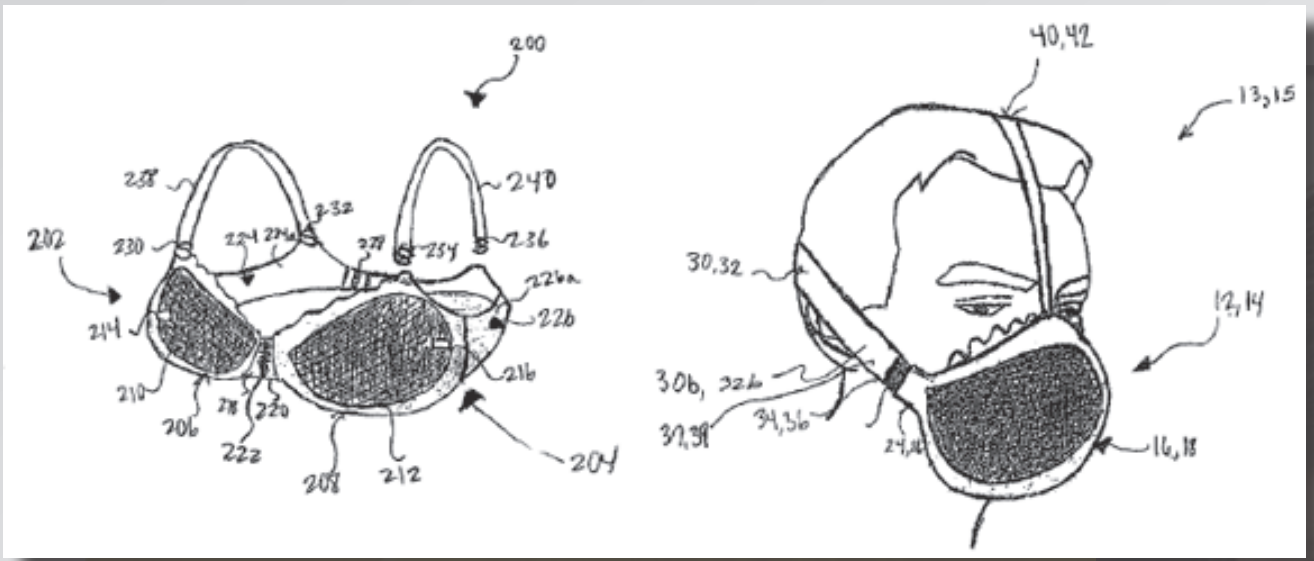
**Nobel Prize in Physics 2010**

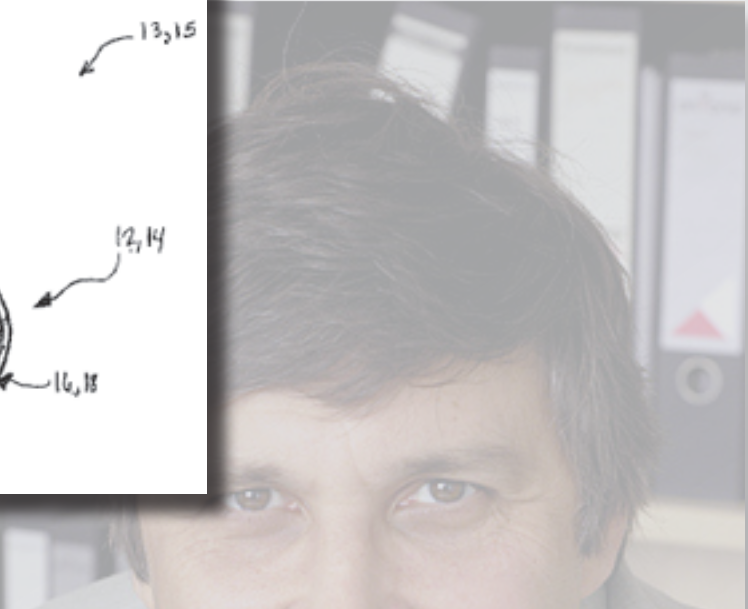
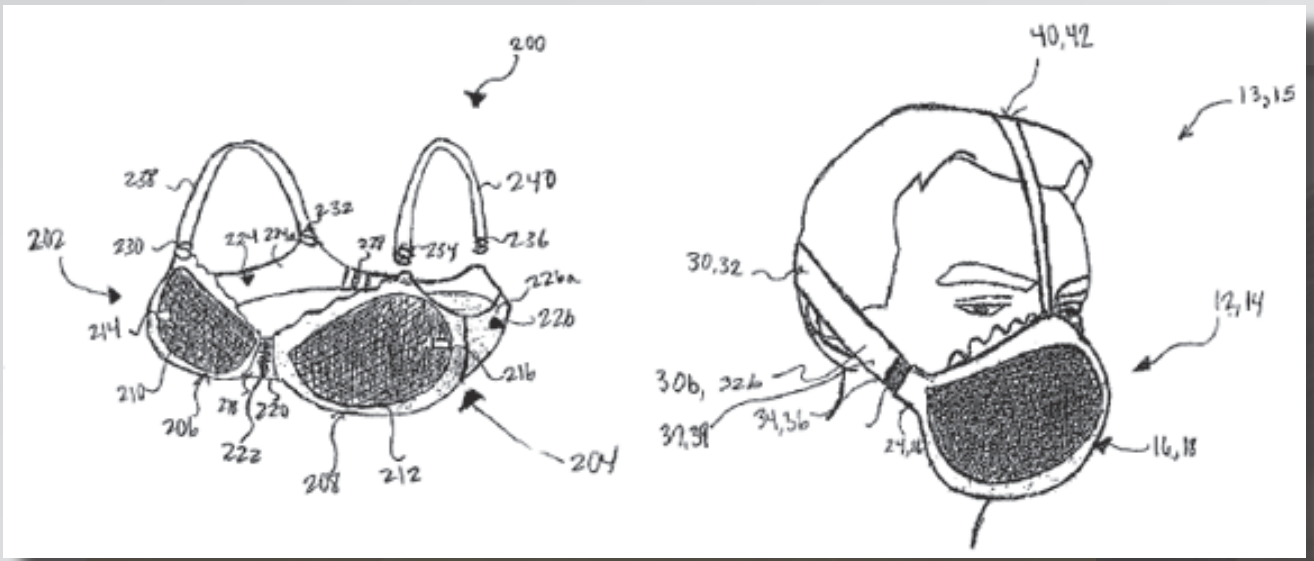


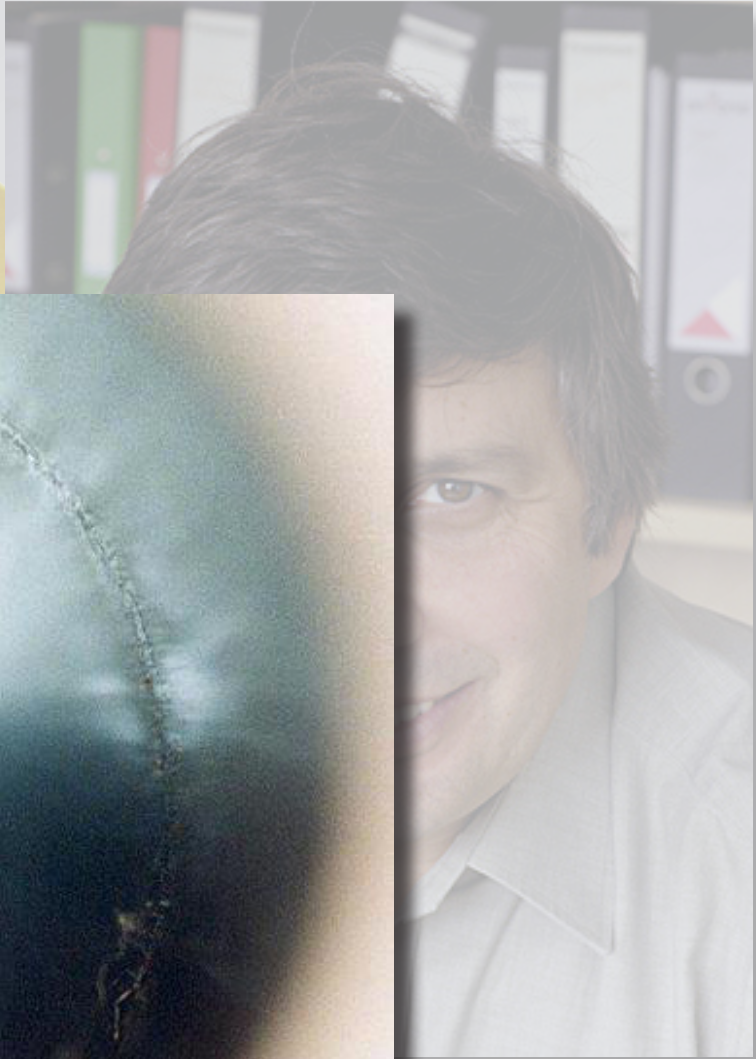
**Nobel Prize in Physics 2010**

**Ig Nobel Prize in 2000**





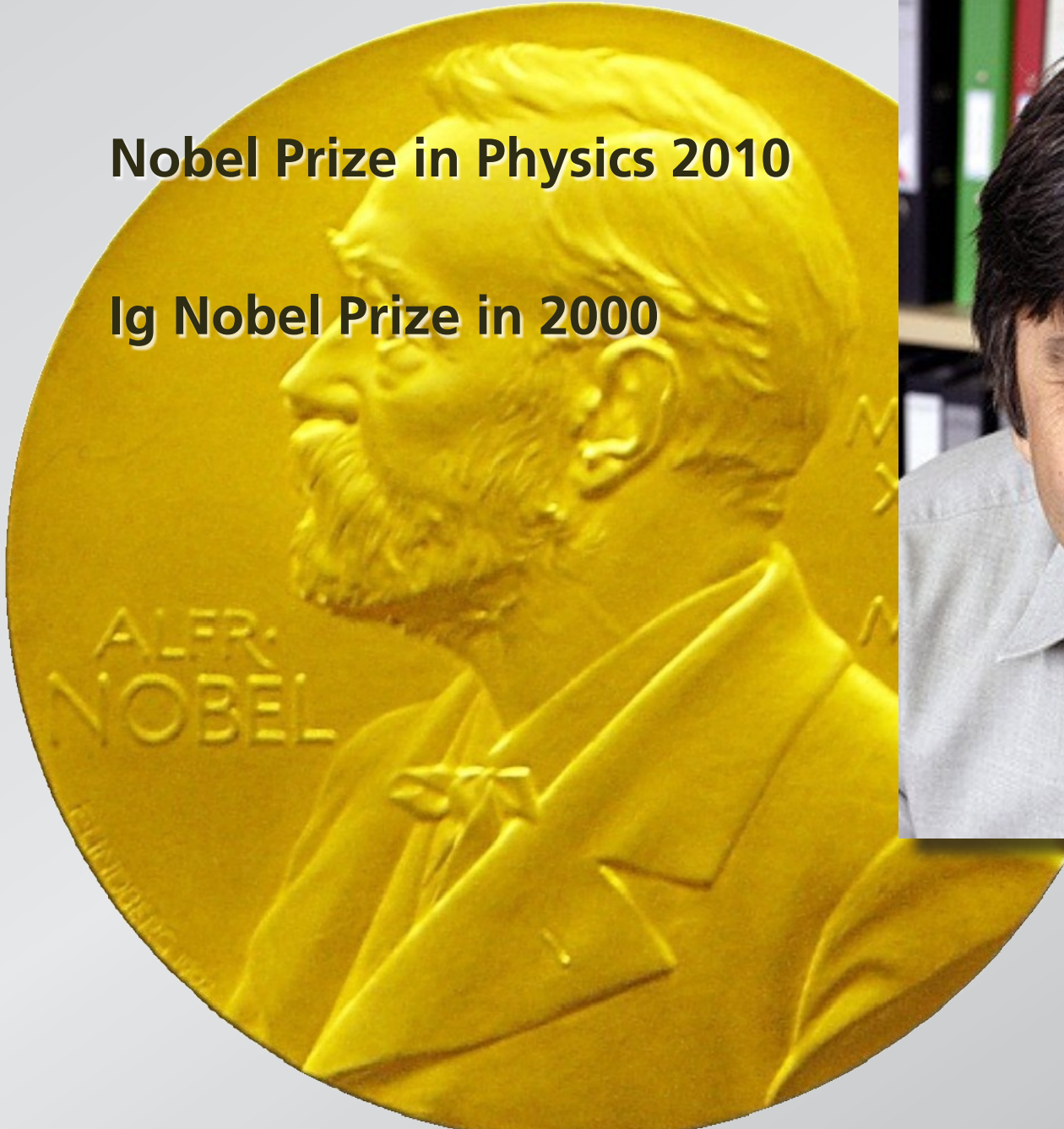




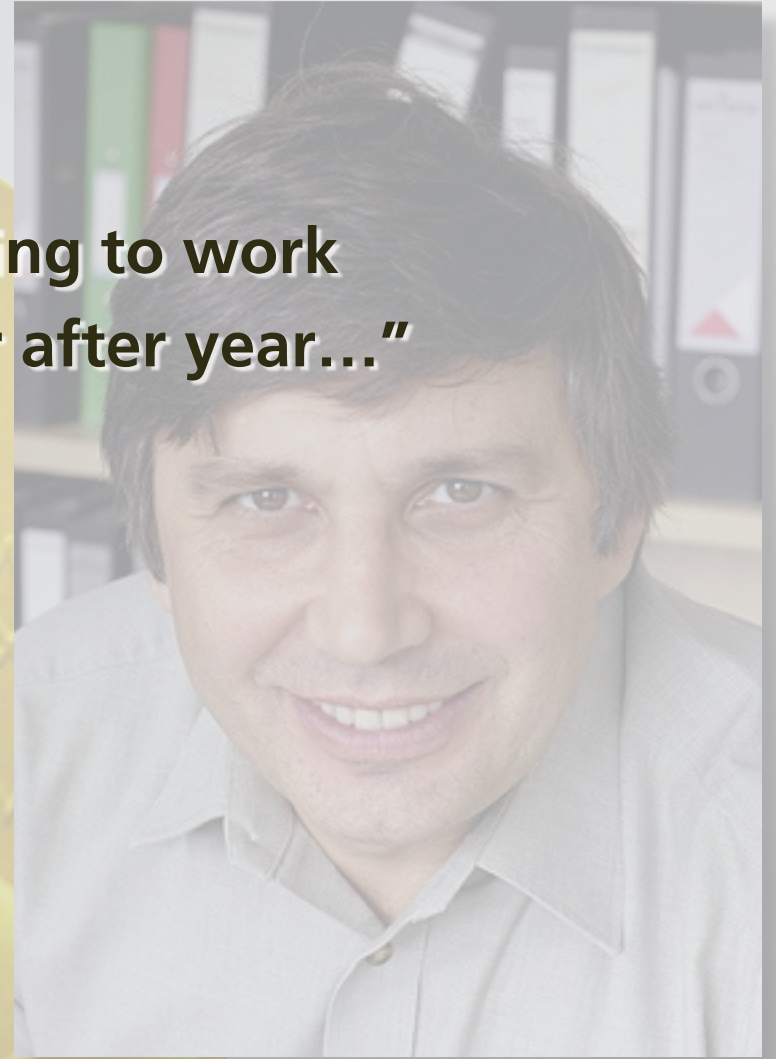


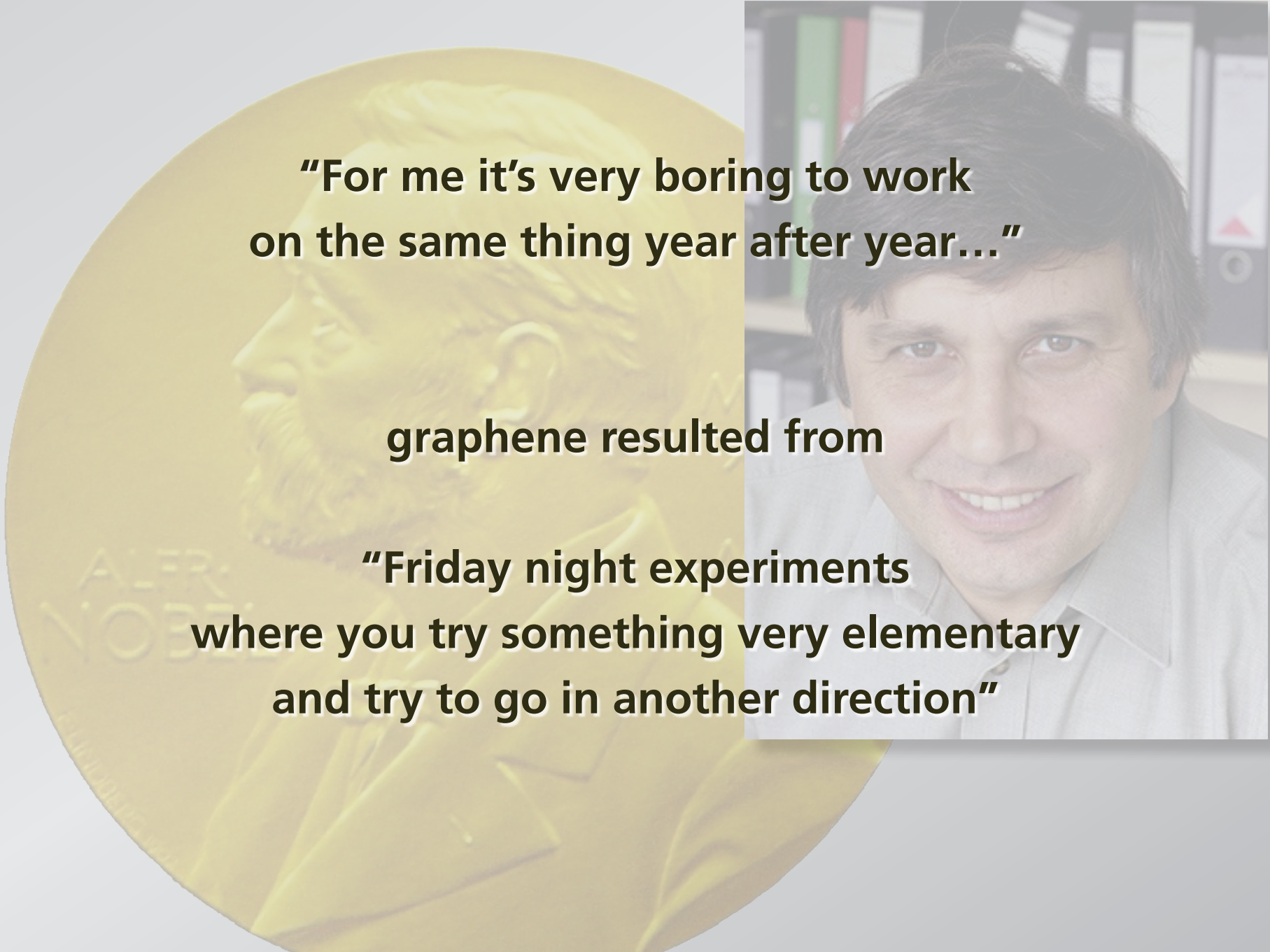
**Nobel Prize in Physics 2010**

**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”**

A glowing lightbulb with a warm yellow light emanating from it. The bulb is centered in the frame, and its glow fills the background. The text "how can we foster/teach innovation?" is superimposed on the lower half of the bulb.

**how can we foster/teach innovation?**



**Need to...**

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

**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**







What are the factors that determine the rate of...  
1. The rate of...  
2. The rate of...  
3. The rate of...  
4. The rate of...  
5. The rate of...

THE UNIVERSITY OF TEXAS AT AUSTIN  
DEPARTMENT OF CHEMISTRY  
LECTURE HALL





1 education

2 PI



**1** education

**2** PI

**3** test




**better pay  
attention!**

**1** education

**2** PI

**3** test



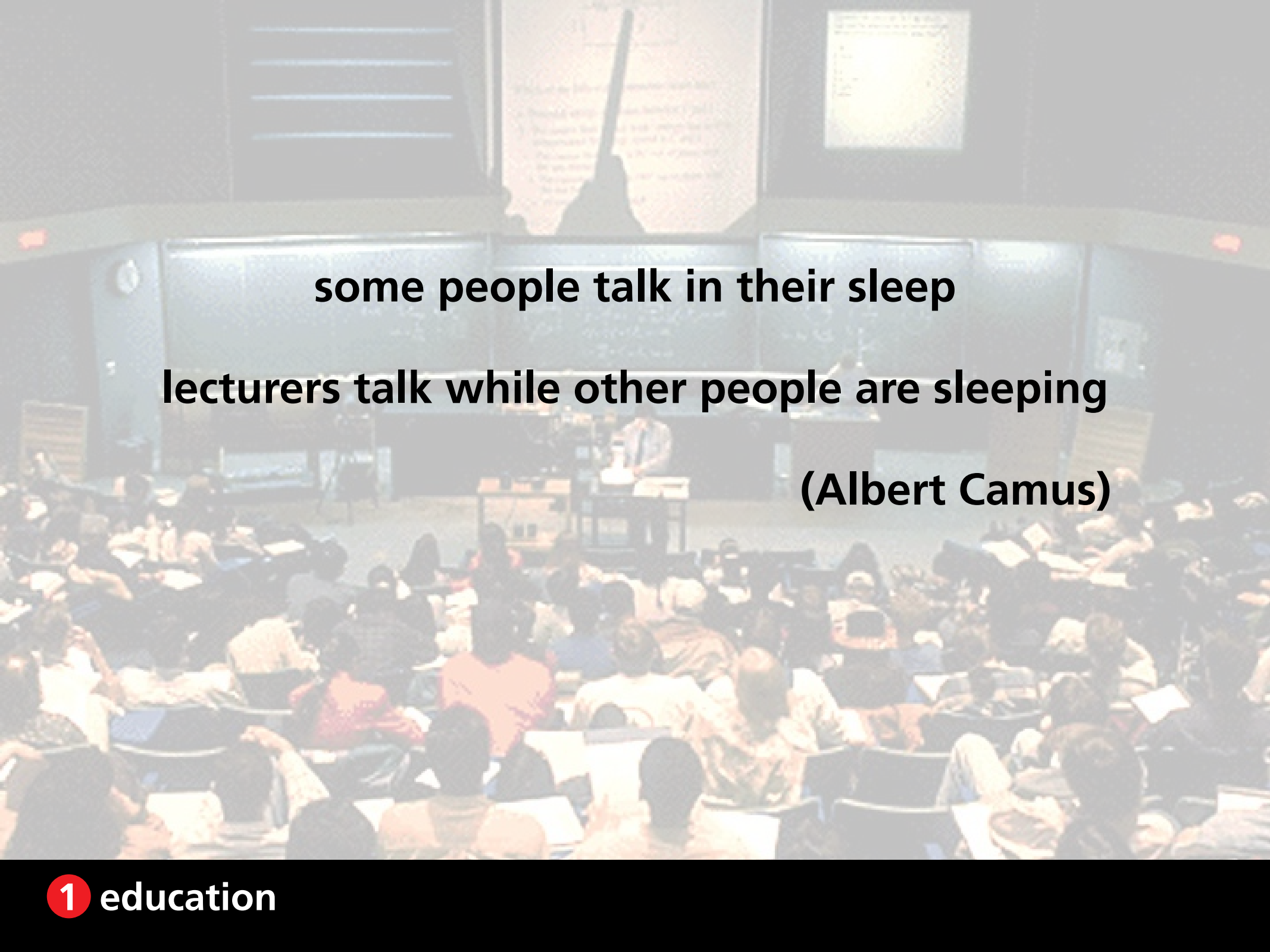
**What happens  
in a lecture?**



A large lecture hall with a professor at a podium and students in the audience. The professor is standing at a podium on the stage, facing the audience. The audience is seated in rows of chairs, facing the stage. The room has a curved wall and a large screen at the front. The text "some people talk in their sleep" is overlaid on the image.

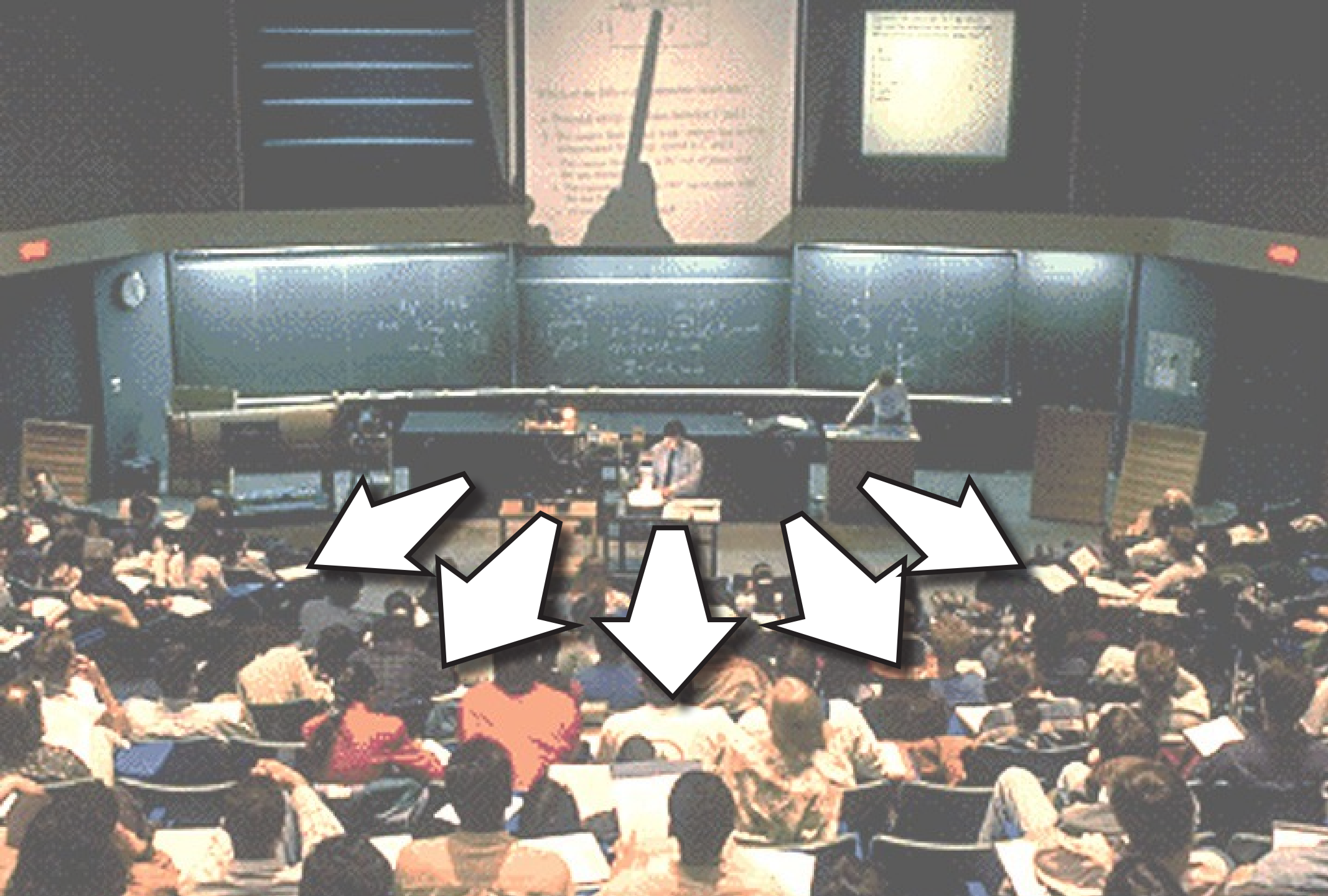
**some people talk in their sleep**



A large lecture hall with a lecturer at a podium and an audience of students. The room is filled with people, many of whom appear to be sleeping or resting. The lecturer is standing at a podium in the center, facing the audience. The audience is seated in rows of chairs, and many people have their heads down or are looking away. The room has a high ceiling and large windows. The text is overlaid on the image.

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





The result?

EDUCACION

**Lack of learning**

EDUCACION

**Lack of learning**

**Lack of retention**

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

**EDUCACION**





**assessment promotes memorization and stifles creativity**

**EDUCACION**

**problem**

**EDUCACION**

**problem**

**outcome**

**EDUCACION**

**problem**

**solution**

**outcome**

**EDUCACION**

problem

solution

outcome

**KNOWN**

EDUCACION

problem

solution

outcome

UNKNOWN

KNOWN

EDUCACION

problem

solution

outcome

UNKNOWN → KNOWN

problem

EDUCACION

problem

solution

outcome

UNKNOWN

KNOWN

problem

procedure

EDUCACION



problem

solution

outcome

UNKNOWN

KNOWN

problem

procedure

answer

EDUCACION

problem

solution

outcome

UNKNOWN

KNOWN

problem

procedure

answer

KNOWN

problem

solution

outcome

UNKNOWN

KNOWN

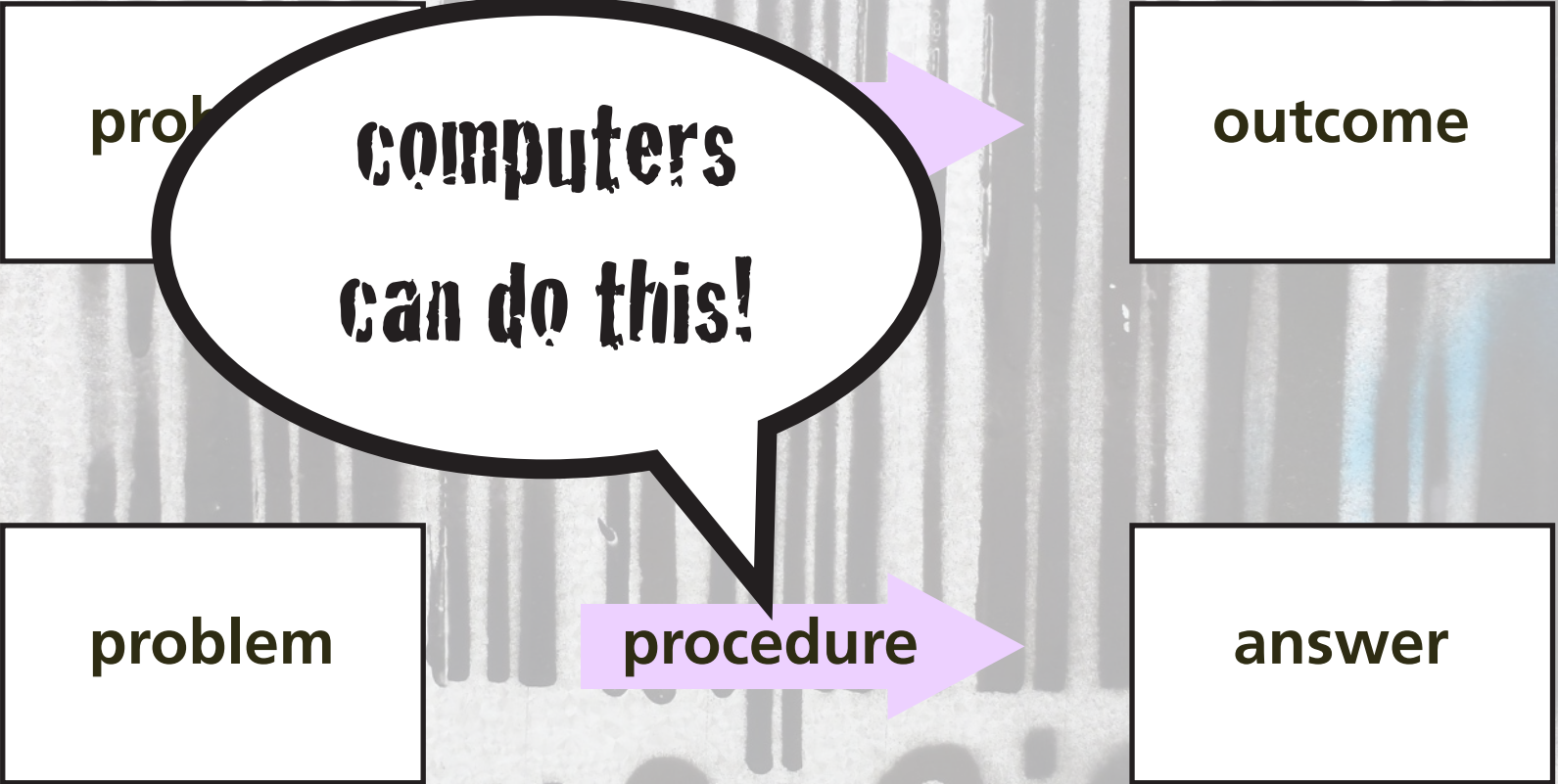
problem

procedure

answer

KNOWN

UNKNOWN



problem

solution

outcome

problem

pre... ver

**REAL**  
**problem solving**

**problem**

**approach 1**

**approach 3**

**approach 2**

**outcome**

**EDUCACION**

**problem**

**approach 1**

**approach 3**

**approach 2**

**outcome**

**assessment incompatible with real problem solving**

**EDUCACION**

## Traditional assesement

- focuses on outcome, not process

EDUCACION



## Traditional assesement

- focuses on outcome, not process
- discourages risk taking

EDUCACION

## Traditional assesement

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

EDUCACION

## **Traditional assesement**

- **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. 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)**

# Peer



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

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

INSTRUCTION

question

1 education

2 PI

question



think

question



think



poll

**question**



**think**



**poll**



**discuss**



**question**



**think**



**poll**



**discuss**



**repoll**

**question**



**think**



**poll**



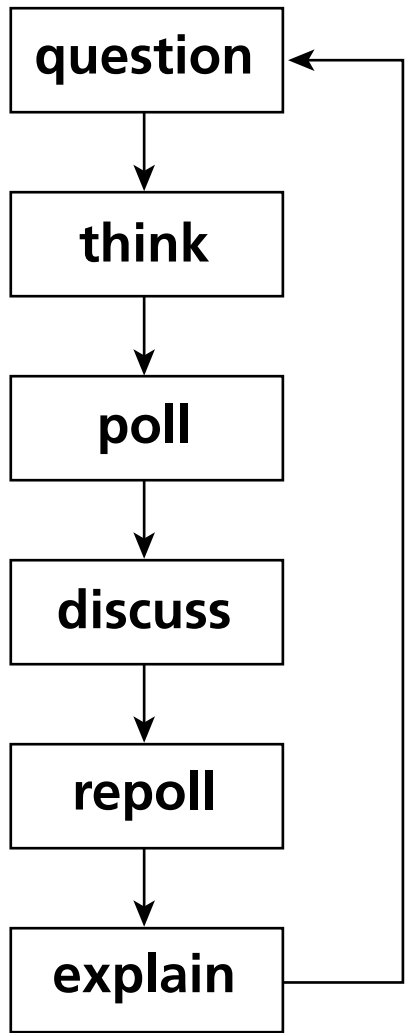
**discuss**

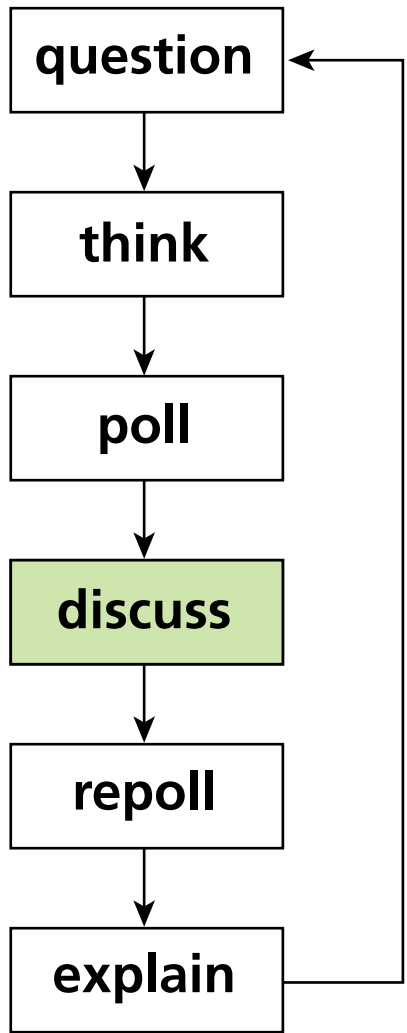


**repoll**



**explain**





Let's try it!

QUESTION

think

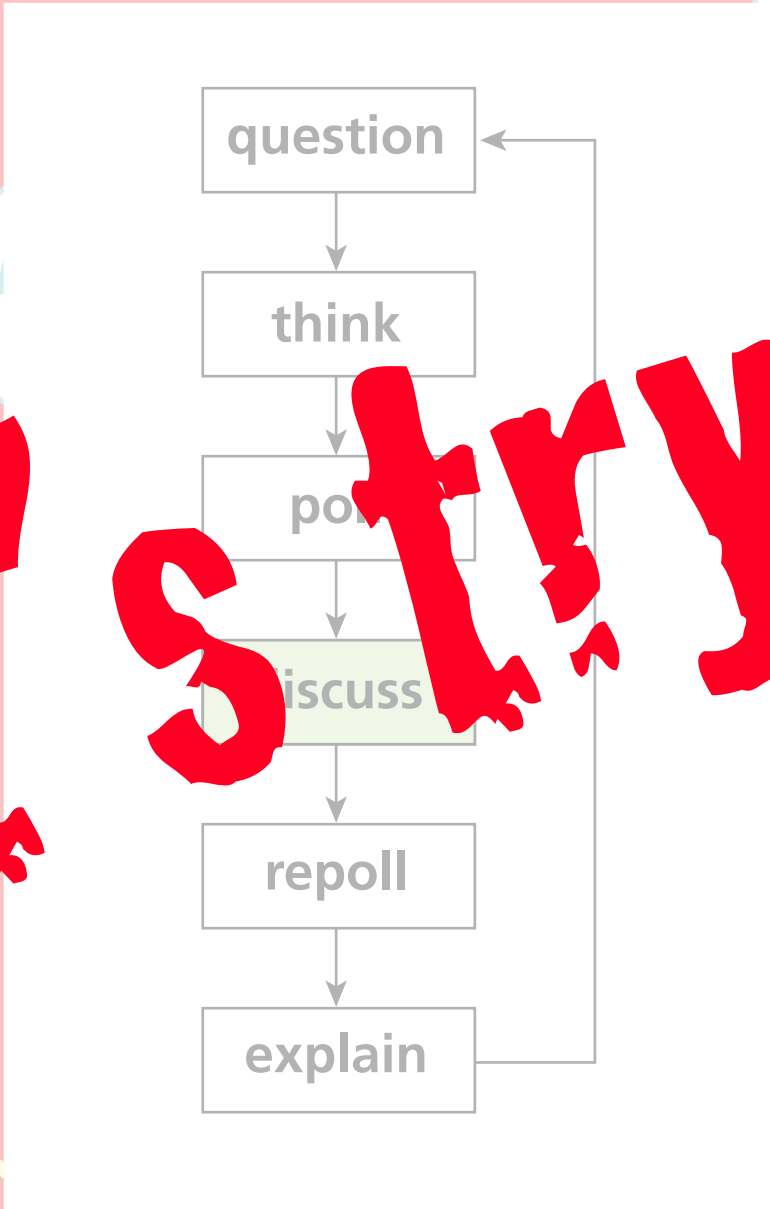
poll

discuss

repoll

explain

ACTION

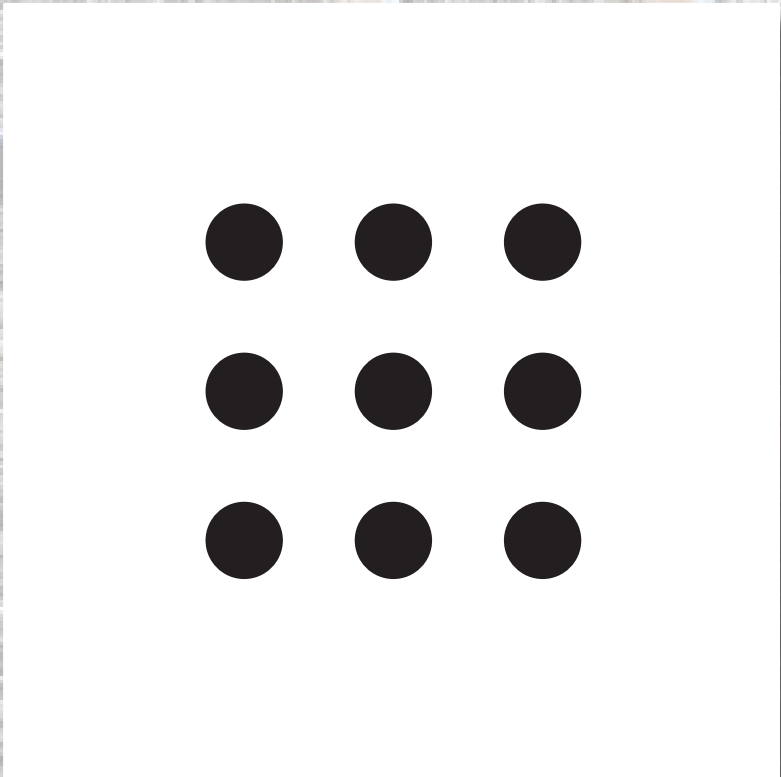
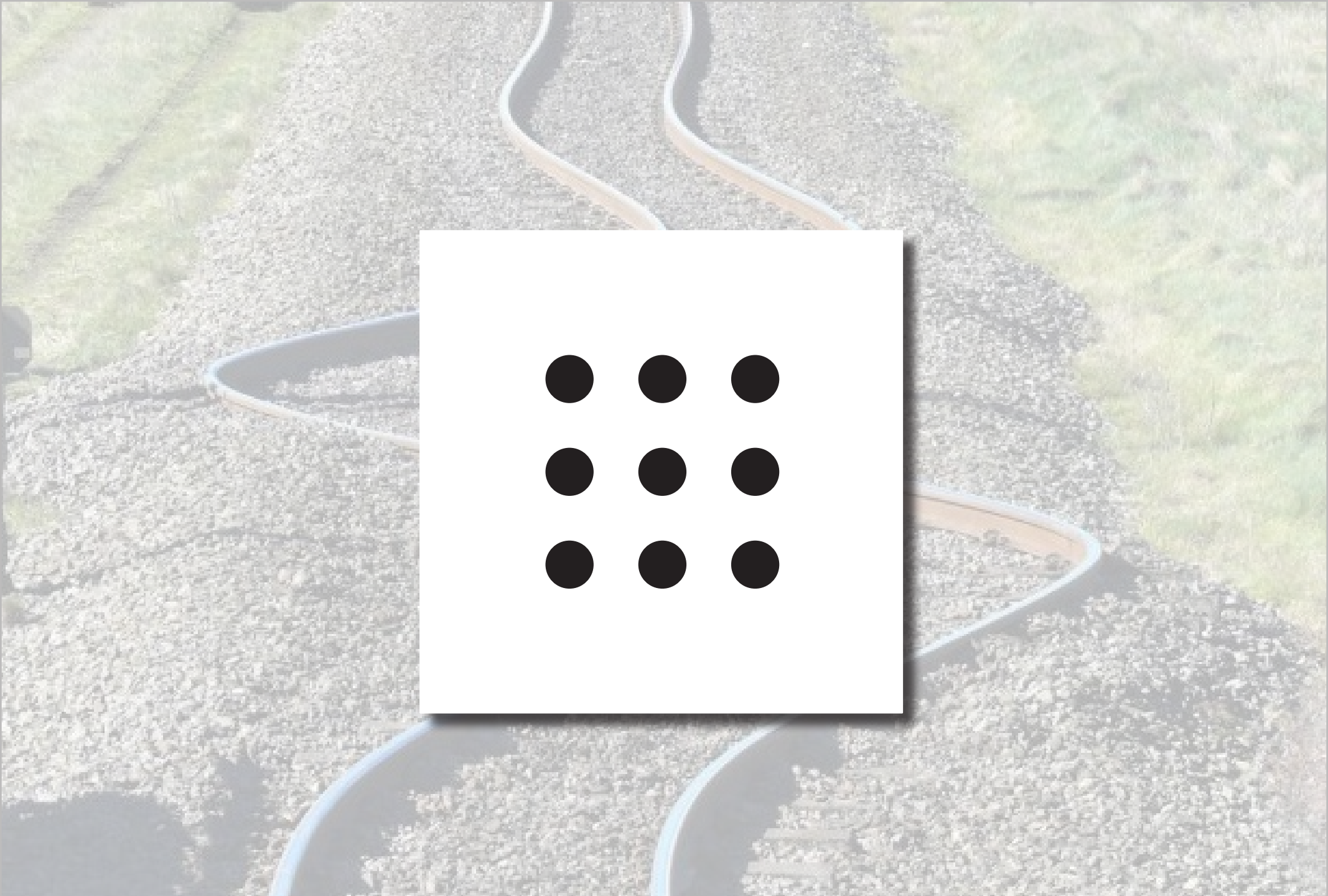


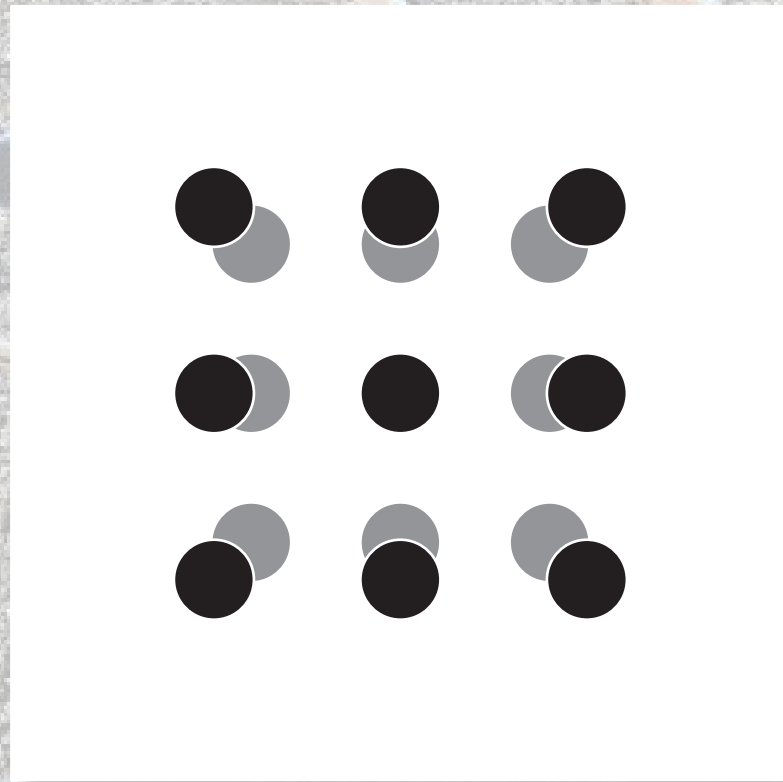
1 education

2 PI

An aerial photograph showing a long, wavy metal expansion joint installed on a gravel surface. The joint is made of a light-colored metal and is designed to accommodate thermal expansion and contraction. The gravel is dark and textured, and the surrounding area is green grass. The text "thermal expansion" is overlaid in the center of the image.

**thermal expansion**





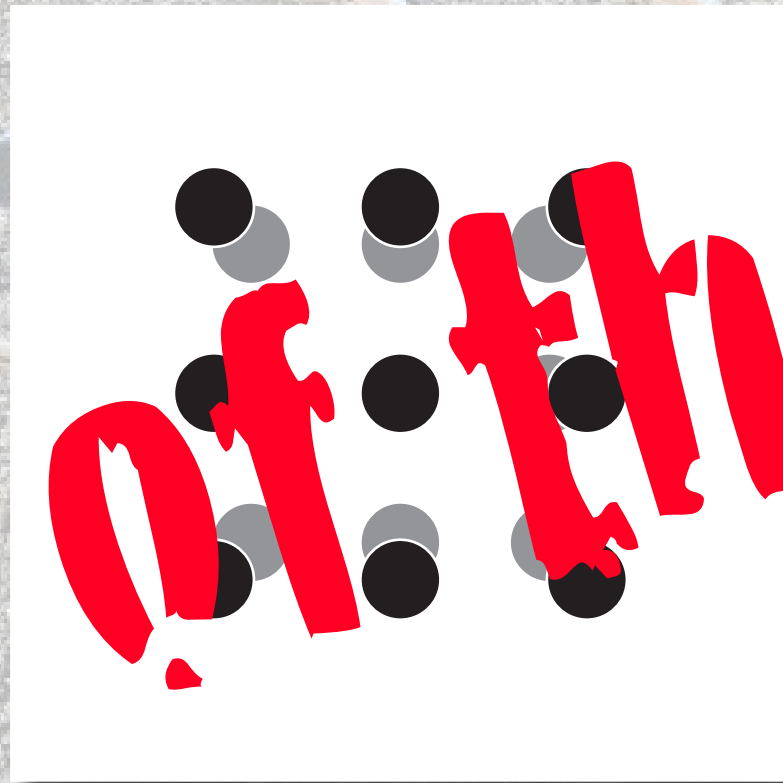


**all of them**

**1** education

**2** PI

**all of them!**

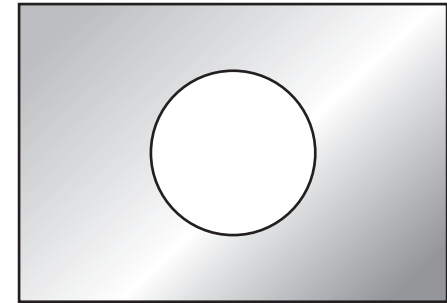


**1** education

**2** PI

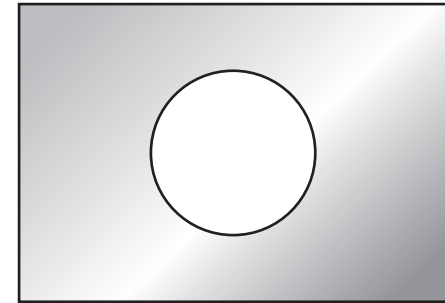
**3** test?

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



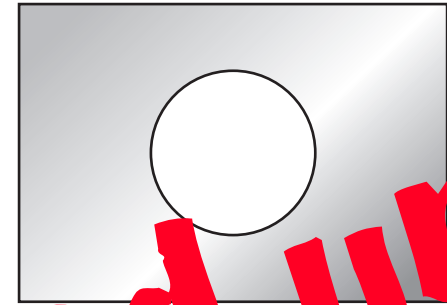
**Consider a rectangular metal plate with a circular hole in it.**

**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.



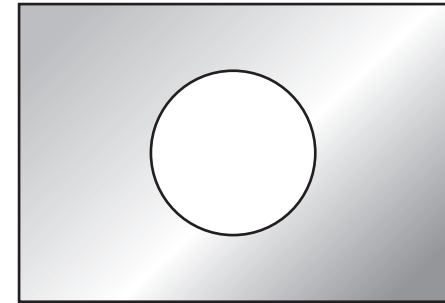
When the plate is uniformly heated, the diameter of the hole

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

**you got all fired up!**

**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...**

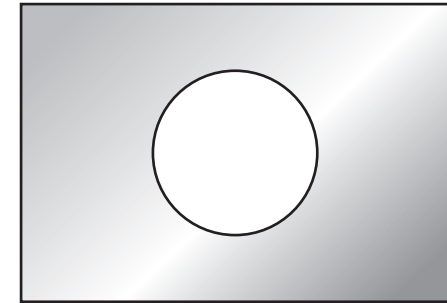
- 1. made a commitment**
- 2. externalized your answer**
- 3. moved from the answer/fact to reasoning**

**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**

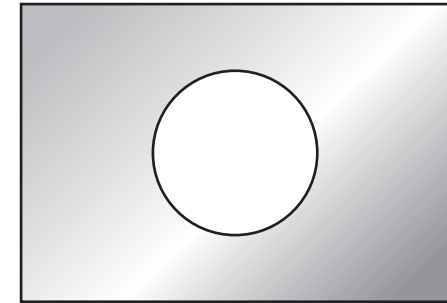
**Consider a rectangular metal plate with a circular hole in it.**



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

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

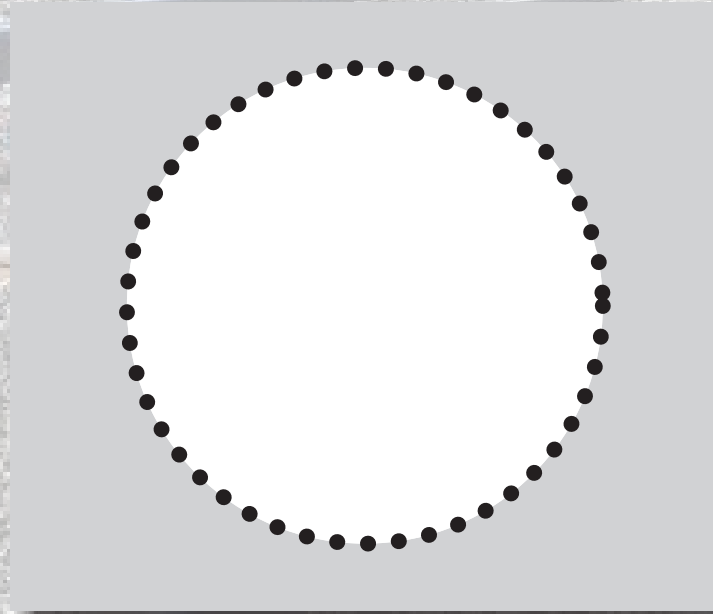
Consider a rectangular metal plate with a circular hole in it.



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

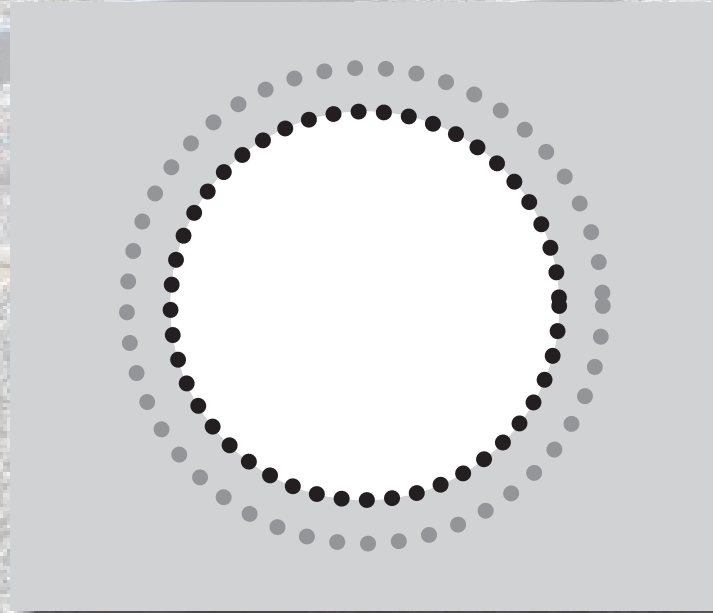


1 education

2 PI

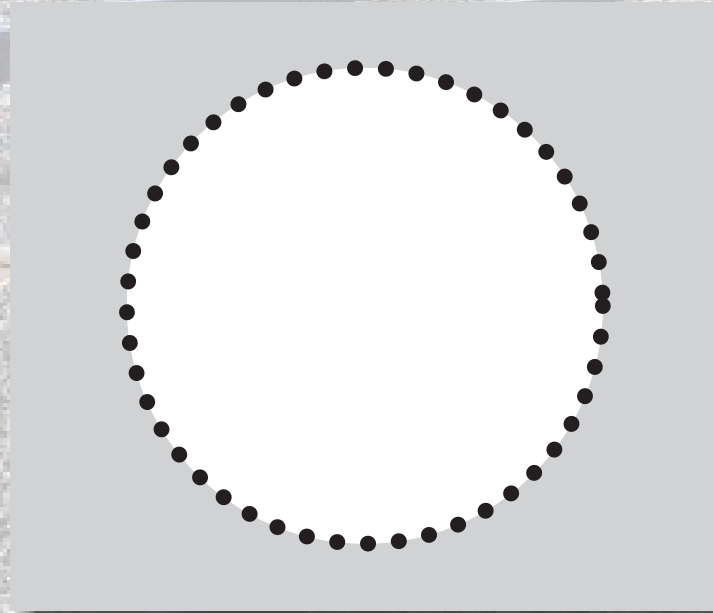
3 test

consider atoms at rim of hole





consider atoms at rim of hole

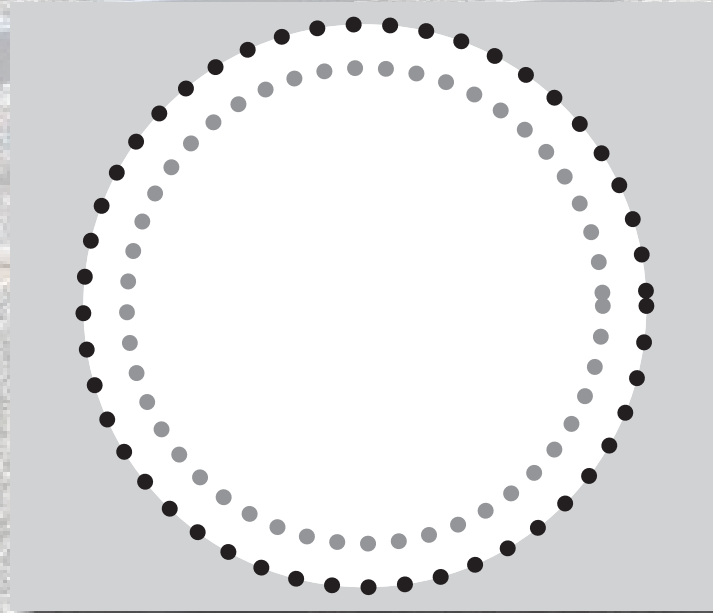


1 education

2 PI

3 test

consider atoms at rim of hole



1 education

2 PI

3 test

consider atoms at rim of hole

**you won't forget this**



**1** education

**2** PI

**3** test

# Peer

back to PI

INSTRUCTION

1 education

2 PI

3 test

Peer  
Higher learning & gains

INSTRUCTION

1 education

2 PI

3 test

**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

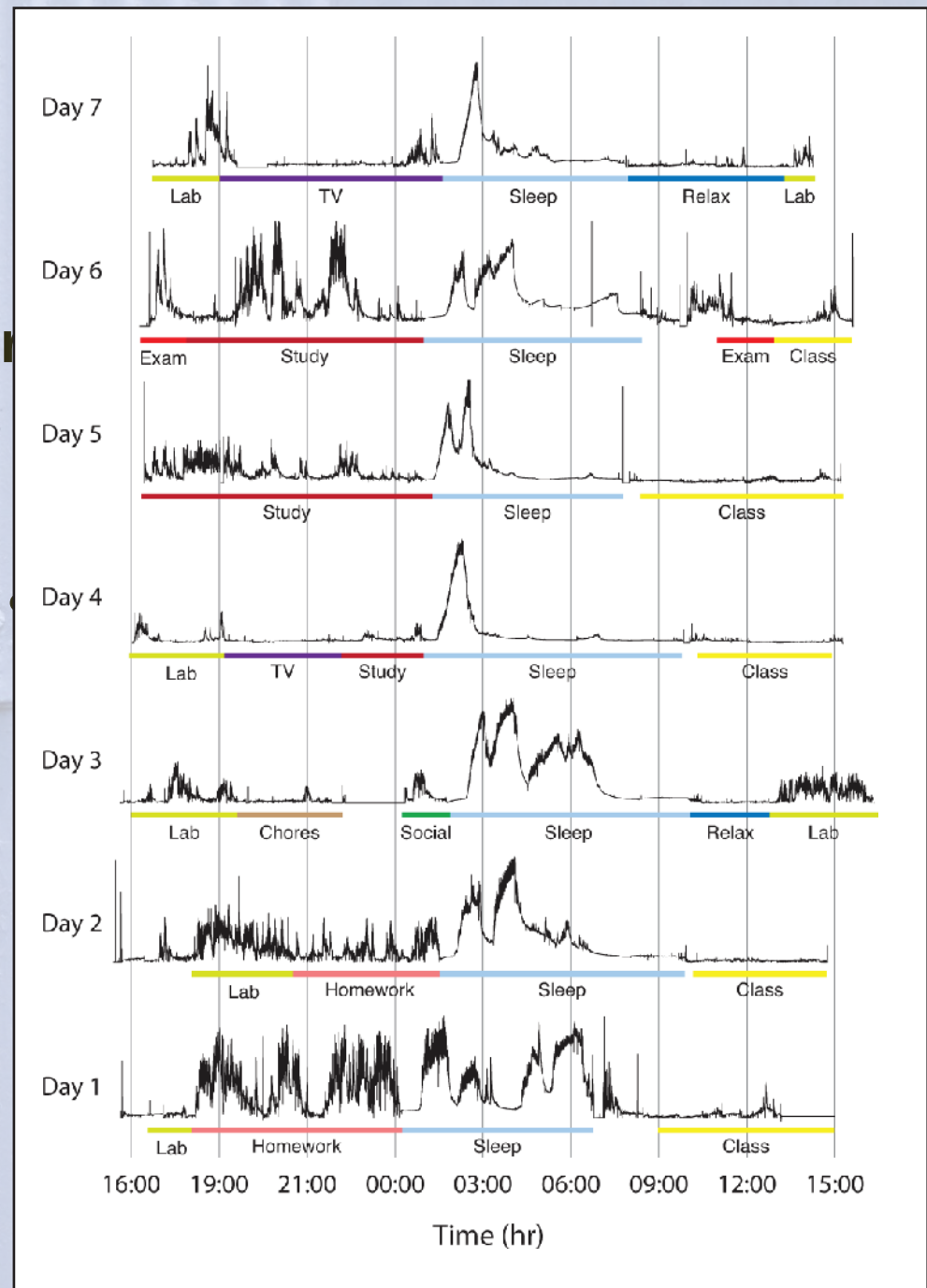


**in a lecture, students...**

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

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

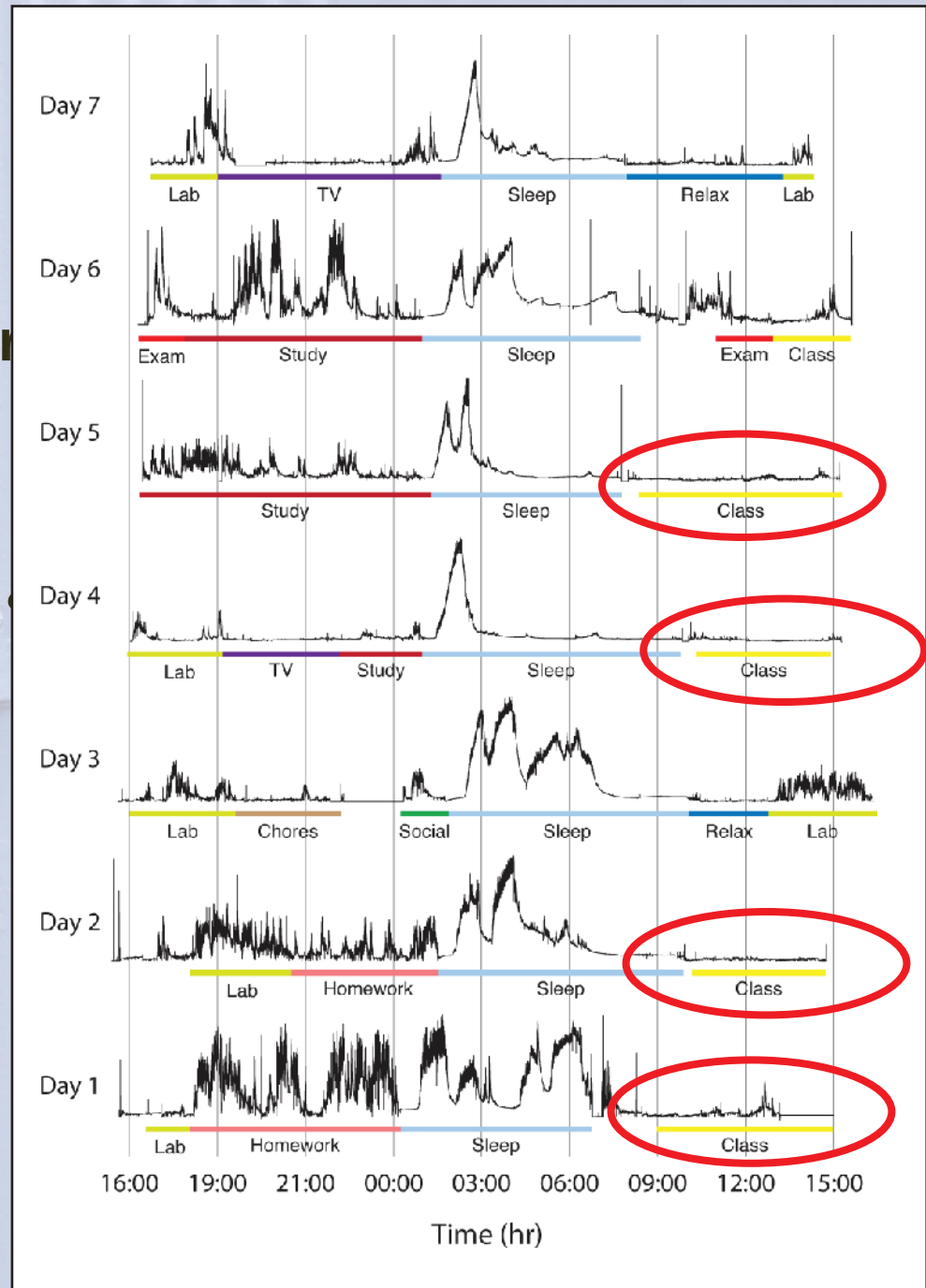
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

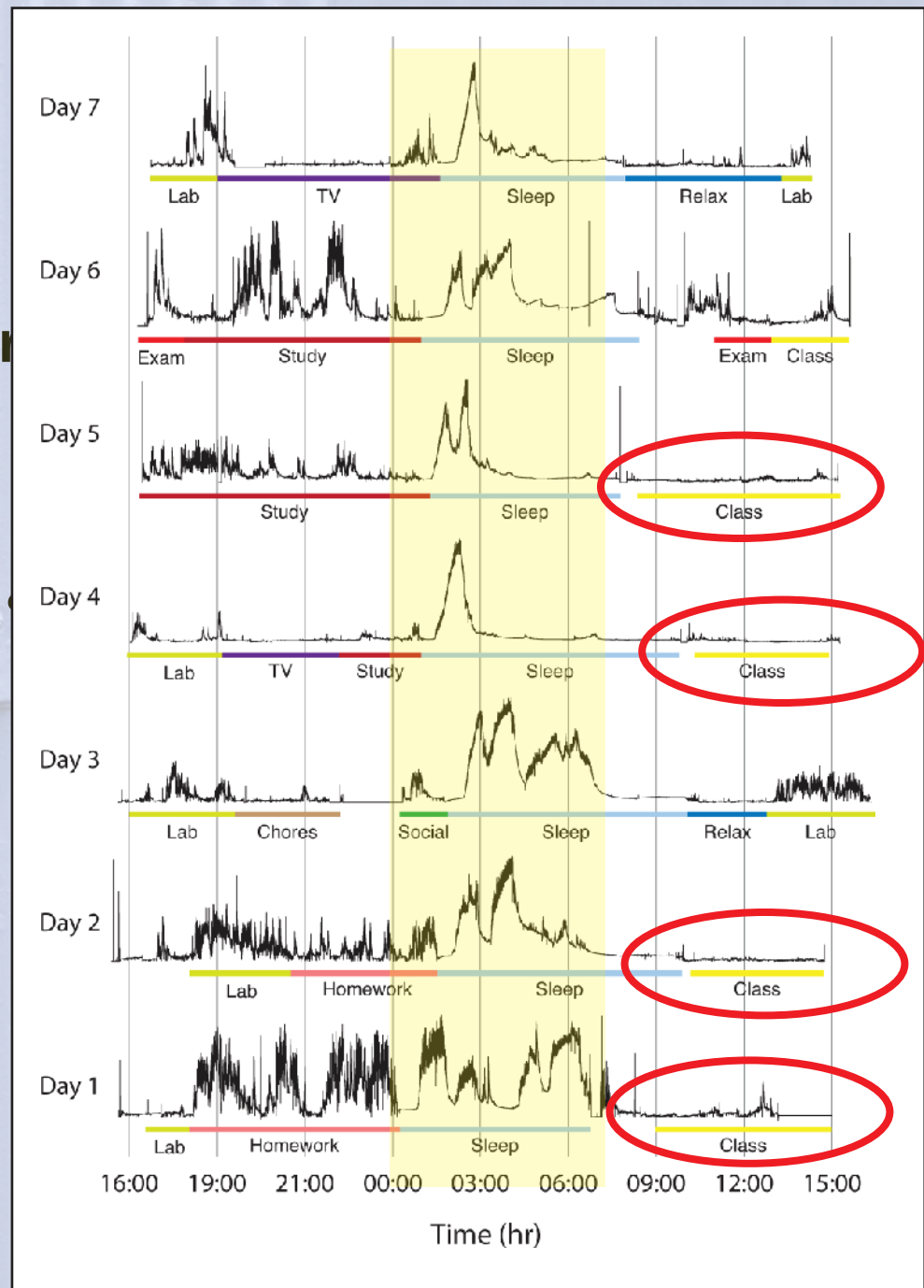
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

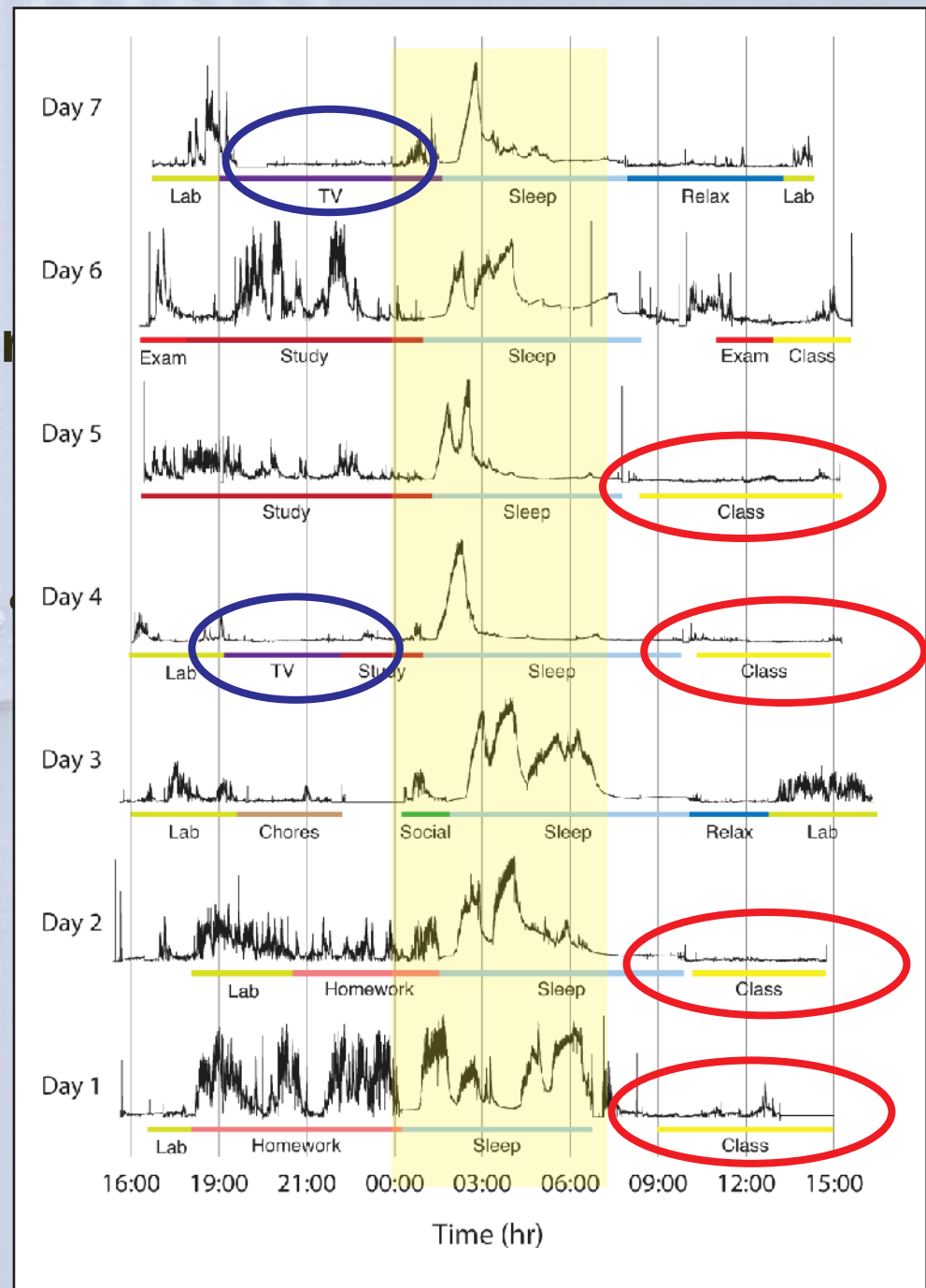
1 education

2 PI

3 test

in a lecture

1. don't pay utmost



doi: 10.1109/TBME.2009.2038487

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



**an illusion. . .**

**1** education

**2** PI

**3** test



**Education is not just about:**

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

**1** education

**2** PI

**3** test



**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

**1** education

**2** PI

**3** test

**Funding:**

**National Science Foundation**

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